School of Education

The Effect of Student Perceptions of Teacher-Student Relationships and Classroom Emotional Climate on STEM Education

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Human Ethics

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number #HRE2018-0084

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Keywords

Classroom Emotional Climate, integrated STEM learning, STEM education, STEM Learning Environments, student perceptions, teacher-student interactions.

Abstract

Science, Technology, Engineering and Mathematics (STEM) are essential investments in Australia’s future. Technology and innovation are key drivers of international competitiveness, which is necessary for the long-term stability and growth of Australia's economy. While demand for STEM literacy is rising, STEM enrolment and achievement in Australian education is falling. Reduced national capability in STEM is recognised as being partly due to the need for updated policy documents, an increase in STEM related jobs and a decline in STEM education enrolments. Learning environment research has proven the use of extensively tested and validated to effectively measure student perceptions of their learning environments. This case study has aimed to make a positive contribution to STEM education in Australia by determining how upper-primary student perceptions of their STEM Learning Environment (SLE) and their interactions with their teacher affect engagement with STEM education. Additionally, the project has sought to determine characteristics of SLEs from the perspectives of students, including their perceived preferred perception of these environments. Research indicates a significant gender imbalance within STEM careers, so this project proposes an additional focus that will consider female engagement. The study of upper-primary students is significant because career aspirations are often formed before the age of 14, and limited studies have been undertaken within SLEs at this age. It is hoped that this study may support the development of more effective upper-primary SLEs, promoting students to successfully engage with STEM in future education, and develop aspirations of STEM careers. The study sample consists of 100 Year 5 students in SLEs at an independent private school in Perth, Western Australia. To contextually understand the experiences of participants, a mixed-methods interpretivist case study was utilised across three phases, encompassing both quantitative and qualitative data. In the first phase of the project, questionnaires were implemented to quantitatively measure student perceptions of their classroom emotional climate and their interactions with their teacher. In the second phase, focus groups of students were purposively selected from within these classes to gather further qualitative data about these perceptions; the effect they have on engagement with STEM, and what students perceive to be preferred SLEs. During the third phase, questionnaires and focus group data were analysed to determine key themes and draw conclusions. They key findings from this data indicated that Student Freedom, Peer Collaboration, Problem Solving, Communication and Time all impact students' perceptions of their attitude towards STEM education. Additionally, the respondents outlined their perceived preferred perceptions of Hands-On Learning, Physical Environment, Choice, Technology and Peer Collaboration within their SLEs.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

ACARA: Australian Curriculum, Assessment and Reporting Authority

AGDET: Australian Government Department of Education and Training

AISWA: Association of Independent Schools of Western Australia

ANOVA: Analysis of Variance

CEC: Classroom Emotional Climate

CEWA: Catholic Education of Western Australia

CFA: Confirmatory Factor Analysis

CLASS: Classroom Assessment Scoring System

CV: Coefficient of Variance

EFA: Exploratory Factor Analysis

ICSEA: Index of Community Socio-Educational Advantage

KMO: Kaiser-Meyer-Olkin measure

LEI: Learning Environment Inventory

MCI: My Class Inventory

MET: Measures of Effective Teaching

OECD: Organisation for Economic Co-operation and Development

PISA: Program for International Student Assessment

QTI: Questionnaire on Teacher Interaction

SCSA: School Curriculum and Standards Authority

SLE: STEM Learning Environment

S-STEM: Student Attitudes towards STEM

STEM: Science, Technology, Engineering and Mathematics

STEM CEC: STEM Classroom Emotional Climate

TOSRA: Test of Science Related Attitudes

TSI: Teacher-Student Interactions

WAPPA: Western Australian Primary Principal's Association

WIHIC: What is Happening in this Classroom? Questionnaire

List of Appendices

Chapter 1: Introduction

1.1 Chapter Introduction

The purpose of this research project was to explore the perceptions of upper-primary students on their STEM Classroom Emotional Climates, and their relationship with their teacher to determine if there are any factors that influence their attitude towards STEM education. An additional focus on the perceptions of females has featured within this project to determine if differences between gender perceptions exist. This was achieved through the testing of a framework, by implementing a questionnaire and semi-structured focus groups within Year 5 classrooms. The purpose of the first chapter is to provide background information that introduces the concepts within the study; the research objectives and framework; the context of the study; the researcher's personal perspectives and viewpoint; and the significance of this research within the fields of learning environments and STEM education.

1.2 Background

Within education, the acronym STEM is increasingly referred to as the full or partial integration of Science, Technology, Engineering and Mathematics with 21st Century learning skills, and is an established international focus (Koul, Fraser, Maynard & Tade, 2017; Timms, Moyle, Weldon & Mitchell, 2018). According to the Education Council (2015), investment in STEM is a priority for multiple international governments. The current drive to advance STEM education in Australia is evident within policy documents, and is essential for the future workforce to remain internationally competitive (Australian Government Department of Education and Training (AGDET), 2017; Office of the Chief Scientist, 2013; Hudson, English, Dawes, King & Baker, 2015). Research indicates that this drive is partially due to the need for updated STEM policy as part of international economic competitiveness, an increase in STEM related jobs, a lack of STEM qualified educators, and the decline of STEM education enrolments and performance (Bissaker, 2014; Education Council, 2015; Education Services Australia, 2018; Kennedy, Lyons & Quinn, 2014; Koul et al., 2017; Office of the Chief Scientist, 2013; Timms et al., 2018). While the first three reasons are essential national considerations of STEM, this project will be focussed on the capacity of STEM Learning Environments (SLEs) to influence student engagement with STEM to potentially address the declining STEM numbers.

There are many prevailing issues within Australian education that reveal our current systems are not prepared for the challenge of implementing and growing our STEM capacity (Timms et al., 2018). With declining performances and policy papers which outline urgent issues within this sector (Timms et al., 2018), it is no surprise that it is a major focus within both Australian politics and education. With a STEM qualified workforce being critical to Australia's economic success, investment in quality STEM education is essential to ensure an adequate number of aspirants to accommodate the predicted growth of the industry (Barkatsas, Carr & Cooper, 2018). Therefore, it is imperative that research seeks to reverse this trend to determine ways that STEM education in Australia can be sent in an upwards trajectory, where scores are improving and enrolment statistics are rising. While most studies that target STEM education have been conducted within high schools, research has shown that engaging students prior to the ages of 11-14 is instrumental in generating long-term interest (Caplan, Baxendale & Le Feuvre, 2016). It is through these crucial primary years that students develop and establish their foundational skills, knowledge, and perhaps most importantly, their curiosity. Rosicka (2016) adds that the fundamental skills required within the STEM disciplines can begin being learnt within the earliest years of primary school, and therefore should be a focus to begin developing an early self-belief through positive engagement. Therefore, it is evident that the primary schooling years are a critical stage to address the gap facing STEM education at this time (Rosicka, 2016). For these reasons, this study will focus upon upper-primary students, and the ways in which associations between positive teacher interpersonal behaviours, and attitudes to STEM, influence student emotions.

Due to the undeniable need to invigorate a young generation's interest in STEM education, the question is asked as to how research can determine effective strategies for student engagement within these integrated disciplines. The extensively tested field of learning environment research is an expanse of knowledge built on for many decades. It develops our understanding of classrooms spanning from pre-primary through to university, and throughout lifelong learning environments, inclusive of any subject area (Koul et al., 2017). Fraser (2012) states that student perceptions of their learning environments are highly significant due to the large extent of time that they spend within classrooms. A pervasive approach for measuring perceptions within this field is through the use of extensively tested and validated questionnaires. There are a large number of questionnaires developed through comprehensive and significant learning environment research, and many more that have been developed through pre-existing scales that are modified to suit specific contexts (Fraser, 2012). While there have been a large number of questionnaires available to measure the perceptions of students within classrooms, this research project utilised one specifically designed to measure SLEs. For the purpose of this study, an SLE refers to a general primary classroom, within which the teacher implements an integrated approach to the STEM disciplines, and supports students to develop 21st Century capabilities. This will be elaborated further within Sections 2.2, 2.3 and 2.5. Investigating correlations between student cognitive and affective outcomes, and their perceptions of the psychosocial dimensions of their classroom, remains one of the most established approaches to achieve this over time (Fraser, 2012). One conclusion drawn by Fraser (2012) is that classrooms should be changed to suit the student perceived preferred learning environment. One method with significant merit is through measuring these perceptions by combining qualitative and quantitative data collection (Fraser, 2012). For these reasons, a mixed-methods study using an extensively validated questionnaire and semi-structured focus groups has been chosen to measure the perceptions of upper-primary students within SLEs, and their perceived preferred environment for effective engagement.

Hattie (as cited in Caplan et al., 2016) believes that how we teach is as important as what we teach, and that we need to measure this impact through the eyes of our students – their excitement, their engagement, their sense of mastery, and their drive to learn more. Within the research there is a large bank of knowledge about teacher perceptions and their impact on education, however; research around student perceptions is less common, particularly within the primary school context. Student perceptions of their learning environments play a critical role in their engagement and success. Ferguson (2012) claims that through the significant time that young students spend with their teachers, we should not doubt their importance for providing valid, reliable and important observations about the quality of teaching that they experience. A large body of research exists that consistently reveals an empirical relationship between the teacher-student relationship, student achievement and attitudes. Knopke (2016) asserts that students' perceptions of STEM are shaped by values, beliefs and education. The focus of this study is the impact of SLEs and teacher-student interactions on student attitudes towards STEM; specifically, their effect on student participation and motivation to engage positively with STEM education in an upper-primary context. Upper-primary contexts are particularly valuable to this study, as this is the age in which students may begin experiencing motivation and engagement within the STEM disciplines, leading them to potentially pursue these through further study in high school. Luckner and Pianta (2011) maintain that more research is required to study teacher-student relationships within upper-primary contexts. Marginson, Tytler, Freeman and Roberts (2013) also state that early education and primary contexts are essential for the laying of STEM foundational concepts. It is for these reasons that this research project focuses upon the perspectives of upper-primary students, and how their experiences within SLEs may have impacted their motivation and drive to pursue, or avoid, further study within the STEM disciplines.

According to Marginson et al., (2013), most countries tend to have similar issues around women being underrepresented within STEM careers. In fact, the participation of females in Australia has not altered in two decades (Marginson et al., 2013).The Office of the Chief Scientist (2014; 2013) states that measures are required to raise female engagement in STEM and that these measures could help bridge the STEM skills shortage gap. Due to the research that a female's motivation to pursue careers within these industries can be determined by their early childhood exposure to STEM (Timms et al., 2018), it is suggested that measures are put in place to determine what engages girls early with these concepts. Marginson et al., (2013) also suggest that early experiences are essential to motivate girls, and that designing learning experiences and pedagogical approaches that are suited to female learning styles, as well as males, could be essential to the improvement of enrolment numbers. A further focus will therefore be to analyse literature regarding female participation in STEM, and a gender gap in enrolments which has been highlighted through the research. The study focusses specially on any patterns that may occur within female student responses that differ from patterns within male responses, seeking indicators of what females potentially perceive to be indicative of quality SLEs, with the goal being to increase their engagement and participation.

1.3 Research Objectives

While large bodies of research have been conducted within classroom learning environments, including the impact of educator and student perceptions of learning environments on engagement and achievement, little has been focussed upon primary-aged student perceptions within SLEs. Currently, trends in enrolment and achievement across STEM disciplines are negative in Australia (Timms et al., 2018), and therefore there is a drive to identify ways to effectively engage students within these learning areas. This research intends to add to the body of literature that explores the perceptions of students during the early stages of their learning and career trajectories. This will be achieved through an attempt to identify elements of SLEs and teacher-student relationships that impact a child's decision to pursue further STEM education.

1.4 Conceptual Framework

This study brings together two areas of research to seek to determine the dimensions of learning environments which impact a student's motivation to pursue further STEM education: (a) their perceptions of STEM Learning Environments through Classroom Emotional Climate and (b) their perceptions of their relationship with their teacher. This relationship is hypothesised in Figure 1, and will seek to determine their attitudes towards the STEM disciplines. Additionally, a third question (c) will seek to determine characteristics of a STEM Learning Environment, and student perceived preferred perceptions of their characteristics.

The framework is based on the concept that a student's perceptions of their relationship with their teacher, and their perceptions of their Classroom Emotional Climate (CEC) within SLEs directly impacts their attitudes, engagement and interest in STEM. If students are experiencing negative CEC (e.g., disrespectful relationships and confrontational management styles) and perceive negative teacher-student relationships, they will experience disengagement and disinterest within the STEM disciplines, which will negatively impact their likelihood of pursuing further learning and a career within these fields. If students are experiencing positive CEC (e.g., respectful relationships and helpful/understanding management styles), and perceive positive teacher-student relationships, they will experience potential future engagement and interest in the STEM fields, and this will have a positive influence on their decision to pursue further learning and potential careers within these disciplines.

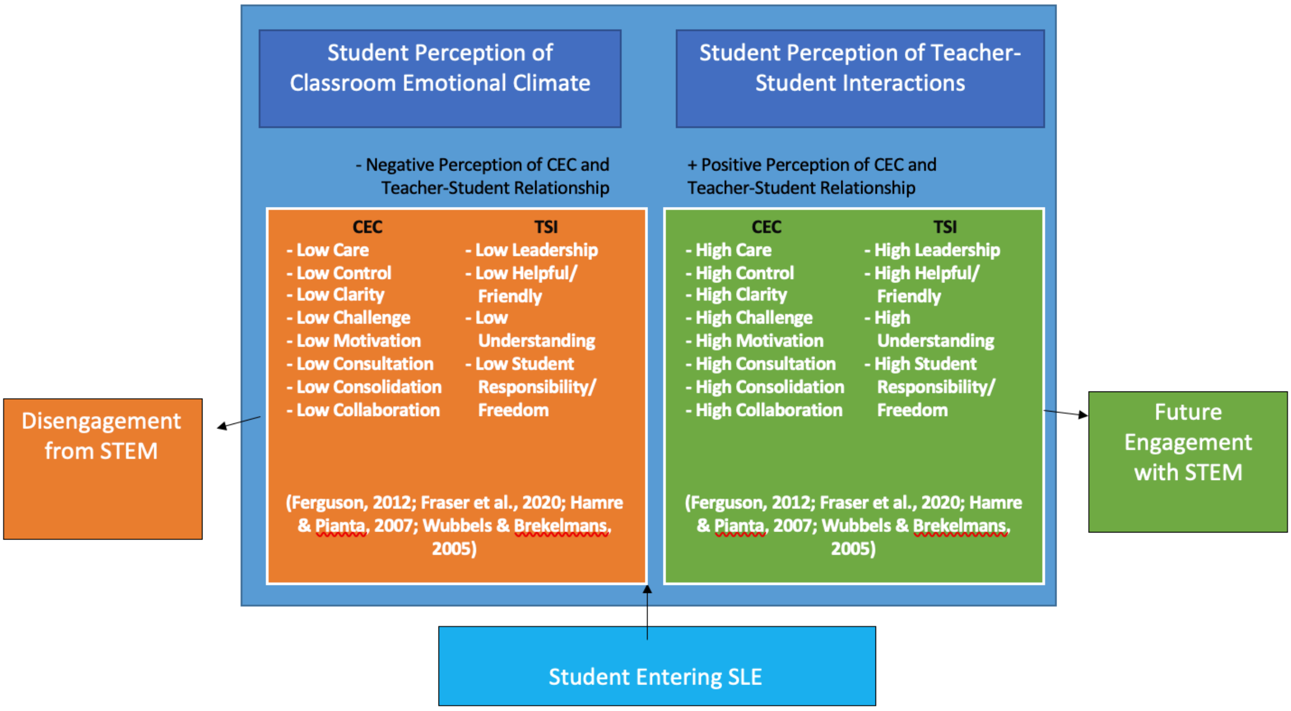

FIGURE 1.1: MODEL OF HYPOTHESISED RELATIONSHIP BETWEEN STUDENTS' PERCEPTIONS OF TEACHER-STUDENT RELATIONSHIPS AND CLASSROOM EMOTIONAL CLIMATE, AND THEIR ATTITUDES TOWARDS STEM

1.5 Research Questions

This proposed research project aims to investigate how upper-primary student perceptions of (a) their STEM Learning Environment and (b) their relationship with their teacher affect their attitudes, engagement and interest in STEM. Additionally, it seeks to determine the characteristics of a STEM Learning Environment, and student perceived preferred perceptions of these characteristics.

1. How do upper-primary student perceptions of the emotional climate of their STEM Learning Environment impact attitude towards STEM?
    a. What do students perceive to be their preferred emotional climate of a classroom?
    b. Do any variations in perception, or attitude towards STEM, exist between genders?

2. How do upper-primary student perceptions of their relationship with their teacher impact attitude towards STEM?
    a. What do students perceive to be their preferred teacher interpersonal behaviour?
    b. Do any variations in perception, or attitude towards STEM, exist between genders?

3. What are the characteristics of a STEM Learning Environment?
    a. What do students perceive to be their preferred STEM Learning Environment characteristics?

1.6 Context

The study was undertaken within an independent co-educational primary school in the northern suburbs of metropolitan Perth, Western Australia. In Australia, independent schools function as separate entities responsible for their own strategic directions, behavioural management policies, cultures, and belief structures that suit their cultures and communities (Association of Independent Schools of Western Australia (AISWA), n.d.). It is the individual school's responsibility to ensure student welfare and to meet the standards of the Education Act. The school comprises of several areas of learning: Early Learning (Years K-1) and the Junior School (Years 2-5) co-exist on the primary school campus, whereas the Middle School (Years 6-8) and the Senior School (Years 9-12) co-exist on an adjacent campus.

The junior school, which includes students from Year 2 to Year 5, has an emphasis on student active participation within their educational philosophy and seeks to foster a life-long love of learning through inspiration and the development of thinking skills. They use an enquiry-based pedagogy with a focus on literacy and numeracy skills among other areas. They have an additional focus on sustainability and are involved in the United Nations 2030 Sustainable Development Goals learning program.

The school has an ICSEA (Index of Community Socio-Educational Advantage) value over 1100, indicating an above average score for educational advantage. This figure is used to measure parent occupation, parent education, geographical location and proportion of Indigenous students (Australian Curriculum, Assessment and Reporting Authority (ACARA), n.d.). The higher the ICSEA value, the higher the level of educational advantage that the students have. It does not reflect school resourcing or facilities, staff or teaching programs (ACARA, n.d.). The median ICSEA value is 1000 as calculated by ACARA (n.d.), and typically ranges from 500 to 1300.

The quantitative data was collected within the 4 Year 5 classes by the researcher during 2020, with visits being impacted by school shutdowns due to COVID-19. When independent schools returned to campus in Term 3 of 2020, the researcher personally visited the classrooms involved to administer the questionnaire. The sample was approximately 100 Year 5 students across four classrooms with four teachers involved in the research. The gender of the participants was almost evenly distributed, with 54 females and 46 males involved. The teachers were not present in the room during the implementation of the questionnaire; however, they joined the classroom for the initial conversation about STEM, and the classroom learning projects that students had undertaken which related to these areas. While the instrument was appropriately worded, the students had the option of working through each item with the researcher for literacy support to ensure understanding.

The quantitative data was manually processed onto an Excel spreadsheet, before being entered and analysed using IBM SPSS Statistics Management software. A number of analysis methods were conducted using the data, which are discussed within Chapter 3: Research Design. The results of this analysis is then outlined and explored within Chapter 4: Quantitative Results, with an overall discussion of both quantitative and qualitative data presented within Chapter 6: Discussion.

The qualitative data was collected by the research team during 2020, mid-Term 4. 12 students were identified to form semi-structured focus groups based on their responses to the quantitative questionnaires. A range of students were selected based on their attitudes towards STEM (Items 75 – 84), responses to written item 103, their gender and their classroom, which is discussed at length within Chapter 3: Research Design. The focus groups were run with four children per interview and were recorded using an audio device. The recordings were then submitted to a professional company for transcription. Thematic analysis was used to analyse the qualitative data, with results being outlined in Chapter 5: Qualitative Results, and in further detail within Chapter 6: Discussion.

1.7 Personal Views and Perspectives

I approach this research from my worldview, which has been influenced by my personal experiences within the education system. Currently, I am employed on a full-time basis as a Level 3 teacher within a Department of Education school, teaching upper-primary students, running an elective STEM club and contributing significantly to whole-school STEM resources, procedures and policies, and through running professional development for staff. I was fortunate from a young age to be influenced by my family, who engaged me with the sciences and never limited my interest regardless of my gender, which is not reflective of all female experiences. My primary education was at a school that excelled at mathematics, sciences and technologies learning, with passionate staff, including Richard Johnson, winner of the 2013 Prime Minister's prize for science teaching, and Australia's nomination for the 2016 Global Teacher Awards. These positive experiences engaged me early within the STEM disciplines and inspired me to pursue further learning in these areas. I decided to study teaching as I wanted to impact other children with the same positive experiences that I had been given, otherwise I would have pursued a degree in the sciences.

Firstly, I believe that relationships and positive classroom environments underpin all that we do as educators. Our success with our students relies on our abilities to consistently and constantly reflect on our current classroom behaviour and habits to improve our practice. I also think that as an educator we can consider what we do as being highly effective, but if our students don't perceive it the same way, it may be completely ineffective and not conducive to learning. This raises an essential question as to why educators, not only researchers, don't more frequently seek out their students' perspectives, rather than of leadership and colleagues. We as educators have access to some of the most free, available and valuable data for our professional growth with us throughout our careers, and I hope to inspire others to consider how their students can positively impact their teaching.

Secondly, I value the contributions of the STEM disciplines to society and strongly believe that they will play an increasingly important role, not only in Australia's economic success, but also for the human race to solve problems relating to significant issues facing us, such as global warming, food shortages, or the COVID-19 global epidemic. I also share my concerns, as through my experience working with schools, I have heard educators refer to STEM as a "buzz word" that will die out, and others making comments about the difficulty of the associated mathematics and sciences, therefore placing little importance in their professional development. I hope that through this research I can contribute to the growing body of evidence suggesting the critical nature of STEM education to our society, to positively impact teacher and student attitudes towards these disciplines.

I have approached this research project to bring together the areas of learning environments, teacher-student relationships and attitudes towards STEM education, as I believe that a significant improvement can be made to address Australia's shortage of achievement and enrolment across the STEM disciplines, particularly focussing on females who are significantly underrepresented and deserve equal access to these roles.

1.8 Significance

According to The Foundation for Young Australians (2017), Australia is experiencing disruptions that have been the most significant since the industrial revolution. STEM education is a national priority due to a skills shortage which may negatively impact our international competitiveness and economic success. It has been described as an essential element in many of the global issues currently facing contemporary society, such as global warming and overpopulation (Thomas & Watters, 2015). Through an international comparative study of STEM education and policy within other countries, Marginson et al., (2013) draw conclusions that Australia is at risk of being left behind as our national sense of urgency is lacking. Currently, enrolments and performance within STEM education in Australia is declining, while the demand for qualified workers within these areas is rising (Timms et al., 2018). This research is especially significant in attempting to determine how students currently perceive their emotions within SLEs, and the way their relationship with their teacher is impacting their attitude and drive to pursue further education within these disciplines.

A significant element of this study is the focus on primary school student perceptions and how they can be motivated at an early age to pursue STEM study and careers. In 2011, Becker and Park conducted a meta-analysis of integrated STEM projects with empirical data. Of these 28 studies, only 3 were conducted within primary schools, highlighting a significant gap where it is suggested the motivation and engagement with STEM is ignited. Tytler, Osborne, Williams, Tytler and Cripps Clark (2008) state that career aspirations are often formed before the age of 14, highlighting the importance of quality STEM education in upper-primary schooling. This research seeks to determine effective learning environments for inspiring and engaging upper-primary students in STEM. Although a significant body of research exists within learning environments, the significance of this study is regarding how learning environments relate to STEM in particular, and the gender imbalance within STEM. With enrolments and performance in STEM declining, it is essential that research continues to seek ways of reversing this trend. Considering the implications of learning environments as discussed, investigating the gap within SLEs may assist with conclusions about these figures. Due to the context of upper-primary education, this study will explore which environmental influences initially engage students in STEM, and which environmental influences create a culture of success and aspiration for students.

Furthermore, with females continuing to be less engaged than males, a particular focus may highlight preferences that females have within SLEs and what may need to be considered to reverse this trend. It is hoped that this research project will assist in the promotion of STEM education and aspiration within STEM careers.

1.9 Thesis Outline

Chapter 1 within this thesis introduced the research project by presenting a background to the research which connected to the research objectives. A hypothesised model of the conceptual framework shows the project's relation to the current literature associated with the research, and how the questions addressed fit within the model. The context of the study was also presented along with a brief overview of the methodology utilised.

Chapter 2 presents the literature review which extensively analyses a body of research that relates directly to the constructs of this study, including STEM education and industry, learning environments, teacher-student relationships, student engagement and gender differences.

Chapter 3 explains the research design of the study, and reports on the methodology, research design, participants, selected instrument, methods of data analysis and ethical considerations.

Chapter 4 presents an overview of the quantitative results from the study, including the data demographic, data preparation, descriptive statistics, attitudes to STEM, differing responses between genders and a summary of the key findings.

Chapter 5 reports on the overview of the qualitative results from the study, including data preparation, coding, themes that arise from the data and a summary of the key findings.

Chapter 6 discusses the analysis of the findings from the research questions and presents an overall discussion. This is discussed within the context of the literature review.

Chapter 7 presents the final conclusions of the thesis, including the limitations and applications for educators, before providing potential recommendations for future research.

1.10 Summary of Chapter

This chapter has discussed the background of the research project by introducing the key concepts that underpin this study. Furthering this, the conceptual framework and research questions were presented to guide and structure the project, followed by the context, personal viewpoints of the researcher, significance of the findings, and the thesis outline. Chapter 2 will now discuss in detail the literature driving this research project, including an overview of instruments used within the field of learning environments.

Chapter 2: Literature Review

2.1 Chapter Introduction

Chapter 1 introduced the purpose of this study, which was to identify dimensions of student perceptions within SLEs and teacher-student relationships that positively contributed to engagement within the STEM disciplines. This second chapter will present a literature review of research that directly relates to the purpose of the study. The research questions seek to determine the preferred perception of classroom emotional climates within STEM Learning Environments; the perceived preferred perception of teacher-student relationships, with a focus on variations between gender differences; and the characteristics of a STEM Learning Environment. An additional focus on gender is too determine if females prefer elements within their learning environments that differ from males, and how this information can be used to improve female engagement with the STEM disciplines.

This chapter reviews literature that pertains to the two key fields of study: STEM education and learning environments. It draws together critical constructs including background and contextual information, recommendations from experienced researchers from the field, and previous instruments and approaches utilised within these areas which directly relate to the study.

2.2 Integrated STEM Learning

An exact definition for STEM education has been a lengthy debate and is essential for the successful implementation of quality learning and engagement (Barkatsas et al., 2018; Blackley & Howell, 2015; Rosicka, 2016; Timms et al., 2018). Barkatsas et al., (2018) go as far to state that educators have been grappling with this “ill-defined” field, whilst Nadelson & Seifert

(2017) explain that it is difficult to develop a definition for STEM as it is used across an array of contexts and requires flexibility. Due to its contextualised and amalgamated nature from multiple disciplines; politics, research and education have found it difficult to define exactly what STEM needs to encompass. There are arguments which assert that STEM is best taught through separate content areas for a greater depth of understanding; however, in Western education there is a greater movement for STEM to be taught through an integrated approach (Thomas & Watters, 2015). Kelley and Knowles (2016) argue that teaching through individual "silos" remains an archaic barrier to integrated and innovative STEM education. While there are arguments for both approaches, this study will be focussed upon STEM as integrated practise.

According to Nadelson and Seifert (2017), integrated STEM education is the combination of concepts and content from the separate STEM disciplines, where the skills and knowledge become considered in the context of a problem rather than specific to each discipline. In the context of the problem, students draw from their understanding of previously learnt information to pinpoint what is required for success, rather than focus on one particular area. They view open-ended problems that naturally require knowledge and skills from the four disciplines, as opposed to segregated STEM education which doesn't reflect industry experiences and requirements (Nadelson & Seifert, 2017). A framework developing around STEM education also indicates that information from other disciplines, such as the arts and humanities, could be included, and that not all four of the STEM domains are necessary within individual learning experiences (Blackley & Howell, 2015).

Currently, there are calls for the improvement of the STEM curriculum and instruction (Honey, Pearson & Schweingruber, 2014). Blackley and Howell (2015) state that over time teachers, particularly within primary schools, have unsuccessfully battled to enact the STEM agenda led through politics, leading to STEM being implemented through a pedagogical lens. Many researchers argue that STEM needs to be interdisciplinary to adhere to the realities of industry, and that students need to be making real-world connections (Honey et al., 2014; Margot & Kettler, 2019; Nadelson & Seifert, 2017). Blackley and Howell (2015) agree by outlining that STEM education requires authentic contexts to create meaning for participants. Students need to experience real connections with industry and be engaged through authentic STEM professionals (Timms et al., 2018). Teaching this through purposeful and intentional integration rather than content isolation positions students to understand why they are learning and how knowledge is connected to concepts outside of the classroom (Rosicka, 2016). This connects to the concept that understanding the application of knowledge is as important as the knowledge itself (Kelley & Knowles, 2016). This also creates a space where students are given the opportunity to experience failure authentically, which teaches the imperative concept of reflection that leads to a more positive growth mindset approach to problem solving (Rosicka, 2016). The development of these skills is often referred to as being a fundamental element underpinning student's success in an unknown and changing workforce, indicating the essential nature of the integrated approach to teaching STEM. These skills will be discussed in further detail in Section 2.3.

Adding to this is the idea that integrated STEM education is reflective of the constructionist approach to education, providing a context for students to actively construct knowledge about abstract understandings which promotes the recall and transfer of learning (Sanders, 2009). Nadelson and Seifert (2017) extend this definition by explaining that we are entering an age where information needs to be presented through a sophisticated synthesis that merges disciplines and prepares students for careers which will be transdisciplinary. They also assert that teaching STEM through integration is critical for the preparation of students who will later be able to both analyse and synthesise large amounts of information from multiple disciplines to solve problems during their careers (Nadelson & Seifert, 2017). Sanders (2009) believes that sufficient evidence has been collected with regards to achievement, interest and motivation to promote the further investigation into this integrated approach, while Honey et al., (2014) state that little research exists to determine which specific factors increase retention, achievement, interest or valued learning outcomes. They believe that with the education community moving towards integration as a means of instruction, that researchers need to invest energy, creativity and resources into discerning high-quality and evidence-based practises for integration.

Integrated STEM learning is an essential element of this study, as research has shown that integrated STEM through the use of contexts enhances student engagement and motivation towards their learning (Nadelson & Seifert, 2017). This therefore plays an essential part for measuring student perceptions of their SLEs. For the purpose of this research project, STEM education will be referring to the constructivist method of the full or partial integration of the four disciplines of STEM, within which students are presented real-world problems from multiple disciplines where they require their knowledge and skills to solve.

2.3 STEM Employability Skills

The development of transferable skills within young people will be essential for their ability to navigate flexible and complex careers (The Foundation for Young Australians, 2017). One of the key arguments for an international focus on STEM education is the development of STEM skills which are critical for preparing students for future unknown working conditions, making them essential for Australia's economic success (Caplan et al., 2016; Honey et al., 2014; Marginson et al., 2013; Margot & Kettler, 2019; Nadelson & Seifert, 2017; Stobaugh, 2019; Timms et al., 2018). Additionally, the demand for occupations requiring these skills has risen 70%, and they also offer a higher pay (The Foundation for Young Australians, 2017). Throughout literature, these skills are referred to by several names: 21st century competencies, 21st century skills, employability skills, STEM capabilities and STEM skills to name a few (Honey et al., 2014; Office of the Chief Scientist, 2012; Office of the Chief Scientist, 2015; Timms et al., 2018), but generally they refer to a similar set of skills with some interchangeable differences. Through a comprehensive study of STEM-related literature, Honey et al., (2014) explain that these competencies are an amalgamation of intrapersonal, interpersonal and cognitive characteristics. They typically include metacognition, critical thinking, flexibility, initiative, innovation, collaboration, communication and responsibility (Honey et al., 2014).

In 2013, the Office of the Chief Scientist (2015) commissioned Deloitte Access Economics to conduct a survey that measured Australian employer's attitudes towards STEM skills and STEM skilled employees. 1 065 employers from a range of industries responded, with not all answering each question. The survey utilised a Likert 5-Point Scale, which gave the possibilities of Very Important, Important, Moderately Important, A Little Important and Not Important. While specific skills that employers valued varied across sectors, the respondents rated active learning, critical thinking, complex problem-solving and creative problem-solving as the most important attributes and skills for the work place, with at least 50% of respondents indicating each to be very important (Office of the Chief Scientist, 2015). Time management, interpersonal skills, and an understanding of business operations ranked slightly less in importance, with between 40 – 50% of respondents indicating these skills to be very important (Office of the Chief Scientist, 2015). Programming was at the bottom of the list, and was only ranked as very important by approximately 25% of respondents (Office of the Chief Scientist, 2015). Additionally, within a question that asked respondents to list other essential skills, communication was considered overwhelmingly important (Office of the Chief Scientist, 2015). This remains almost consistently across lists of STEM-related skillsets. While responders were generally satisfied with the quality of STEM graduates they had hired, out of 429 responders, one in three believed that there is a "mismatch" between applicant skillsets and those required for roles (Office of the Chief Scientist, 2015). This survey demonstrates that while we are making some progress in the quality of our STEM education, there is still a lack of alignment between education and industry, and that further research into preferred STEM skillsets required by employers needs to be undertaken.

More recently, the World Economic Forum (2020) discuss the impact of COVID-19 and automation on the disruption of current work conditions for both employees and employers. They outline data suggesting that time allocated to tasks will be equally dispersed between humans and robots, indicating a significant need to make changes within industry over the next five years. While this is the case, The World Economic Forum (2020) also outline that even though an approximate 85 million jobs may be displaced, these will be replaced through the potential development of 97 million new roles. These new roles will require additional sets of skills, which will act as drivers of economic success through societal cohesion and technological enhancement (World Economic Forum, 2020). In line with the projected industry needs over the next five years, the top 15 skills required by employees for 2025 is outlined in Table 1 (World Economic Forum, 2020). These have been indicated by employers as skills which will be essential leading up to workplace changes by 2025.

TABLE 2.1: TOP 15 SKILLS FOR 2025 (WORLD ECONOMIC FORUM, 2020).

1. Analytical Thinking and Innovation	9. Resilience, Stress Tolerance and Flexibility
2. Active Learning and Learning Strategies	10. Reasoning, Problem-Solving and Ideation
3. Complex Problem-Solving	11. Emotional Intelligence
4. Critical Thinking and Analysis	12. Troubleshooting and User Experience
5. Creativity, Originality and Initiative	13. Service Orientation
6. Leadership and Social Influence	14. Systems Analysis and Evaluation
7. Technology Use, Monitoring and Control	15. Persuasion and Negotiation
8. Technology Design and Programming	

The development of STEM skills within students is an essential goal required to establish a STEM-capable workforce, therefore making these skills and their acquisition a critical component within STEM education. The Office of the Chief Scientist (2012) states that universities play critical roles when engaging young people in STEM fields, and that their curriculum should potentially be designed to explicitly teach these skills within their teacher training. While this is important at an undergraduate and postgraduate level, universities require a steady stream of applicants to enter these courses with significant skill levels, making education at primary and secondary levels an integral part of the engagement process. If these skills become a focus of primary schooling, students will already be developing the foundational attributes required for success in their future learning pathways. Integrated STEM learning that involves the development of STEM skills has been a focus for this study, which, as discussed within the literature, is reflective of quality practise and an essential element required for successful students of the STEM disciplines.

The School Curriculum and Standards Authority (SCSA) (2014), outline the general capabilities of the Western Australian Curriculum as a significant contributor to the development of 21st Century learners, which are competencies that naturally intertwine within the mandated learning areas to add richness and depth. Table 2.2 outlines each of the seven capabilities, which have been developed to include knowledge, skills, behaviours and dispositions (SCSA, 2014). According to SCSA (2014), they have been created to support students to develop the necessary attributes to live and work in the 21st Century. As previously stated, the STEM pedagogical approach positions students naturally to develop these capabilities through the integrated and problem-based nature of the learning.

TABLE 2.2: GENERAL CAPABILITIES IN THE WESTERN AUSTRALIAN CURRICULUM (SCSA, 2014).

Literacy
Numeracy
Information and Communication Technology (ICT) Capability
Critical and Creative Thinking
Personal and Social Capability
Ethical Understanding
Intercultural Understanding

There are some similarities and differences between the capabilities list developed by education, and ones created through industry. Critical and creative thinking appear in some format within each of the skillsets, along with personal and social capabilities. The capable use of technology also appears on each list with differing specifications. Further research may seek to merge or combine these lists to make a more definite guideline for educators.

2.4 Learning Environments

Learning environments are the psychosocial and emotional dimensions of a classroom identified from the perspective of the educator and/or student (Fraser, 2012). These dimensions refer to the nature of a classroom, and relationships, perceptions and attitudes within a classroom. After four decades of research Fraser (2012) determined that students spend significant time in classrooms so it is essential we consider their perceptions. Ferguson (2012) agrees, stating that student perceptions in tertiary contexts are frequently used to evaluate teaching, but they are seldom used in other contexts such as schools. Research has demonstrated that elements of learning environments such as teacher-student relationships and Classroom Emotional Climate (CEC) relate strongly to a child's social-emotional growth and academic achievement (Rucinski, Brown & Downer, 2018), therefore making them a key consideration in determining ways to engage and motivate students.

In 2014, a three year study in senior secondary Western Australian schools collected the responses of 10 345 students across 684 schools with a total of 548 teachers involved in the research (Bell & Aldridge, 2014). The aim of the research was to use student feedback of their perceptions of their educators to improve teaching and learning. Bell and Aldridge (2014) suggest three key reasons why using student perceptions is an effective way to improve quality teacher practise: firstly, using participant observations determines findings that an external observer wouldn't be able observe; secondly, students experience a range of learning environments and are therefore well-positioned to make comparisons between them; and thirdly, that student observers spend large periods of time with their educators, and therefore are able to make more consistent and accurate impressions of teacher behaviour. While this study was conducted on senior secondary students, its validation at the senior secondary level opened the door for this research to be considered at lower secondary and then upper primary children.

An established practice in measuring student perceptions of learning environments is through extensively validated questionnaires (Koul et al., 2017). Abundant research has validated numerous frequently-used questionnaires and found distinct correlations between student cognitive outcomes, attitudinal outcomes and learning environments (Fraser, 1986, 2012). Watt (2016) builds on this by concluding that teachers convey expectations through their learning environment, which directly impacts students' perception of their achievement in all learning areas, and particularly STEM. This indicates a distinct connection between student perceptions of learning environments and attitudes towards STEM.

Byrne, Hattie and Fraser (2015) and Wubbels and Brekelmans (2005) suggest that historically, research has generally been conducted on actual classroom environments, rather than environments students perceive to be effective. There is also a larger body of research in the high school context surrounding the effects of learning environments, teacher-student interactions and students' attitudes towards STEM. This gap offers a potential area for research in upper-primary education, where the nature of emotional learning environments directly impacts students' perceptions of STEM. Further development of this literature may support conclusions about the decline of STEM enrolments and could assist to reverse this trend.

2.5 Development of Learning Environment Instruments

The field of learning environment research combines an array of quantitative and qualitative research (Fraser, 1998). A large number of questionnaires have been developed over time by a range of researchers within classroom learning environment research, which is a popular method for measuring participant perceptions. Fraser (1998) notes that student perceptions are an integral part of learning environment research, and that even when teachers are inconsistent, students have observed them for long enough periods of time to make consistent judgements. In order to determine a questionnaire most appropriate to this study, a range of questionnaires have been considered and outlined to provide a history and context for the researcher's choice.

2.5.1 Learning Environment Inventory (LEI)

The Learning Environment Inventory (LEI) was originally developed and validated towards the end of the 1960s, and contains 105 statements that reflect a typical school classroom (Fraser, 1998). It positions students to respond using four options: Strongly Disagree, Disagree, Agree and Strongly Agree (Fraser, 1998). This instrument measures across a large number of scales: Cohesiveness, Friction, Favouritism, Cliqueness, Satisfaction, Apathy, Speed, Difficulty, Competitiveness, Diversity, Formality, Material Environment, Goal Direction, Disorganisation and Democracy (Fraser, 1998).

2.5.2 My Class Inventory (MCI)

The My Class Inventory (MCI) was developed as a simplified version of the LEI appropriate for children between ages 8-12, but was also found to be effective with junior high school students (Fraser, 1998). Several key changes were made between the instruments: the MCI was reduced from the LEI's original 15 scales down to 5, wording was simplified to improve comprehension, and the LEI's four point response was reduced to a simple yes/no function (Fraser, 1998). The scales include Cohesiveness, Friction, Satisfaction, Difficulty and Competitiveness (Fraser, 1998).

2.5.3 What Is Happening In this Class? (WIHIC)

The What Is Happening In this Class? (WIHIC) questionnaire combines modified scales from a range of questionnaires with additional scales that reflect contemporary education (Fraser, 1998). Refinement of the WIHIC condensed the original 90-item nine-scale instrument down to 50 items with seven scales (Fraser, 1998). The scales include: Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation and Equity (Fraser, 1998).

2.5.4 Questionnaire on Teacher Interaction (QTI)

The Questionnaire on Teacher Interaction determines dimensions of teacher-student interpersonal behaviour in terms of Influence (dominance-submission) and Proximity (opposition-cooperation) [See Figure 2.1] (den Brok, Levy, Brekelmans & Wubbels, 2005). The original Dutch version has 77 items divided between 8 sections which are answered using a Likert 5 Point Scale (den Brok et al., 2005). The QTI was originally developed in 1982, and has been utilised in many research projects with a database that exceeds 300 000 students, tens of thousands of classrooms and over 6 000 teachers (den Brok, Brekelmans & Wubbels, 2006). The QTI is important to their study, as it has directly impacted the instrument used to collect the quantitative data.

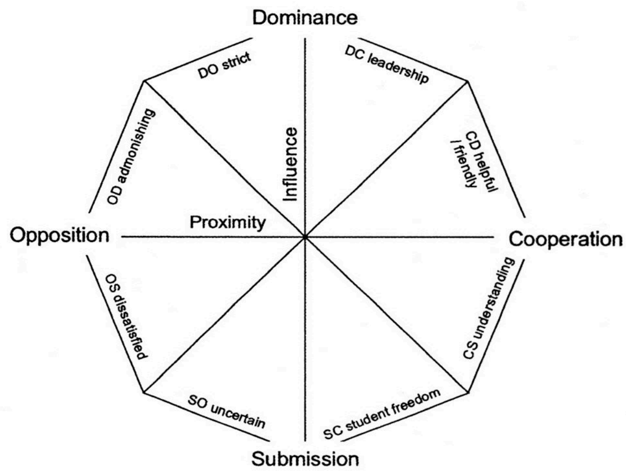

FIGURE 2.1: THE MODEL FOR INTERPERSONAL TEACHER BEHAVIOUR

2.5.5 Classroom Assessment Scoring System (CLASS)

The Classroom Assessment Scoring System (CLASS) Framework proposes that interactions between students and teachers can be measured across three domains: emotional support, classroom organisation and instructional support (Hamre & Pianta, 2007). Empirically supported, the model has been tested within the classrooms of over 4000 Pre Primary – Year 5 students within the United States (Luckner & Pianta, 2011). The emotional support domain is evidenced by warmth and/or negativity; the classroom organisation domain is evidenced by time management, behaviour and attention; and the instructional support domain is evidenced by the richness of instruction and feedback (Hamre & Pianta, 2007; Luckner & Pianta, 2011).

2.5.6 Tripod 7Cs Survey

The Tripod 7Cs survey was developed through the Measures of Effective Teaching (MET) Project that was run through the Bill & Melinda Gates Foundation, referring to three areas: content knowledge, pedagogic skill, and relationships (Ferguson, 2012). It was used to test the perceptions of students across a wide range of schools throughout the United States of America. Between the years 2001 to 2012, close to one million students completed Tripod surveys, with surveys being tailored specifically to ages of students, and with small changes being made to further develop validity and reliability (Ferguson, 2012). Through these surveys, students were given the opportunity to provide feedback about their schools, teachers, and specific classrooms (Ferguson, 2012). The Tripod survey measures instructional quality within seven dimensions: Care, Control, Clarify, Challenge, Captivate, Confer and Consolidate (Ferguson, 2012). As this survey is an integral part of the questionnaire used within the research project, it will be discussed further within Section 2.6 and 3.4.

2.5.7 Test of Science Related Attitudes (TOSRA)

The Test of Science Related Attitudes (TOSRA) consists of seven scales, with each scale containing 10 questions that are answered using a Likert 5 Point Scale (Fraser, 1981). The target audience of the instrument were middle and high school students, and sought attitudes towards science. It was tested across a range of public and private schools in Australia, and two American Catholic schools (Fraser, 1981). The Attitudes to STEM section of the selected instrument for this study is based on items from this test, and is therefore an important element of this research project. This will be discussed further within Section 3.4.

2.5.8 STEM Classroom Emotional Climate Questionnaire

Fraser, McLure and Koul (2020) claim that there is currently a gap within the learning environments field where ‘economical, multidimensional and valid’ questionnaires for assessing the dimensions of Classroom Emotional Climate (CEC) are lacking. This is particularly relevant for questionnaires that focus upon this construct within integrated STEM education classes. Fraser et al., (2020) developed and validated a new questionnaire through extensive exploratory and confirmatory factor analyses, Rasch analysis and several other techniques. The questionnaire was initially developed through the combination of some of the items from the CLASS system and the Tripod 7Cs (Fraser et al., 2020). The dimension of collaboration was also added, and a dimension on STEM attitudes that was based on items from the Test of Science Related Attitudes (Fraser et al., 2020). This questionnaire, which will be discussed at length in Chapter 3, was chosen for the purposes of this study, as it is designed specifically for measuring student perceptions of their SLEs.

2.6 STEM Learning Environments

STEM Learning Environments (SLEs) are the integrated learning contexts where students engage with at least two STEM disciplines while practising multi-disciplinary skills to solve problems (Yang & Baldwin, 2020), within which the psychosocial and emotional dimensions are measured to gain the perspective of the educator and/or student. An essential question that has arisen relates to which dimensions of SLEs will promote student engagement through positive emotional climates (Fraser et al., 2020). Currently there is little known about SLEs (Fraser et al., 2020), and with the renewed international motivation for the development and improvement of STEM education, it is imperative that research seeks to determine these factors. Due to the depth of knowledge constructed through learning environment research over decades, there is cause and theoretical grounding to develop and utilise instruments to measure potential factors that are influencing students within these specific environments.

Yang and Baldwin (2020) assert that there are challenges associated with the design and implementation of such environments, including the breakdown of traditional content boundaries for purposeful integration. Teacher confidence and content-specific knowledge can also be a challenge associated with developing SLEs (Rosicka, 2016), as negative associations with these disciplines will hinder a teacher's ability to promote a positive learning environment for students. According to Hackling, Murcia, West and Anderson (2014), attitudes towards STEM in both secondary and tertiary schools will not change until primary students are immersed in quality STEM education by qualified teachers. Rosicka (2016) recommends that there should be a focus within primary schools on sustained professional learning for ongoing support and reflective practise. As educators develop their confidence and attitudes to implementing these integrated disciplines improve over time, they may be able to positively impact their student's motivation and engagement.

Discussions through research debate which methodologies and practises will best support student engagement within STEM education. Margot and Kettler (2019) believe that to support a student to achieve their full potential, schools need to refine and develop high-quality instructional pedagogies associated with teaching these disciplines. Rosicka (2016) promotes active learning through integrated approaches that focus upon the development of skills and the application of knowledge with the intention of motivating students to seek knowledge and deepen their learning. Honey et al., (2014) state that this makes content relevant which enhances persistence, interest, motivation and achievement. Positioning students to nurture their curiosity and allowing them to seek answers to questions through these methods are also important elements of SLEs (Rosicka, 2016). Fostering these skills within students may positively develop their confidence and interest in further learning and career pathways.

While fewer studies have been conducted within STEM Learning Environments, one study by McLure, Koul and Fraser (2021) focussed on differences between the perceptions of male and female junior high school students on their Classroom Emotional Climate and their attitude to STEM education, when comparing coeducational government and coeducational nongovernment schools. They also sought to find gender differences between classrooms that were implementing integrated STEM education, and curriculum areas taught as separate subjects (McLure et al., 2021). The researchers determined that males in the government schools had more positive attitudes towards integrated STEM education, though there were no significant differences between genders in nongovernment schools (McLure et al., 2021). Additionally, McLure et al., (2021) found that students of both genders within nongovernment schools were significantly more positive about all aspects of their learning environment, and their attitude to STEM education. While this research is significant to this project, a focus on upper-primary school student perceptions, and any differences between genders, may highlight how attitudes differ between primary and high school contexts.

Another study by Koul, McLure and Fraser (2021) investigated gender differences of junior high school students within coeducational government schools. A sample of 246 students from Years 7 – 10 from 24 classrooms participated within the study, which utilised the Classroom Emotional Climate (CEC) questionnaire, specific to measuring perceptions when participating in integrated STEM projects (Koul et al., 2021). They determined that the females had relatively more negative views of their learning environment and attitude to STEM, and were less motivated by their STEM project than the males were (Koul et al., 2021). Similar to the previously mentioned study, this project differs by focusing on perceptions within upper-primary classrooms, to determine student perceptions of SLEs within a younger age bracket.

A study in India trialled a theoretical model of STEM learning through the use of a Makerspace environment (Sheffield & Koul, 2021). This project measured the engagement and interest of primary-aged students through self-reflection; assessed their knowledge and understanding of the STEM activities; and identified 21st Century skills, or 'transversal competencies' that were demonstrated during the tasks (Sheffield & Koul, 2021). This project utilised three surveys comprising of questions with Likert 5 point scales to examine student engagement and participation (Sheffield & Koul, 2021). The students indicated positive attitudes and engagement towards the project tasks, and were able to identify the different aspects of STEM that they were engaging with during a reflection. While this study has some similarities to this research project, the students have reflected upon integrated STEM projects that they have been completing with their teachers over long periods of time, rather than Makerspace projects implemented through the study, creating a different learning environment.

SLEs create the context for this research project, and are an essential element of the design. Due to the relatively new nature of these environments, it is important that an appropriate SLE was selected for the research to be undertaken within. The research environment will meet the criteria described above in order to effectively test how SLEs and teacher-student relationships influence student motivation and attitudes. This context will be described in further detail within Chapter 3.

2.7 Classroom Emotional Climate

Classroom Emotional Climates (CEC) are a construct of learning environments and are the extent to which a teacher promotes positive emotions and makes students feel comfortable (Brackett, Reyes, Rivers, Elbertson & Salovey, 2011). According to Hamre and Pianta (2007), educators who develop positive CEC are aware of student emotional and academic needs; show care and concern; listen to their perspectives and actively taken them into account; and foster cooperation between peers. As a contrast, classrooms which contain negative or low CEC may include poor emotional connections between the teacher and student; and there may be regular humiliation, threats, disrespect and physical aggression (Reyes, Brackett, Rivers, White & Salovey, 2012). It is more likely within these environments that the teacher doesn’t consider the emotional or cognitive needs of a child, or their perceptions, when designing and implementing lessons (Reyes et al., 2012). This can result in poor educational experiences where student perception of their environment and learning outcomes are significantly impacted. Neutral CEC also exists, where a middle-ground of both these tendencies are present, but students are unsure of how to approach their teacher and display inconsistent regard (Reyes et al., 2012). Through the continued collection of evidence and research, it is suggested that classrooms which have high CEC, where student need is considered and positive relationships are fostered, are environments within which academic success ensues (Reyes et al., 2012).

Reyes et al., (2012) state that student success may be impacted by emotional connections that they make in their classroom. Therefore, CEC is measured by the quality of emotional and social interactions between teachers and students (Reyes et al., 2012). The Tripod Survey instrument was developed to measure CEC under seven headings referred to as the 7C's (Care, Control, Clarity, Challenge, Captivation, Conferral and Consolidation) (Ferguson, 2012). The 7C's have been influenced by multiple researchers over decades and each C is measured using several survey items (Ferguson, 2012). The Measures of Effective Teaching Project (2001-2005) determined that the Tripod Survey acts as an effective tool for directing development and evaluating effectiveness of teaching (Ferguson, 2012). Another instrument for measuring CEC is the Classroom Assessment Scoring System (CLASS) which measures across three major foci: emotional support, classroom organization and instructional support (Pianta, La Paro, Hamre, 2008). Both instruments directly contributed to the validated questionnaire being used for the study, as discussed within Research Methods Section 3.3.1.

As previously stated, the emotional quality of teacher-student relationships has been determined as a predictor of academic success (Rucinski et al., 2018). Classrooms which are indicative of a highly positive CEC are more likely to have engaged, enthusiastic and academically successful students (Reyes et al., 2012). Rucinski et al., (2018) suggest that children's perceptions of CEC may be varied by individual relationships with teachers, but can also be influenced by peer-to-peer contact. To avoid potential bias introduced by peer-to-peer perceptions, it is important to show multilevel understanding by measuring CEC simultaneously alongside teacher-student relationship quality (Rucinski et al., 2018). This research project measures both student perceptions of STEM CEC as well as teacher-student relationships to seek data from both a classroom and personal relationship level to maintain integrity and reduce bias where possible.

2.8 Teacher Attitudes Towards STEM

Teacher attitudes towards STEM education play a significant role in determining the quality of the learning and the experiences perceived by their students. Margot and Kettler (2019) strongly believe that a teacher's background and views influence their instructional practice, and therefore teachers have a strong impact on a student's participation. A significant number of research projects have measured the relationship between the years of teaching experience and attitudes towards STEM education, and these have determined mixed results. According to a finding made by Margot and Kettler (2019), years of experience are not consistently related to STEM perceptions; however, teacher interest or value in STEM may moderate their attitude. They also found that gender, age and personal STEM experiences could also impact their perceptions of STEM education (Margot & Kettler, 2019). While these are important factors in determining teacher attitudes towards STEM, there are multiple other challenges which impact this important construct. More related to this research project are the SLEs within which teachers immerse their students, and the data that can be collected from the student perceptions of these experiences.

Currently there are few studies that exist which have determined educator beliefs towards STEM and the connected pedagogical approaches (Margot & Kettler, 2019). Timms et al., (2018) state that teacher interest in STEM is an issue facing schools, and adds to this by explaining that teacher quality is also a key issue. This is particularly relevant within primary education where generalist teachers have minimal discipline-specific knowledge through a lack of field specialisation. If teachers perceive that they do not have the required knowledge to teach a subject or approach competently, it may lead to avoidance or poorly executed learning. Murphy, MacDonald, Danaia and Wang (2019) state that the way to meet the complex integrated and inquiry-driven approaches required for STEM education is to have highly skilled educators across all levels of schooling. This element impacting teacher attitudes towards STEM, is the notion that teaching through integration is a bigger challenge than teaching content through isolation (Rosicka, 2016). Kelley and Knowles (2016) argue that the process of content integration is very complex, particularly when combining this approach within authentic STEM contexts. In-service teachers with little or no experience with content integration would potentially find this process daunting and may lack the confidence to make changes to their practise with little support or direction. Teachers who struggle to make connections between the content disciplines cause student disinterest (Kelley and Knowles, 2016), which in turn negatively impacts teacher attitudes. Quality professional development is required for educators to make changes to their teaching of these concepts to ensure confidence and proficiency during implementation (Kelley & Knowles, 2016).

One interesting finding from research is that teachers believe students become more motivated with learning in general when they participate in STEM education, and noted overwhelmingly positive responses from their students during this type of learning (Margot & Kettler, 2019). This is a significant positive outcome for STEM education, as if teachers are experiencing positive responses from students, it may positively impact their attitudes towards teaching these disciplines, which in turn will positively impact student perceptions of their teacher and learning environment. Without disruption, the cycle of poor teacher attitudes, impacts student attitudes, which in turn again impacts teacher attitudes, leading to negative effects on students pursuing STEM disciplines and careers. Furthering these challenges, Blackley and Howell (2015) outline that a key issue impacting teacher attitudes towards STEM education is actually understanding what it means. As discussed earlier in the literature, an exact definition for STEM across education, politics and industry is still debateable, and therefore remains a challenge for educators to enact changes required of them to achieve quality STEM education. It is through this confusion that teachers may be receiving mixed messages about what is expected from them, or an inability to access professional learning for concepts they are unsure of. As the definition of STEM education continues to develop and becomes apparent within schools, educators may begin to start moving beyond this challenge as confidence develops from the support of educational research.

Teacher attitudes will not be a focus of this particular research project; however, as they play an integral role in the development of student perceptions, they are an important construct to consider in terms of related research. Alternatively, student perceptions of their teacher's attitude will be measured through the use of an academic questionnaire. This data will then be enriched through the use of semi-structured focus groups to determine the experiences of students and the impacts of these perceptions on their own attitudes.

2.9 Student Attitudes towards STEM

As there is a direct link between engagement and attitudes towards STEM, a focus on student perspectives of these disciplines is an integral element to this study. Wiebe, Unfried and Faber (2018) state that researchers have now started to focus on the perceptions of younger elementary students rather than high schoolers. A study that surveyed 15 000 public school students from Grade 4 through to 12 that used the Student Attitudes towards STEM (S-STEM) Survey, found that students as young as elementary age have begun to form attitude associations between academic and life experiences, and the options that they have for career pathways (Wiebe et al., 2018). Adding to this, Wiebe et al., (2018) found that challenges to motivation are of particular importance during upper-primary education, as this is where they determined that attitudes started shifting away from STEM career pathways. This highlights one of the key reasons why this research project will focus upon upper-primary aged students. They also determined that attitudes are not static over primary and secondary education, and that gender showed significantly different interest levels across the career paths (Wiebe et al., 2018). As this is a common trend within research, gender will also play a key role within this study to determine different preferences within SLEs and teacher-student relationships, as differing opinions between males and females have been highlighted in several studies.

Murphy et al., (2019) refer to the term ‘STEM dispositions’ to describe student attitudes and thoughts towards STEM achievement and their preference for pursuing STEM disciplines as a career. Murphy et al., (2019) also state that positive self-perceptions across these disciplines are an integral element to students feeling engaged and interested in STEM, therefore developing these traits from an early age is integral. The findings about fluidity within attitude may indicate that future positive experiences with STEM education may position students to reconsider their options. While this could have negative or positive connotations, it means that a focus on improving STEM learning could reengage students with negative attitudes. Marginson et al., (2013) strongly suggest that measures such as strategies, approaches and programs should be developed in order to improve student attitudes towards studying within the STEM disciplines. Across Australia, students are not pursing these areas within further high-school education as they are perceiving this study as something undertaken by students with “talent”, rather than subject areas that are accessible to all through hard work (Marginson et al., 2013), which again is a thought associated with attitude that may be challenged through more positive experiences. As a critical part of student engagement, learning environments will be the lens that student attitudes towards STEM are measured through, due to the significant impact that these dimensions have on attitudes and motivation.

2.10 Teacher-Student Relationships

The study of teacher-student relationships plays a key role in learning environment research. The Office of the Chief Scientist (2013) states that inspirational teaching plays a crucial role in nurturing a love of STEM and influencing study and career decisions. The AGDET (2017) goes further, stating that teachers with the correct balance of discipline knowledge and pedagogy directly impact student internalisation and inspiration to pursue STEM. An inspiring teacher is an expert with the curriculum and uses high-impact activities that promote skill and motivation (AGDET, 2017; Hudson et al., 2015). De Loof, Struyf, Boeve-de Pauw and Van Petegem (2019), state that a teacher’s motivational style can directly influence the motivation and engagement of a student, and that taking motivational styles into account when attempting to stimulate student interest is highly valuable. These factors may influence student perceptions of their relationship with their teacher, and impact attitudes towards STEM.

A strong influence on a child’s academic, social and emotional development are the interactions they receive within the classroom (Hamre & Pianta, 2007). Luckner and Pianta (2011) maintain that it is valuable to study teacher-student relationships as they are a direct indicator of how students are influenced by teacher behaviour. It is through these studies that researchers can seek to determine teacher’s indirect and direct behaviours that influence children (Luckner & Pianta, 2011) Fraser and Walberg (2005) state that it can assist in the prevention of classroom problems such as behavioural issues, and can promote positive teacher-student interactions. Students who experience a relationship with their teacher in a SLE where they are given enough support to maintain success is positive (Struyf, De Loof, Boeve-de Pauw & Van Petegem, 2019). When students experience the opposite they are more likely to exhibit negative or undesirable behaviours and attitudes towards tasks.

There are several instruments which have been designed to measure teacher-student interactions. Wubbels and Brekelmans (2005) reported on a 25-year research program that used the QTI instrument, which collected data from secondary-education teachers and students measuring perceptions of teacher-student relationships. The study originated within the Netherlands and expanded internationally to a large number of countries. The model tested two dimensions: dominance-submission and cooperation-opposition (Wubbels & Brekelmans, 2005). Wubbels and Brekelmans (2005) found that the QTI could be used as a feedback instrument through which teachers could compare the perceptions of themselves and their students.

The CLASS Framework is a theoretically driven and empirically supported instrument which is administered to conceptualise teacher-student interactions (Hamre & Pianta, 2007). Originally it was tested in the United States within

4000 classrooms of students between Pre-Primary and Year 5 (Luckner & Pianta, 2011). It measures the quality of the interactions that children experience within the classroom (Luckner & Pianta, 2011). The framework is developed through three domains: emotional support, classroom organisation and instructional support (Hamre & Pianta, 2007; Pianta et al., 2008). The emotional support domain is measured through the emotional climate of the classroom, which is reflective of the warmth and/or negativity of interactions; classroom organisation consists of how the teacher manages behaviour, attention and time; instruction support includes the measurement of the quality of the instruction and feedback, in addition to promoting student's cognitive and language development (Hamre & Pianta, 2007; Pianta et al., 2008). The CLASS Framework and the QTI are fundamental to this study, as they form parts of the STEM CEC instrument used to gather quantitative data within this study.

2.11 Student Engagement and Motivation

Engagement is an essential element of education as it is a predictor of student outcomes (Reeve, Jang, Carrell, Jeon & Barch, 2004). It can also be used to reveal motivation which is underlying, predicting the achievement and potential completion of compulsory learning (Reeve et al., 2004). It is a psychological construct within education that can be defined as a student's connection to their learning, including commitment and attention (Western Australian Primary Principal's Association (WAPPA), 2018). Behavioural dimensions of engagement include persistence, effort and attention; while the emotional dimensions include interest, enthusiasm and enjoyment (Reeve et al., 2004; Struyf et al., 2019). The Grattan Institute (2017) states that when teachers design the right classroom environment, students are positioned through a number of strategies to learn more. While overcoming student disengagement is a complex endeavour, positive classroom climates are an element that assists to address this issue (Grattan Institute, 2017). While there are a wide range of factors that cause disengagement from learning, collecting information about why students are disengaged may give insight into potential solutions to this issue. Engagement is also an essential part of the teacher-student relationship, and measuring student perceptions of their relationship with their teacher indicates the effectiveness of their STEM learning environment.

According to WAPPA (2018), the impact of engagement upon student achievement is clear, and that it has evident psychological impacts that effect children. They state that Australian primary school students are behaviourally engaged, but have lower levels of emotional and cognitive engagement, which prevents true active engagement (WAPPA, 2018). Across general education, research from Australia indicates a widening spread of achievement as students continue to progress through their schooling years, indicating a need for early and continued intervention to sustain engagement and development (WAPPA, 2018). This is also relevant within STEM education, where students begin making decisions from a young age to pursue, or not pursue, careers within this field. Disengagement from the STEM disciplines happens at an early age, and therefore any initiatives targeting students won't be effective unless primary level interventions are successful (Caplan et al., 2016). For the purposes of this study, emotional engagement, which refers to a student's perceived relationship with their teachers, peers and school, including emotions, beliefs and a sense of belonging (WAPPA, 2018), will be the focus of the research as it directly relates to learning environments and teacher-student relationships.

As previously stated, a teacher's motivational style can have a direct impact on a student's motivation and engagement (De Loof et al., 2019). A transmission model of education was commonplace when society required 'factory-style' workers, and focussed upon information that was recited and reproduced (Stobaugh, 2019). According to Furrer and Skinner (2003), when people are engaged they express this through active-involvement. They are persistent, goal-oriented and focussed (Furrer and Skinner, 2003), and they attempt to make changes within their environment (Koenigs, Fiedler & deCharms, 1977). Disengaged people display much different behaviours. They allow external factors to regulate their task involvement (Koenigs et al., 1977) and are apathetic and distracted (Furrer & Skinner, 2003). Motivation is based on a continuum, which ranges from amotivation (no motivation) through to instinsic motivation, which is self-driven rather than being based on outside factors (De Loof et al., 2019) Teacher's motivational styles vary along a continuum which ranges from highly controlling to high autonomy-supportive (Deci, Schwarts, Sheinman & Ryan, 1981). When a teacher facilitates learning within an autonomy-supportive motivational environment, they identify student needs and nurture their interests which supports students to develop self-motivation (Reeve et al., 2004). At the controlling end of the motivation spectrum, the teacher constructs the agenda and interferes with student motive by defining what they should think, feel and do (Reeve et al., 2004). Students that are experiencing autonomy-supportive environments have greater perceived competence, mastery and intrinsic motivation (Deci et al., 1981).

In a study undertaken by De Loof et al., (2019), they hypothesized a link between teacher motivational styles, autonomous intrinsic motivation and higher levels of student engagement in STEM education. The study involved the implementation of integrated STEM education in Belgium, and involved students solving contextual STEM-related problems across 17 different schools, each with a single Grade 9 class selected (De Loof et al., 2019). One of the key links between this research project and the one conducted in Belgium, was the aim to determine ways to increase interest in STEM education leading to further study and career pathways. Through this study, De Loof et al., (2019) found a positive link between a teacher's motivational style and student engagement, explaining that it is highly relevant for educational research to focus on these factors, and to further investigate which factors impact students within SLEs. This concept links into the teacher-student relationships aspect of this research project, and is an essential element of learning environment research.

Rosicka (2016) also determined that student participation within STEM education was found to raise general student engagement in 11 reports. A mixed-method study that used the observational data of 24 STEM lessons, and qualitative data collected from seven focus groups with 67 Grade 9 students, suggested that the use of integrated STEM disciplines leads to higher levels of student engagement (Struyf et al., 2019). This indicates that engagement with STEM learning may have positive impacts across all areas of learning, and therefore is an essential investment for Australian education. As a key component of education, motivation and engagement will play a large part in this study, where student perceptions of their engagement with STEM education will be analysed as part of determining a quality STEM Learning Environment. This completion of learning may be directly linked to a student's career trajectory, and if they experience positive engagement with the STEM disciplines throughout compulsory schooling, these experiences may be connected to their decision to pursue further studies.

2.11.1 The STEM Pipeline

A students learning trajectory through STEM education needs to be considered from their earliest learning experiences through to their secondary schooling and beyond (Murphy et al., 2019). Ball, Huang, Cotten and Rikard (2017), and Tytler et al., (2008) define the STEM Pipeline as a means of monitoring the engagement of students within a STEM learning trajectory from primary schooling through to tertiary education. This concept monitors students' engagement early in learning and how students are inspired to move through the education system into more advanced STEM disciplines (Ball et al., 2017). Through this metaphor, a student's journey into a STEM career is identified at each stage of their learning path. This includes engagement from primary schooling, compulsory high school, non-compulsory high school, tertiary education and finally the transition into a STEM career. Watt (2016) conversely defines the concept of the STEM Pipeline as a means of monitoring student decisions to drop out of STEM disciplines throughout their education. Watt, Shapka, Morris, Durik, Keating and Eccles (2012) believe that viewing the STEM Pipeline with this perspective allows for questions and research to be developed to identify patterns and trends for drop-out rates. According to Timms et al., (2018), educators and policy makers are looking for a place to begin for determining ways to increase the "flow" from the outset, and create an early influx of students seeking further STEM education.

Marginson et al., (2013) suggest that this needs to be a focus, as by growing the numbers of students entering and maintaining the study of the STEM disciplines will expand the talent pool in which the high achievers in these areas can be selected from.

The significance of this concept to this study is not to actively monitor students as they progress along the STEM Pipeline, but rather to seek student perspective about what initially engages students with STEM education and begins them on their journey towards further study and careers. It is to determine student perceptions on what creates a quality SLEs and how students can be motivated early to engage with quality STEM education. This research also seeks to determine a female perspective on engagement with STEM, and if there are specific ways to motivate primary school aged girls to pursue these disciplines as they progress into secondary schooling. Using this information, it will be considered how SLEs can impact student's engagement from an early age to pursue further knowledge and skills that will lead them towards electing to study STEM subjects in high-school, and hopefully continue this through to a career.

2.12 The STEM Gender Balance

According to the Commonwealth of Australia (2019), the only way to inspire careers within the STEM field, including girls, is through quality foundational STEM education. In 2011, 84 percent of STEM-qualified people in Australia were male, with engineering having the greatest imbalance at 93 percent male (Commonwealth of Australia, 2016). Within Australian industry, there is a lower STEM engagement of females, and a dire lack of women from low-socioeconomic status, non-metropolitan areas, and Aboriginal and Torres Strait Islander peoples (Education Council, 2015). Both industry and tertiary education have determined an imbalance of women entering STEM roles (Knopke, 2016). A trend within research evidences that women have been underrepresented in these disciplines for a long time (Broadley, 2015; Petherick, Pettorelli & Sumner, 2017; Timms et al., 2018). This research is essential to the progress of STEM within Australia due to the current report of skills shortages in these fields (Office of the Chief Scientist, 2014).

The literature identifies several key issues that affect women entering STEM disciplines. One issue is the effect of women's consciousness of stigma through institution, family and media, including attitudes, behaviours and self-concepts (Casad, Petzel & Ingalls, 2018; Knopke, 2016, Watt, 2016). More significantly to this study, learning environments that are not supportive of female participation have a large impact on motivation and engagement (Knopke, 2016). A female's motivation to pursue STEM education in senior secondary schooling can be determined through the experiences they received prior to and during their lower schooling years (Timms et al., 2018), and therefore negative experiences significantly impact the likelihood of females engaging in future STEM education. The engagement of women within these roles is critical to Australia's economic success, as it is imperative to ensure an adequate number of STEM graduates for the industry's predicted growth (Barkatsas et al., 2018). A higher number of women entering these fields would assist with bridging the current skills shortage gap.

Timms et al., (2018) believe it is imperative to engage females prior to and early within their schooling. The Commonwealth of Australia (2019) state that is through the facilitation of a child's curiosity within the STEM disciplines that assists in the engagement of young females within the pipeline, and that girls' perception of STEM education is strongly influenced by their teachers and parents (Commonwealth of Australia, 2019). Creating engaging learning environments where females feel confident, supported and enthusiastic about their learning may see changes to this devastating trend. This would not only further diversify the STEM workforce, but would also begin to create a more steady flow of candidates within the STEM pipeline, equalling an improved economic situation for Australia.

Reflecting on these key points, this study will have an additional focus on female engagement within STEM education, and how SLEs may specifically impact females in differing ways to males. Through the analysis of student perceptions, a comparison will be made between male and female perceptions to see if there are different indicators of what creates an engaging and supportive SLE for girls. Specifically this will be done with upper-primary aged females to begin researching what initially motivates them to join the STEM pipeline towards further study and careers within these disciplines.

2.13 Summary and Implications

It has been clearly outlined that students are not being prepared for the labour market in which STEM has a prominent role, particularly due to the use of educational models which were introduced centuries ago (World Economic Forum, 2020); confusion about the meaning of STEM within education (Barkatsas et al., 2018; Blackley & Howell, 2015; Rosicka, 2016; Timms et al., 2018); and learning environments and teacher-student relationships which are not conducive to student engagement (Hamre and Pianta, 2007; Rucinski et al., 2018). Research suggests that when students are not experiencing the engagement from their learning required to pursue further STEM education, then they are unlikely to pursue career pathways within the STEM disciplines. Seeking to reverse this trend may result in higher achievements within STEM education, larger numbers of enrolments across the STEM disciplines, and more industry-ready STEM graduates to actively contribute to the economic and international success of Australia. With research suggesting that questionnaires are an appropriate and accurate method of measuring learning environments and teacher-student relationships, this researcher has identified a range of relevant instruments used in past studies to determine a suitable instrument to achieve the objectives of this research.

This research seeks to determine dimensions of STEM Learning Environments and teacher-student relationships that positively engage students with the STEM disciplines from the perspective of an upper-primary student. The goal of this research is to determine if there are particular ways that educators can support students through their learning environments and with their relationships to engage and develop positive attitudes towards their STEM education. Upper-primary students have been specifically chosen for this study as their perceptions within SLEs have not been frequently researched, and research suggests that students choose their career trajectories at this approximate age. Seeking to understand what would set them along the pathway of the STEM Pipeline towards careers within these disciplines would assist with the early engagement and aspirations of primary aged children. Furthering this, with an additional focus on female engagement with STEM, this research seeks to determine if there are differences between the preferences of male and female students. With males being more likely to engage with the STEM disciplines, there may be strategies and approaches that need to be researched to specifically engage females within SLEs.

2.14 Summary of Chapter

This chapter presented the literature that underpins this research project, including STEM's importance to society; methods and instruments grounded within the extensive research undertaken within the field of learning environments and teacher-student relationships, including how these can be used to explore the relatively newer construct of STEM Learning Environments; and literature suggesting these implications on STEM education for student retention and engagement. The next chapter will present the research design of the project, including methodology, design, participant context, selected instrument, quantitative and qualitative data analysis methods, and ethical implications.

Chapter 3: Research Design

3.1 Chapter Introduction

The previous chapter presented a literature review that contextualised this study within the research fields of learning environments and STEM education. Current research around STEM as economic priority, STEM education and SLEs were presented within the review, along with current and historic research around learning environments and instrumentation for measuring CEC and teacher-student relationships. Implications for how learning environments and teacher-student relationships may directly effect a child's motivation and engagement to identify a positive attitude towards STEM, and pursue further STEM education were also discussed.

This chapter outlines the methodology and research design of this research project, including a justification for the use of a mixed-methods approach using both quantitative and qualitative data collection. It further explains the participants, instrument, procedure and timeline, methods of analysis, ethics and limitations.

3.2 Methodology and Research Design

This research project will use a case study approach for determining student perceptions of their SLE, and their interactions with their teacher. A case study is the use of a single context, which is studied in detail, by utilising a range of data collection methods that are deemed appropriate (Punch & Oancea, 2014). Punch and Oancea (2014) recommends that, due to the explicit boundaries of the context within a case study, and since not everything within the boundaries can be studied, the use of research questions to create focus is essential. This research, utilising the case study methodology, will be guided by the research questions outlined in Section 1.5. Punch and Oancea (2014) also outline the concern about generalisation with case studies, and that there is an argument about whether or not you can apply research to other contexts. In order to address this argument, they recommend focusing on what is common within the context that can connect to external contexts, rather than focussing upon uniqueness (Punch & Oancea, 2014). While schools, classrooms and socio-economic status vary across educational institutions, there are still a range of commonalities among them which can be considered for some generalisability, however; limitations are outlined in Section 7.4, and care should be taken whenever applying this research to another context.

A paradigm is a set of concepts or definitions for a way of looking at the world and determining how research should be conducted through making the thinking process behind the project explicit (Ling & Ling, 2017; Punch & Oancea, 2014). Ling and Ling (2017) argue that paradigms are a crucial consideration for research which is ethical and rigorous, and should be carefully considered. It is possible to have more than one paradigm guiding a research project. Generally studies are guided by one of these sets of concepts only. Individual paradigms have their own sets of guiding boundaries, however; these are not set in stone and may have varying interpretations (Ling & Ling, 2017). For example, a positivist paradigm generally uses quantitative research measures. For the purposes of a particular study, it may also be useful to employ qualitative research methods with the quantitative. While this is not the regular approach for this paradigm, it is still acceptable.

The researcher for this project is guided by the neo-positivist paradigm. Through this, patterns and consistencies within social phenomena are sought after through objectivity (Ling & Ling, 2017). Ling and Ling (2017) discuss the neo-positivist paradigm as being a way of viewing research as a human pursuit, which is subject to error, changes over time and has findings which are open to challenge. Neo-positivists typically seek to fill research gaps and contribute new understandings to these areas, which is referred to as the deductive mode (Ling & Ling, 2017). Within this research project, learning environments have been extensively studied over a long period of time; however, the concept of SLEs are relatively new to research, and are therefore a gap within this area. Furthermore, neo-positivists design studies that acknowledge probability and contemporary understandings through analysis and evidence. As outlined further in Section 3.2.1, this study combines the rigorous analysis of both quantitative data, and a thematic approach to analysing the qualitative data, which specifically identified patterns and consistencies within the responses.

This research project aims to measure the perspectives of students within their SLEs, and their relationship with their teacher. It is designed to utilise a mixed-methods approach that will combine the use of qualitative and quantitative data from the perspective of co-educational upper-primary school participants. Cohen, Manion and Morrison (2018) suggest that a mixed-methods approach allows researchers to bring together two ways of looking at the world. A mixed-method approach enables collection, analysis and comparison of both qualitative and quantitative data to better understand the research problem or question. To effectively seek answers to the research questions, a mixed-methods neo-positivist correlational case study is an appropriate approach within this discipline. Within neo-positivist paradigms, this research will measure the perceptions of upper-primary students in STEM classrooms using questionnaires and semi-structured focus groups.

3.2.1 Methodology

The initial steps of this project included ethics approval, which were applied for and obtained both through Curtin University and Catholic Education of Western Australia (CEWA). According to Punch and Oancea (2014), across all areas of research design ethical challenges will arise, and that educational researchers need to be aware of any rules or implications associated with their research. Ethics were carefully considered during the design of this research project, and will be discussed in greater depth within Section 3.7. Only once ethical permission had been obtained, did the researcher then identify a range of schools that were known for implementing quality SLEs, and contact the schools to be a part of the research project.

After obtaining approval, questionnaires were implemented within the selected classrooms at the school. Wubbels and Brekelmans (2005) have determined that questionnaires are an effective way to measure and map student perceptions. Abundant research studies have been conducted internationally on the reliability, validity and effectiveness of these instruments (Wubbels & Brekelmans, 2005). The instrument used within this study will be outlined in detail within Section 3.4 and Table 3.1. It is a combination of three extensively tested questionnaires, namely Classroom Emotional Climate (CEC), positive scales of Questionnaire on Teacher-Student Interaction (QTI) and attitude scales from the Test of Science Related Attitudes (TOSRA) (Fraser et al., 2020). This questionnaire was used to determine quantitative data that will specifically assess students' perceptions of their Classroom Emotional Climates, their teacher-student relationships, and their attitude towards STEM, within a STEM learning context. Each instrument has been developed with a Likert 5-point scale, ranging from Never to Always. Initially this involved collecting consent through the ethical area of autonomy by seeking a 'gatekeeper' that understands both the research and care of the participants (Punch & Oancea, 2014). The importance of this is to seek permission from someone in a place of authority, such as a principal, who has the ability to balance the needs of both invested parties. As explained by Punch and Oancea (2014), once situated within the context, the researcher should then seek consent from the participants themselves, and their legal guardians if necessary. All permissions were gathered prior to the implementation of the instrument within classrooms.

In the next stage of the research project, qualitative data was gathered through semi-structured focus groups to help form a deeper understanding of student perceptions. According to Punch and Oancea (2014), focus groups are often used in conjunction with questionnaires to delve deeper into perceptions, views and information. Students were selected based on their responses to the questionnaire. Silverman (2017) states that purposive sampling positions a researcher to critically consider the generalisability of their sample. The focus groups were formed with a combination of students who indicated a positive or negative perception within the STEM disciplines. This was to determine additional factors to the questionnaire that may be influencing student engagement or disengagement. Item 103, an optional written response, was also a factor in the selection. Due to a focus on female perceptions around STEM, there was a slightly higher number of female to male ratio chosen. A variety of responses were selected, ranging across both positive and negative responses. Participants will be discussed in further detail within Section 3.3. The themes collected from the interviews were also used to determine aspects of SLEs to address research question 3.

Punch and Oancea (2014) raise an issue of validity and bias of interview responses within focus groups. However, they suggest that careful planning, design and training can counter these issues. Silverman (2017) recommends that the leader of a focus group should offer different types of stimulus to promote discussion so that answers are not led and directed. For these reasons students were given prompting questions that were specifically designed to promote conversation between the participants rather than being led by the researcher [See Appendix B]. Audio recording devices were used to gather information from the participants and were translated into transcripts using a professional service.

3.2.2 Research Design

This study was carried out in four phases, which will be outlined below. Firstly, the context was determined through the selection of a school that was implementing integrated STEM education. The second phase included the implementation of the quantitative questionnaires. Thirdly, qualitative focus groups were utilised to determine a greater understanding of the participants' perceptions. Finally, the data analysis phase was used to highlight findings and draw conclusions.

Phase 1 – Context - Selecting a School

For the purpose of this research project, it was integral to select schools that implemented an appropriate context for data collection. In order to measure effective SLEs and teacher interactions from student perspectives, an appropriate school was required that was well known for their implementation of quality STEM education. A single school was selected for several reasons. Firstly, 100 students was the initial scope of the proposed research project, which was able to be achieved through the selection of a school with an appropriate cohort size. A second reason for the inclusion of only one school was the issues with accessibility that arose due to the COVID-19 school shutdowns. During this time, students, parents and visitors were not allowed on site, which significantly impacted the feasibility of the research. Additionally, the added strain on educational organisations to move their practice onto online platforms was already applying significant strain to leaders and educators, and schools were not seeking further workload opportunities due to this stressful period of time.

While initially several schools were approached, including schools within the CEWA sector, an independent private school was selected due to their quality practise and number of potential participants. This school indicated its willingness to participate, and was suitable due to its additional involvement within several STEM programs, such as Circuit Breakers; classroom teacher-led SLEs; and its engagement in school discussions around quality approaches, including, but not limited to, the Solutions Fluency pedagogical approach.

Phase 2 - Quantitative Questionnaires

Responses were collected across four Year 5 classrooms within the selected school from 100 students. Each classroom had the instrument administered separately by the researcher who read through each item during implementation. The hard copies of the questionnaires were collected after a verbal discussion with the students about their experiences with STEM and projects they had been completing. These responses were manually transferred to an electronic spreadsheet and entered into the IBM SPSS Statistics software for analysis. Student names were removed after the selection for Phase 3 to support the anonymity of the research project. It was important that these questionnaires were originally not anonymous due to the need to select specific students to participate within the semi-structured focus groups.

Phase 3 – Qualitative Focus Groups

Twelve students from Phase 2 were selected to participate within Phase 3 of the research. Selection was based on student responses to the questionnaire. These samples of students were purposively selected from their cohorts based on their gender and responses to the questionnaires to ensure diversity of representation. The selection criteria for the group included a mix of genders with a mix of responses (positive and negative responses to the SLE items), and is outlined within Table 5.1. A slightly higher ratio of females to males were included due to the research project's focus on female participation. To counteract potential bias, prompting questions were developed to elicit responses from students that have not be led by the focus group leader [See Appendix B]. Three semi-structured focus groups were run in total with four children within each. The audio file recordings were then transcribed using a professional transcription service in preparation for analysis.

Phase 4 – Data Analysis and Interpretation

The data from the questionnaires and focus groups were analysed to test the hypothesised model shown in Figure 1.1. IBM SPSS 27 Statistics Data Management software was used for the quantitative data analysis as discussed further in Section 3.6.1. Points of data were uploaded through the responses to the Likert 5-Point Scale. Qualitative data was analysed through thematic analysis using the Data Analysis Framework in Table 3.2, and is discussed in further detail in Section 3.6.2.

The new material expected from this data will be students' perceptions of preferred SLEs, with a focus on what they find inspiring and engaging. It is hypothesised that students with positive perceptions of their SLEs will be more engaged with STEM and have greater aspirations of working within these fields. A further focus will be on whether females have different preferences to males, highlighting the need for changes to SLEs that are indicative of positive female engagement with STEM. It is hypothesised that females will have different preferences to males, which may suggest more effective environments to engage females with STEM.

3.3 Participants

The study gathered data from 100 Year 5 students at an independent private school approximately 20km north of Perth from four classrooms. The four classroom teachers of the participating students in the study had developed and implemented STEM projects collaboratively. While they didn't specifically refer to their integrated learning as "STEM education" to their students, their approaches utilised all of the aspects of these learning tasks. One of the design cycles referred to by staff was Solutions Fluency, a pedagogical approach suggested but not required of staff at the school. It focusses on the development of skills for future employment and follows an inquiry cycle of the "Six Ds": define, discover, dream, design, deliver and debrief (Global Digital Citizen Foundation, 2021). When asked, nearly all students had heard of the acronym STEM and knew its meaning, and all students could name learning projects they were involved in that developed STEM skills.

The participants experienced a range of STEM learning tasks that ranged from using technologies such as iPads, laptops, website building software and Minecraft Education; to unplugged engineering projects that involved physical design competencies. Groups of students also participated in elective clubs, such as an after-school STEM club and the Western Power Circuit Breakers program within which they use technologies such as the Micro:bits to design solutions to powering networks within cities. Students were asked to draw from one of these experiences when completing the questionnaire, and to focus on the way their teacher behaved specifically during these learning experiences.

Initially, there was a single visit to the school to discuss the research project with staff, which occurred in Term 1 of 2020, however; with schools closing with minimal notice due to COVID-19, the study was delayed during the outbreak as students had transitioned to learning online. The implementation of the questionnaire was therefore undertaken in Term 3 of the learning year in order to allow participants enough time to develop quality relationships with their teachers and to determine an overall impression of their learning environment, an integral concept for the QTI scales (Wubbels & Brekelmans, 2005).

It is interesting to note that conducting the research so soon after the school shutdowns may have had implications upon the results of the questionnaire, as students had just experienced learning, environmental and technological conditions that were highly irregular and unfamiliar. The researcher reflects that comparative data prior to and post the school shut downs would have made an interesting addition to this study, and may have been reflective of increased anxiety and decreased emotional resilience within students.

3.4 Instrument

As discussed within the literature review, questionnaires are a widely accepted tool for accurately measuring perceptions within learning environments. As there are a large number of rigorously tested and validated questionnaires within this field, and these have been altered to suit contexts by adopting scales from pre-existing questionnaires (Fraser, 2012), it was essential to select a questionnaire appropriate to this specific research project. The Questionnaire on Classroom Emotional Climate (CEC) was developed for SLEs, and was chosen due to its nature of being appropriate for both the intended age of the participants and the context of their learning environment. It measures the perceptions of CEC, Attitudes to STEM and Teacher-Student Interactions, which relate directly to the conceptual framework and research questions.

The questionnaire layout [See Appendix A] initially prompts participants to consider a STEM learning experience that they have recently undertaken, and how many hours per week they believe they learn using this approach. Students are also requested to identify their gender as this is an essential part of the analysis process. The instrument measures CEC across eight scales: Care, Control, Clarity, Challenge, Motivation, Consultation, Consolidation and

Collaboration (Items 1-17) (Fraser et al., 2020); Attitude towards STEM within one scale (Items 75-84) (Fraser, 1981); and Teacher-Student Interactions across four scales (Items 85-102) (Wubbels & Brekelmans, 2005). All items across the 10 scales prompt students to respond using a Likert 5-point scale. The questionnaire finishes with a final optional open-ended question where participants are urged to share anything further about their experiences (Item 103). Sample items and the response structure are provided in Table 3.1.

This questionnaire was validated within a previous study in a junior high school context, and this research project was able to build on the earlier work (Fraser et al., 2020). Due to the questionnaire being validated within this age group, the researcher used their professional judgement and experience within an education setting to determine the suitability of the questions for slightly younger participants. The items are stated simply using terminology that is well-suited to an upper-primary age bracket. *'My teacher gives me feedback on the work I do'*, is an example of an item within the Consolidation scale, and is reflective of the simple wording used across the items within the questionnaire [See Appendix A]. To ensure clarity during implementation, the researcher read through each item with the participants to allow for a range of reading levels and comprehension, and to give opportunities for the participants to ask questions as required. The validation of the high school aged questionnaire is presented in the next section, followed by the functional validation of the primary aged questionnaire by the researcher.

3.4.1 Questionnaire on STEM Classroom Emotional Climate for High School Contexts

Due to little research being performed within SLEs, Fraser et al., (2020) developed and validated a questionnaire on Classroom Emotional Climate specific to these environments which was implemented within a junior high school setting. The items from the Emotions scales of the questionnaire were originally based on the Tripod 7 C's student perceptions survey and the Classroom Assessment Scoring System (CLASS) (Ferguson, 2012; Fraser et al., 2020; Hamre & Pianta, 2007). Within the Attitudes scale, the items were specifically adapted for use within SLEs through the use of selected items adapted from the Test of Science Related Attitudes (TOSRA) instrument (Fraser, 1981; Fraser et al., 2020). The final section of the questionnaire is based on the Questionnaire on Teacher-Interaction (QTI), utilising the scales of Leadership, Helpful/Friendly, Understanding, and Student Responsibility/Freedom (Wubbels & Brekelmans, 2005). Firstly, through the use of six focus groups, the questionnaire was piloted to gain feedback which was used for the revision of the instrument (Fraser et al., 2020). The second phase had further modifications relating to student participation within STEM activities. The modified questionnaire was implemented on 598 students across 57 classrooms within 20 schools.

According to Williams, Onsman and Brown (2010), several tests need to be used to determine the suitability of the data for factor analysis. Fraser et al., (2020) then used Exploratory Factor Analysis (EFA) to reduce the items of the questionnaire across seven dimensions: Consolidation, Collaboration, Control, Motivation, Care, Challenge and Clarity. According to Yong and Pearce (2013), EFA is used to determine complex patterns within large datasets to then assemble common variables into descriptive categories. This is useful for studies that use questionnaires to focus on key factors rather than having too many variables, with the aim being to reduce a set of variables into a smaller number of dimensions (Field, 2018; Yong & Pearce, 2013). It is recommend that larger sample sizes are used to diminish error, with 300 being the minimum recommended number of participants, which was achieved with the number of participants almost doubling this figure. Firstly, the Kaiser-Meyer-Olkin (KMO) measure was used to determine variance among variables, with a higher variance equalling a higher suitability for factor analysis (Williams et al., 2010). Secondly, Bartlett's Test of Sphericity was used to test for redundant variables that can be summarised, with the aim to reduce the questionnaire's length by removing the items with the lowest factor loadings (Fraser et al., 2020).

The final instrument was evaluated using Confirmatory Factor Analysis (CFA) to confirm goodness-of-fit with the theoretical model (Fraser et al., 2020).

According to Brown (2014), unlike EFA, CFA requires the researcher to have a strong conceptual structure to guide the evaluation of their factor model, and is usually used in the later phases of validation. Each CEC scale also obtained values within acceptable limits for reliability, fit and unidimensionality through Rasch analysis (Fraser et al., 2020). This indicates a high level of correlation. Fraser et al., (2020) also outline successful validity through Cronbach's alpha testing, concurrent validity testing, discriminant validity indices and predictive validity. Possible limitations of this instrument are also described through the literature, including the potential misinterpretation of items, distortion of responses due to pressure of the sensitivity of items, questions that may have missed essential details, and students modifying answers to give expected responses (Fraser et al., 2020).

The study was conducted with 658 participants from Western Australia, which is a reasonable sample size for learning environment research, however it is recommended that further large scale tests are undertaken with the instrument to improve its generalisability (Fraser et al., 2020). It has applications for a range of research projects, and Fraser et al., (2020) suggest combining it with qualitative methods to assist in the explanation of the quantitative findings from the questionnaire. This recommendation is an integral part of this research project, as qualitative data gathered from semi-structured focus groups is being used to elaborate upon the quantitative data gathered.

3.4.2 STEM Classroom Emotional Climate Questionnaire for Primary Aged Students

As discussed in Section 3.4, the questionnaire used for this research project was a product of a STEM Classroom Emotional Climate study developed by Fraser et al., (2020), and functionally validated through reliability testing. Furthering this, the researcher determined the appropriateness of the questions presented to students, including vocabulary, length and response types. Table 3.1 shows an overview of the questions and responses included within the questionnaire.

The validity and reliability and this questionnaire will be discussed further within Chapter 4 - Quantitative Results, outlining the accuracy and implications of the results from the implemented instrument within the primary setting. Furthering this, within Chapter 7 additional applications of this instrument will be discussed for further use within primary-aged classrooms to assist educators with measuring their students perceptions of CEC and the teacher-student relationship.

3.5 Procedure and Timeline

Phase 1 (2019): Ethics and Context: Obtained all necessary ethics, determined appropriate schools for the research project and approached the schools for participation. Selected school appropriate for the study and gained all necessary ethical permissions required for proceeding.

Phase 2 (2020): Implementation of the Questionnaire on STEM CEC: Questionnaire was implemented within the four Year 5 classrooms within the selected school by the researcher. The raw data was manually processed into an Excel spreadsheet for further analysis.

Phase 3 (2020): Semi-Structured Focus Groups: Implementation of the focus groups with specific participants to further explore student perceptions of STEM education. 12 students participated within the groups. Audio recording devices were used and transcripts were created by a professional company.

Phase 4 (2020/2021): Data Analysis and Interpretation: Responses from students in Years 5 at the sample schools was analysed to seek data regarding student perception of their teacher-student relationships, their STEM CEC, and to determine aspects of SLEs. The IBM SPSS Statistical Management software was utilised for the quantitative data analysis, and a thematic approach was used for the qualitative data. Analysis occurred with the goal of answering the research questions.

TABLE 3.1 *OVERVIEW AND EXAMPLES OF THE STEM CLASSROOM EMOTIONAL CLIMATE QUESTIONNAIRE*

Sections of the STEM CEC	Number of Items	Response	Sample Question
Demographic Information	2	Worded	What STEM project are you doing currently (or have you just completed)?
Context		Numerical	How many hours per week do you think you do STEM projects?
Gender	1	Male or Female	Do you identify as a male or female?
Classroom Emotional Climate			
Care	10	Likert Scale: 1–Almost Never to 5–Almost Always	I like the way my teacher treats me when I need help.
Control	8	Likert Scale: 1–Almost Never to 5–Almost Always	My teacher controls my behaviour without raising his/her voice.
Clarity	9	Likert Scale: 1–Almost Never to 5–Almost Always	My teacher explains difficult things to me clearly.
Challenge	9	Likert Scale: 1–Almost Never to 5–Almost Always	My teacher encourages me to keep going when the work is hard.
Motivation	9	Likert Scale: 1–Almost Never to 5–Almost Always	My project makes me want to learn.
Consultation	8	Likert Scale: 1–Almost Never to 5–Almost Always	My teacher asks me questions whether I put up my hand or not.
Consolidation	12	Likert Scale: 1–Almost Never to 5–Almost Always	My teacher gives e feedback on the work I do.
Collaboration	9	Likert Scale: 1–Almost Never to 5–Almost Always	I learn from other students in my STEM group.
Attitude to STEM	10	Likert Scale: 1–Almost Never to 5–Almost Always	These lessons make me interested in studying a STEM subject in the future.
Teacher Interpersonal Behaviours	18	Likert Scale: 1–Almost Never to 5–Almost Always	This teacher is a good leader.
Leadership	4	Likert Scale: 1–Almost Never to 5–Almost Always	This teacher acts confidently.
Helpful/Friendly	5	Likert Scale: 1–Almost Never to 5–Almost Always	This teacher is someone you can depend on.
Understanding	5	Likert Scale: 1–Almost Never to 5–Almost Always	This teacher is willing to clarify things.
Student Responsibility/Freedom	4	Likert Scale: 1–Almost Never to 5–Almost Always	This teacher tolerates a lot of student behaviour.
Other Experiences	1	Worded	Is there anything else that you would like to share with us about your STEM experience?

Phase 5 (2021): Dissemination of the Research: Two conferences were selected for the dissemination of the research findings during 2021. This was effected by restrictions in place for COVID-19, and therefore was limited to local conferences and presentations. A journal article will also be submitted from the thesis.

It is important to note that the project timeline was significantly impacted by the school shutdowns due to the Western Australian COVID-19 outbreak. Original data collection was arranged for the end of Term One (March-April 2019), and could not be resumed until Term Three (August-September 2019). This pushed the research project back by approximately 6 months; however this also had a largely positive effect on the study. Students had a greater amount of time to develop a relationship with their teacher and experience more from their SLE. This allowed the participants to give more detailed and reliable responses to the questionnaire and within the focus groups.

3.6 Analysis of Data

A mixed-methods approach was undertaken within this research project through the collection of both quantitative and qualitative data. The following section will outline the rationale, process and methods of analysis for both types of data.

3.6.1 Quantitative Analysis

Quantitative measures are ones concerning numbers to test and develop theories. Field (2018) states that this process involves looking at your data using graphs, seeking general trends and then fitting a model to determine further findings. The following sections outline the process and methods of analysis applied to the data. These values are then reported upon within Chapter 4: Quantitative Analysis, and discussed further within Chapter 6: Discussion.

3.6.1.1 Pearson's Correlation Coefficient (r)

Pearson's *r* is a measure of simple correlations bivariate data, which means that it describes the relationship between two variables. According to Field (2018), Pearson's *r* is a measure of strength between variables that can vary from -1 (perfect negative relationship), through 0 (no relationship) to 1 (perfect positive relationship). A negative relationship is where the first variable increases and the second decreases, with a positive correlation showing the opposite trend (Field, 2018). The extent to which variables are effected are indicated by where they place on the continuum. Field (2018) adds that another important point to note about Pearson's *r*, is that it also reflects how the correlations fit around the model. A perfect relationship (-1 or 1) shows the data sitting perfectly on the line, with weaker relationships being more scattered. Typically, it is reported using 0.10 as a small effect, 0.30 as a medium effect, and over 0.50 as a large effect (Field, 2018). Frost (2019) also explains that different areas of research will expect different correlation coefficient results, and that research determining patterns in human behaviour are more likely to have correlations weaker than 0.6. Pearson's *r* was calculated to determine simple correlations between the scales, and will be reported upon within the quantitative data analysis in Chapter 4.

3.6.1.2 Standardised Regression Coefficient (β)

Regression analysis aims to draw samples at random from a population to create estimates of a relationship or effect (Frost, 2019). According to Frost (2019), this is an important element of research as it is not possible to measure entire populations. The combination of reporting coefficients and p-values can illustrate the statistical significance and characteristics of the relationships (Frost, 2019). When a regression coefficient is positive, it indicates a positive correlation between the variables, and the opposite when the coefficient is negative.

3.6.1.3 Coefficient of Multiple Correlation (R)

Regression analysis is used to predict the outcomes of a dependent variable when fitting a linear model to data (Field, 2018). When there are several predictors, this process is called multiple regression, which is applicable to this research project. The multiple correlation coefficient is used to determine the quality of prediction for the dependent variable within a linear model. It is reported between 0 and 1, with values closest to 1 indicating a perfect multiple correlation, and 0 indicating the opposite. The coefficient of multiple correlation will be used to determine the quality of the predictions, and will be reported upon within the quantitative analysis in Chapter 4.

3.6.1.4 Coefficient of Determination (R^2)

Like the coefficient of multiple correlation, the coefficient of determination is a goodness of fit measure which is reported between 0 and 1. It represents the amount of variance in the outcome, and is the square of the correlation coefficient (Field, 2018). Its purpose is to judge the regression model for competence (Sahay, 2016). Field (2018) recommends thinking about this number as a percentage rather than a proportion, which can be achieved by multiplying R^2 by 100. The closer this number is to 100%, the more perfect the goodness of fit, with closeness to 0% indicating the opposite. Frost (2019) suggests that not all low values of R^2 are a negative thing however, explaining that different fields of study have different expectations. When attempting to predict human behaviour, it is expected to have an R^2 value of less than 50%, and they are harder to predict than a physical process (Frost, 2019). The coefficient of determination will be reported upon within the quantitative analysis in Chapter 4, and will be used to determine the variance in the data presented.

3.6.1.5 p-Value

A statistical test is used to calculate the probability (p) of getting a score of a particular size from a distribution (Field, 2018). As the score becomes larger, the likelihood of it occurring becomes less. The p value is considered significant when it is below a certain value ($p < 0.05$), and gives reason to reject a null hypothesis (Field, 2018). A reported p value of 0.05 would indicate that within 95% of other cases, the null hypothesis would be rejected. It would also indicate that a researcher would have a 5% chance of making a Type I error, which is when they have rejected the null hypothesis when in fact it is true. Therefore, the smaller the p value, the less likely it is for a Type I error to occur. It also indicates that the observed data was less likely by chance, and is evidence to suggest there are differences between groups. The significance of figures on a table are indicted through the use of asterixis: (*$p<0.05$, **$p<0.01$, ***$p<0.001$). This study utilises the p-Value to identify significant data, and is reported upon within the quantitative analysis in Chapter 4.

3.6.1.6 Independent t-Test Group Statistics

Means testing can be used to consider questions about the data, such as are the differences which are real, or caused by chance or sampling errors (Salcedo & McCormick, 2020). An independent t-test is used for the comparison of the mean from two independent groups (Field, 2018). It is used to determine if there are significant differences associated with the population means (Kent State University, 2021). The closer a value of t is to 0, the less likely it is for there to be a significant difference. t-Testing is used within this research to identify any significant differences between genders, and is reported upon within the quantitative data in Chapter 4.

3.6.1.7 One-Way ANOVA Testing

A common statistical model used to analyse more than two independent means is called an Analysis of Variance, or ANOVA testing (Field, 2018). It is used for more complex tests than t-testing, which only applies between two groups (Salcedo & McCormick, 2020). It determines if there are significant differences between groups, and makes comparisons when two or more groups are involved in the study (Salcedo & McCormick, 2020; Field, 2018). Salcedo and McCormick (2020) explain that when you sample from several groups, variance will occur within different populations as people differ from each other. This results in the F statistic as outlined below. One-Way ANOVA testing has been utilised within this research project to determine any significant differences between classrooms, and is reported upon within the quantitative data in Chapter 4.

3.6.1.8 F Statistic

The F statistic is utilised to report on the variation ratio of how good the model is, to how much error there is (Field, 2018). At a ratio of approximately 1, there are no differences between the groups, and any numbers much larger than 1 indicate differences between the groups (Salcedo & McCormick, 2020).

3.6.1.9 Effect Size

Significance cannot always communicate the importance of an effect, and therefore measuring the size of an effect in a standardised way that can determine the strength of a relationship between variables (Field, 2018). A small effect size may indicate a lack of 'power', potentially requiring a larger sample size (Field, 2018). Due to the fact that effect size measures are standardised, they can be used to make comparisons between different research projects (Field, 2018). Field (2018) recommends reporting effect sizes as they give valuable information that you can't get from a p-value. Effect sizes will be reported upon based on the scales of the questionnaire. Pearson's r is one measure of effect size reported within this study, and was discussed further in Section 3.6.1.1, and Eta^2 will be another effect size measure reported upon within Chapter 4.

3.6.1.10 Eta^2

Eta^2 is a correlational effect size, and refers to the percentage variance accounted for in the research design (Bakker, Cai, English, Kaiser, Mesa & Van Dooren, 2019). Similar to Pearson's r, they are reported by using the benchmarks developed by Cohen in 1962, who contextually recommended the use as an estimate only (small = 0.10, medium = 0.30 and high 0.50) (Bakker et al., 2019). Bakker et al., (2019) give a warning about reporting effect sizes using these benchmarks, as over time the averages for effect sizes have dropped through abundant research, indicating the need for new benchmarks and refined interpretations.

3.6.1.11 Mean Scores

The mean is typically reported on within data sets due to its important tendency to include all points of data and its ability to be stable across different samples (Field, 2018). Field (2018) notes that the mean is usually reported upon within a range of information as it can be influenced heavily by extreme outlying scores. In the case of this research project, mean scores will be reported upon within the quantitative data analysis to indicate the average scores given by the participants from the questionnaire using the Likert 5-point scale for each of the questionnaire scales. As recommended, it is reported upon with a range of other figures as outlined below.

3.6.1.12 Standard Deviation

Standard deviations relate to the spread of data around the mean (Field, 2018). The smaller the standard deviation, in relation to the mean, the closer the data points are to the average number (Field, 2018). Smaller standard deviations from the mean typically indicate more reliable data. Mean scores and standard deviations are reported upon within Chapter 4, indicating the central tendency towards the scales of the questionnaires, and differences between classrooms and genders.

3.6.1.13 Coefficient of Variation (CV)

The Coefficient of Variation (CV) is a ratio for the mean and standard deviation, and it removes the unit of measurement from the standard deviation (Salkind, 2010). It can be used to make comparisons between distributions, including those with differing units of measurement (Salkind, 2010). The higher the number, the larger the standard deviation is in relation to the mean. These figures will be reported alongside the mean and standard deviations within the scale description tables in Chapter 4.

3.6.1.14 Reliability and Cronbach's Alpha Test

Reliability is a measure of whether an instrument can be applied to multiple contexts and continue to be interpreted consistently (Field, 2018; Taherdoost, 2016). One of the most widely used tests of reliability within the social sciences for testing attitudes is Cronbach's alpha (Bonett & Wright, 2015; Field, 2018; Taber, 2017; Taherdoost, 2016). It is commonly used to test the reliability of a scale made up of multiple items within a questionnaire. Taber (2017) states that Cronbach's alpha was developed concerning instruments utilised with a single administration, as opposed to collected re-test data. The approach is based on dividing up test items into groups and determining if results are comparable (Taber, 2017). Field (2018) and Taber (2017) suggest that that alpha is a reflection of how subsets of the instrument would produce results that are similar when all splits are made between items. While generally speaking, within research it is suggested that an alpha reliability score of 0.7 is often an accepted minimal value; however, it is important to note that there is no universal minimal value and it is dependent on the research context being undertaken (Bonett & Wright, 2015).

Due to the nature of the instrument utilised within this research project, Cronbach Alpha Reliability will be reported on for each of the scales within the questionnaire with an acceptable minimum value being 0.7 for individual scales. The researcher seeks to determine the reliability of the items within the scales, indicating their effectiveness for measuring the same concept (inter-relatedness). These results will be discussed further within Chapter 4.

3.6.1.15 Validity

According to Field (2018), validity is an important property alongside reliability that gives a researcher confidence that their instrument is completing its intended purpose. The extent to which an instrument measures what we set out to determine is referred to as validity (Field, 2018). Field (2018) also discusses determining attitudes of participants, which may in fact be seeking to measure perception as opposed to reality, and explains that when we have individual items representing a construct we are measuring, we call this content validity. Taherdoost (2016) outlines that validity can be developed with questionnaires through the use of experts within research areas to ensure that items representing a construct are essential and cover the entirety of the construct. In relationship to the instrument used within this research project, it was developed through the combination of three extensively tested and validated instruments. The validity of the selected instrument will be discussed further within Chapter 4.

3.6.2 Qualitative Analysis

Nowell, Norris, White and Moules (2017) state that rigour and precision needs to be applied to qualitative analysis as it becomes more popular, as to ensure the trustworthiness of the process and results. There is also a need for researchers to be transparent about their analysis methods, and communicate in detail how they have analysed their qualitative data as to continue developing integrity (Nowell et al., 2017). The following sections covering the qualitative data analysis will aim to transparently describe the process used by the researcher.

3.6.2.1 Thematic Analysis Methods

Thematic analysis was utilised for the qualitative data analysis, with the purpose to identify possible themes and patterns within the data. Braun and Clarke (2006) argue that thematic analysis is a key foundational approach of qualitative data analysis, even though it is not always highly appreciated. Research that applies the thematic approach rigorously can produce findings that are valid and insightful (Braun & Clarke, 2006). It is particularly advantageous when highlighting similarities and differences between the perspectives of participants (Braun & Clarke, 2006). This approach was beneficial for determining differences between the perspectives of males and females within the research project, seeking any differences that may assist in answering the research questions regarding gender. Braun and Clarke (2006) also recommend thematic analysis for early career researchers, as it does not require comprehensive theoretical or technical knowledge, making it appropriate for the context of this project.

Thematic analysis is used to identify, analyse, organise, describe and report upon themes within qualitative data sets (Braun & Clarke, 2006). Braun and Clarke (2006) state that one of its key benefits is its flexible nature and its ability to be applicable to a range of contexts, studies and types of research questions. However, with this flexibility comes the issue of potential error, and therefore Braun and Clarke (2006) and Nowell et al., (2017) offer guides for thematic analysis that are clear and create trustworthy findings, with the intent of creating more clarity around this approach. These guides are briefly outlined within the section below (3.6.2.2), and provide the process of thematic analysis broken into a series of phases that guided this researcher's qualitative analysis process.

Braun and Clarke (2012) also describe two key approaches within thematic analysis: inductive and deductive. An inductive approach to thematic analysis is characterised by a researcher who approaches the data set with few preconceptions, and their analysis is driven by what the data set contains (Braun & Clarke, 2012). A deductive approach is characterised by the researcher bringing preconceptions, ideas and topics to the data when they code and interpret it (Braun & Clarke, 2012). They continue to add that typically there will be a slight combination of both as it isn't possible to use purely one method or the other; however, they state that it is essential for a researcher to know the approach they are going to be implementing with a rationale for their choices in order to perform a quality thematic analysis (Braun & Clarke, 2012).

For this research project, a deductive form of thematic analysis was performed on the qualitative data. This is due to the way that the semi-structured interview questions have been created to determine certain types of information from the respondents that link with the research questions and the quantitative questionnaire. Naturally, concepts will emerge that will connect to these preconceived questions and ideas, and these will act as a guide in the formation of codes and then themes. As stated above, a researcher cannot be guided completely by a single approach, so any codes or themes that form that are not linked to the initial concepts of the researcher will still be used to ensure voice and flexibility of the respondents.

3.6.2.2 Data Analysis

Preliminary data examination

The qualitative data was approached with some prior knowledge of the data set, as the semi-structured interviews were conducted after reflection upon the quantitative data, which will assist with detecting meaning and patterns (Nowell et al., 2017). An important initial step once the qualitative data has been transcribed, is for the researcher to immerse themselves within the transcripts, including conducting multiple readings prior to coding (Braun & Clarke, 2006; Nowell et al., 2017).

Coding

According to Nowell et al., (2017), the second phase of thematic analysis is initial coding, which involves the researcher continuing to revisit the data repeatedly. This involves the simplification of data through targeting specific attributes and highlighting important areas of the transcript (Nowell et al., 2017). It is recommended by Braun and Clarke (2006) that the data is worked through systematically, with each item focussed upon equally, and with interesting points within the data being analysed to eventuate into themes. A range of approaches within thematic analysis exist, and whichever coding approach is used, it is imperative that the researcher is consistent in their chosen approach (Nowell et al., 2017).

Themes

The next phase, as outlined within Nowel et al., (2017), is to begin searching for themes within the coded data. A theme should bring together information that assists with answering research questions. Braun and Clarke (2006) state that researchers should know if they are performing inductive or deductive analysis to guide how they approach fitting data into themes. As the researcher determined that the qualitative analysis would be deductive, this method was applied. Deductive analysis involves looking at the data from the researcher's theoretical interest (Braun & Clarke, 2006), which means that the researcher approaches the data with preconceived themes and theories. These themes and theories were developed through the use of semi-structured focus questions, which eluded to particular aspects of SLEs, gathering data to address research question 3.

Braun and Clarke (2006) explain the next stage of theme development is the refinement of themes through reviewing. They outline that themes and codes may be reviewed several times as reflections are made based on overlap, diversity and accurate reflection of meaning (Braun & Clarke, 2006). During this phase, the researcher is seeking meaningful and rational patterns through revision, and should demonstrate clearly how they developed their themes through their data (Nowell et al., 2017). This creates a coherent set of themes that builds a narrative for the dataset (Braun & Clarke, 2006).

Once the themes have been refined, researchers must decide the important characteristics of the theme, and the narrative that each of the themes portray, linking this in relation to answering the research questions (Braun & Clarke, 2006). It is recommended that researchers have a peer reflect on their themes to ensure accuracy and relevance. Once the researcher is able to clearly define the boundaries of their themes, they can move into the next phase of the analysis (Braun & Clarke, 2006). This process was applied to the data collected through the qualitative phase of this study. Transcripts were used to begin the identification of themes, leading to preliminary examination, refinement and finally the development of conclusions, which is outlined further in Table 3.2.

TABLE 3.2 - DATA ANALYSIS FRAMEWORK FOR SEMI-STRUCTURED FOCUS GROUPS

Transcription.	Qualitative audio files to be transcribed using a professional service.
Preliminary data examination.	Multiple readings of the transcripts to get a general sense of the data.
Selection of relevant segments of data.	Highlighting segments that are relevant to the research.
Initial categorisation of data.	Data is categorised based on collective meanings.
Refinement of categories into key themes.	Data is rearranged into more refined categories that represent the core meaning.
Further examination, definition and consensus on categories.	Categories are further defined and refined until consensus on category definitions.
Triangulation of data.	Examining intercepting data to improve reliability.
Drawing conclusions	Data sets are used to draw conclusions based on the hypothesised model.

Drawing Conclusions

The final phase of the thematic analysis process is the creation of a report within which the researcher draws their conclusions (Braun & Clarke, 2006). Braun and Clarke (2006) suggest that the report may contain elements of raw data which assists in the illustration of the narrative, and should be logical and concise in its nature. They recommend that going beyond a simple descriptive account of the themes by including this additional information can create a more convincing validity and justification for the reader (Braun & Clarke, 2006). Nowell et al., (2017) also add that making links between the literature and the qualitative analysis can enhance further validity, and that credibility is directly linked to the coherence of the argument created by the researcher. Finally, the complete report should draw conclusions about the implications of each theme and create a comprehensive narrative for the reader (Nowell et al., 2017).

3.7 Ethics

A range of ethical issues were considered during the design and implementation of this research project. The researcher was careful to ensure non-maleficence and disruption of peace wherever possible within the study. Possible consequences of the research were also reflected upon, and catered for within the design.

This research project involved primary-aged minors completing a questionnaire that represents matters about their education and teacher, that involved personal information and opinions. Due to the sensitive nature of this information, and the potential anxiety for students that may want to please their educator or their need for confidentiality, several precautions were taken.

3.7.1 Permission, Informed Consent and Autonomy

Permission to commence this project was applied for and successfully obtained through the Curtin University Ethics Committee, with no work beginning without prior approval. The ethics for this research project were an amendment to a larger study being conducted within a junior high school context utilising the same instrument to collect data. As stipulated within the Curtin University ethics permission, the researcher submitted ethics permission to Catholic Education of Western Australia (CEWA), which was approved to allow the researcher to contact specific schools; however, an independent private school was chosen for the study due to the suitability of its context.

The initial visit to the school was designed to orientate staff with the project and discuss ethics permissions. The principal and participating staff members were given files that contained all of the necessary information, permission forms and the intended instrument. The principal was also given a school and principal consent form which was signed during the meeting to state that the school was willing to participate within the research project. Each document within the file was read through with staff, and they were given the opportunity to ask any questions or make suggestions about the commencement and implementation of the project. Suggestions were responded to within email form once the design had been amended. Teachers were also given paper copies of permission forms for parents and students; however, the school utilised an online system for parent permission and the researchers agreed to use their methods.

Informed consent was collected for the purposes of the study in three stages: principal, teacher and overall school consent; parents and/or guardians, and then students, to maintain their autonomy (Cohen et al., 2018). Silverman (2017) states the importance of informed consent for all participants as this allows research to be performed openly while minimising any risk of deception. Participants were also made aware of the procedures, purpose, risks, benefits and their right to withdraw (Cohen et al., 2018). Prior to the implementation of the questionnaire and focus groups, student participants were also given a full explanation of the project and intended uses of the data that was being collected.

3.7.2 Anonymity and Confidentiality

Cohen et al., (2018) believe that anonymity requires no identifiable data about the participants during the research, including by the researcher or any other person. As students were required to identify their name and gender within the survey, it was explained that their responses to the questionnaires would only be viewed by the researcher and supervisory team, and that their teachers and principal would not see any individual points of data. This was to reassure the students that they were safe to respond truthfully and reduce any potential bias from this. During data analysis, unclear data was, where possible or required, addressed by contacting the participant. To maintain anonymity where possible, quantitative data was anonymised post focus group selection, and students were not identified within the qualitative transcripts.

Another approach to protect privacy for participants is through confidentiality (Cohen et al., 2018). Confidentiality is an important ethical decision related to this research project due to participants identifying their name and gender. Punch and Oancea (2014) state that maintaining confidentiality can be a difficult task, as persons such as gatekeepers may be able to use contextual clues to identify participants. They suggest that a common way to ensure confidentiality is to store and analyse data that contains no identifiable information about participants (Punch and Oancea, 2014). For the purpose of this research project, all data post focus group selection will contain no identifiable information about participants to maintain confidentiality. As the information is fairly minimal in its sensitivity, these precautions are appropriate to this research project.

3.7.3 Disruptions

Research methods and data collection were highly considered to minimise all disruption to workload and classroom teaching, including the role of the teacher throughout the project. The original key role of the teacher within this research project was to collect permission forms, were supplied by the researcher. As the school collected permissions electronically as per their management systems, this expectation was not necessary for the staff. Beyond this, it was requested that the educator could discuss with their students some of the projects they had been completing, specifically due to the large amount of time the students had been absent from school due to COVID-19. These were the only two requests made of the teachers to ensure that minimal additional workload was added to their already busy schedule.

The school visits were also planned to minimise classroom teaching disruptions, as requested by the educators within the first meeting. A day that suited all four teachers was decided upon to administer the questionnaires. Each class had separate implementation, with each teacher being released from their classroom to perform others duties for the approximate 30 minutes that it took to complete. The teachers requested, if possible, to conduct the semi-structured focus groups within a lunch break to minimise further disruptions to class time, and so they were organised within this time for this reason.

3.7.4 Trust

Due to the short amount of time the researcher spent with the participants, developing a trusting relationship was a difficult consideration to manage. As discussed in Section 3.7.3 Disruptions, taking up a minimal amount of classroom learning time was one of the foci of the research design. During quantitative data collection, the researcher began the session within each classroom by discussing their role as a teacher, making some anecdotes about their own classroom, and discussing the STEM projects with the students that they had been completing. The aim from this was to develop a connection with the students to allow them to feel safer. The respondents were also given the opportunity to ask any questions they had, and to verbally opt out if they did not feel comfortable participating within the project.

3.8 Summary of Chapter

The purpose of this research project was to explore the perceptions of upper-primary aged students on their SLEs and relationship with their teacher, and how this impacts their attitudes towards STEM. One instrument was used to gather quantitative data about the student perceptions, followed by the implementation of semi-structured focus groups to collect qualitative data. The data was gathered from an co-educational independent private school north of Perth, Western Australia. A total of 100 responses were collected for the quantitative data, with 12 students purposively selected for the semi-structured focus groups. The quantitative data was processed using the IBM SPSS Statistics Management software to determine correlations between student perceptions of their learning environment and their indication of their motivation to pursue further STEM education. Qualitative data was analysed using a thematic approach. Ethical considerations were made through all phases of the research project.

Chapter 4: Quantitative Results

4.1 Chapter Introduction

The previous chapter outlined the research design, inclusive of methodology, instruments, quantitative and qualitative analysis methods, and ethical considerations. The purpose of this chapter is to outline the statistical analysis used to interpret the data from the Questionnaire on STEM CEC, and briefly address the research questions based on the results. This chapter indicates the data preparation methods and data demographic before reporting on the findings from the quantitative results. This will include a more focussed overview of the data presented within each table, prior to summaries of each key area within the questionnaire.

4.2 Overview of Results

This research has utilised both quantitative and qualitative research methods to explore the perceptions of upper-primary aged students on their SLEs and relationship with their teacher, seeking ways to improve student motivation and engagement with these disciplines. This chapter presents a general overview of the quantitative data that was collected, prior to conducting the semi-structured interviews.

Overall, the respondents indicated positive results across the Emotions scales in reflection of the CEC within their SLEs. Inclusive of all four classrooms, they indicated an average score of 4.07 out of a possible 5. There were minimal differences between the classrooms and the genders, which the researcher theorises is indicative of the collaborative nature of the teachers across their classrooms.

The Teacher-Student Interactions scales indicated an average mean of 3.87, which is lower than the Emotions scales. An interesting observation within these scales is the clear contrast between Student Responsibility/Freedom and the other scales. It was indicated as being significantly lower than the other scales at 2.47 out of a possible 5, which may indicate why the overall average of the scale is lower. Potential reasons for this will be explored further. The Attitudes scale was reasonably high at 4.08 overall, indicating positive perceptions of STEM. There were similar overall results for the Attitudes and Teacher-Student Interactions scales, where the respondents indicated an average score of 3.91 out of a possible 5.

Attitudes towards STEM specifically also yielded a positive response, where it was indicated at 4.08 out of a possible 5. It is positive to see the correlation between the respondent's attitudes towards STEM, and their associated Emotions and Attitudes relating to the other scales. As the aim of this research was to explore how a student's emotions and their interactions with their teacher impacted their perception of their SLE and STEM education within a quality SLE, it is positive to see these results.

These respondents' perceptions of their SLEs and experiences will be triangulated with the qualitative data to further explore the impacts that emotions has on student attitudes towards STEM education.

4.3 Data Preparation

The individual data points from the Questionnaire on STEM CEC, scales of the QTI, and attitude to STEM adopted from TOSRA, were manually entered into a spreadsheet, with results being checked for abnormalities and errors. A minor number of respondents who had only completed a small number of items of their questionnaire were removed. To differentiate from the theme codes used within the semi-structured interviews, items from the questionnaire are identified within this research project as Q and then a corresponding number. For example, Q28 refers to a question within the Challenge section, *My teachers asks questions that make me think hard.*

The STEM CEC dimensions of the questionnaire had eight scales ranging from item Q1-Q74. This included the scales Care, Control, Clarity, Challenge, Motivation, Consultation, Consolidation and Collaboration. Each scale had its items averaged, with individual scores ranging from a possible one to five using the Likert scale. The scale ranged from Almost Never (1) to Almost Always (5), with lower values reflecting a more negative view of the learning environment, and high values reflecting more positive perceptions. Attitude to STEM was measured using items Q75-Q84, with higher values indicating a more positive attitude towards STEM. The teacher-student interactions were measured across the four QTI scales: Leadership, Helpful/Friendly, Understanding and Student Responsibility/Freedom, ranging from item Q85-Q102.

Item Q103 was an optional written response from the students which was utilised to help determine participants for the semi-structured focus groups and is therefore not reported on within the quantitative data. All items excluding 103 were responded to through a Likert 5 point scale.

4.4 Data Demographic

A total of 100 questionnaire responses from the Year 5 students were suitable for data analysis, which included 46 male and 54 female respondents. A visual overview is included within Table 4.1. All suitable questionnaires included the demographic information of gender, grade and classroom. Student numbers were slightly inconsistent across classrooms, and this was mostly due to a small number of students being removed from one particular class towards the beginning of the questionnaire implementation for scheduled alternative extension classes. To cause minimal disruptions, these students did not participate.

TABLE 4.1 – DEMOGRAPHIC DATA IN PARTICIPATING CLASSES

Classroom	Male	Female	Total
Class 1	9	12	21
Class 2	10	14	24
Class 3	13	14	27
Class 4	14	14	28
Totals	46	54	100

4.5 Functional Validation of the Questionnaire

The questionnaire was functionally validated within a primary setting through the use of a range of methods. Firstly, the reliability of each scale was determined using the data collected from 100 participants used Cronbach's alpha coefficient. Each of the scales were reported upon as being above the required reported minimum of 0.7 (Bonett & Wright, 2015), which reliability figures ranging from 0.77 – 0.97, indicating that items appear to be measuring the same concept within scales. Individual scale alpha figures are reported upon within Table 4.2. The overall mean score for the individual scales was 0.84, indicating a strong overall reliability for the instrument.

Validity is considered the extent to which an instrument can give us confidence that is measures what we intend it to (Field, 2018), and within this research project is considered in terms of its development through other significant research projects that have extensively validated the question scales utilised. As discussed by Taherdoost (2016), questionnaire validity can be developed through the use of experts within research areas where through their experience they can determine if scales are assessing the construct in its entirety. The instrument used within this study was developed by Fraser et al., (2020), learning environment experts who then continued to refine the questionnaire for use in junior high schools contexts as outlined in Chapter 3. The sections of the instrument were developed through the combination of four extensively validated questionnaire used within learning environment research.

TABLE 4.2 – CRONBACH'S ALPHA RELIABILITY SCORES FOR SCALES OF THE QUESTIONNAIRE

Scale	Cronbach's Alpha Reliability
Care	0.87
Control	0.77
Clarity	0.87
Challenge	0.83
Motivation	0.88
Consultation	0.82
Consolidation	0.88
Collaboration	0.84
Attitude to STEM	0.97
Leadership	0.78
Helpful/Friendly	0.80
Understanding	0.88
Student Responsibility/Freedom	0.74
Scale Mean Score	**0.84**

The first instrument developed the Tripod 7Cs to measure CEC through the Bill and Melinda Gates Measures of Effective Teaching (MET) Project that collected data from close to one million students (Ferguson, 2012) (Section 2.4.6), as well as the Classroom Assessment Scoring System (CLASS) project, which was tested with over 4000 Pre-Year 5 students in the United States (Section 2.5.5) (Hamre & Pianta, 2007; Luckner & Pianta, 2011). The Attitudes to STEM portion of the questionnaire was developed through the Test of Science Related Attitudes (TOSRA), and was tested over a range of public and private schools in Australia (Fraser, 1981) (Section 2.4.7). Finally, the final segment of the instrument was developed through the Questionnaire on Teacher Interaction (QTI), which has a database that exceeds 300 000 students, tens of thousands of classrooms and over 6 000 teachers (den Brok et al., 2006; Wubbels and Brekelmans, 2005). The researcher acknowledges the limitations of the use of this questionnaire within the research project, which were introduced in Chapter 3, and will be discussed in further detail in Chapter 7.

4.6 Analysis of Central Tendency, Reliability and Mean Correlations for Emotions Scale

The data collected from the 100 student questionnaire responses indicated some significant results contributing to the research questions. These results are reported in Table 4.3. The mean scores for the CEC scales were relatively high, ranging from 3.85 at their lowest, to 4.30 at their highest out of a possible 5. Control (4.30) was measured as being the highest average of the scales, followed by Care (4.15) and Motivation (4.15). The lowest rated scales were Consultation (3.85) followed by Consolidation (3.90). The standard deviation of scores ranged from 0.55 at the lowest, to 0.74 at the highest. Consultation was reported as having the highest standard deviation from the mean, with Control having the lowest.

Overall the mean scores were reasonably high for self-reporting data. This may be indicative of the quality SLE that was chosen for this research project, and this will be discussed further within Chapter 6. The Coefficient of Variation (CV) reflects the ratio between the standard deviation and the mean of each scale. Reported as a percentage, the closer to 100% the figure, the larger the standard deviations are in relation to the mean. In Table 4.2, the scales from the questionnaire indicates that CV ranges from 12.79% to 23.52%, indicating relatively low-medium figures. This is indicative of data that is less widely spread, and helps to further determine the reliability of the data collected.

The reliability of the scales were also tested using Cronbach's alpha reliability coefficient and were measured at a high value indicating good reliability. This indicates the confidence of the instrument being applicable to multiple contexts and consistent interpretation (Field, 2018; Taherdoost, 2016). According to Bonett and Wright (2015), an acceptable reliability score is over 0.7. The scales from the questionnaire measured between 0.77 (Control) at the lowest, to 0.88 (Motivation and Consolidation) at the highest. All values within these scales fall above the accepted values for Cronbach's alpha, indicating good scores for reliability.

The mean correlation scores indicated high significance ($p < 0.001$) for each figure, with the correlations ranging from 0.44 to 0.67. Consolidation and Clarity are indicated at having the highest level of mean correlations, with Collaboration indicating the lowest. These values can range from -1 to 1, indicating a positive or negative relationship between the variables. The values indicated within the table suggest a medium strength positive correlation between the given variables, which is common within human behaviour studies.

The Eta^2 effect sizes of the data range from 0.12 (Control) to 0.37 (Consolidation), and are considered as low figures. While it is an important consideration to report upon within quantitative data, Bakker et al., (2019) warns that samples sizes need to be taken into consideration when reflecting upon this figure, as studies with smaller sample sizes tend to have lower effect sizes. This data allows for further insight into Research Question 1, where the questionnaire was utilised to determine student perceptions of the CEC within the STEM Learning Environment. Overall, a positive picture has been created from the perceptions of the respondents, who appear to perceive their learning environment as high quality, reflected further within the results of their Attitude to STEM.

4.7 Analysis of Central Tendency, Reliability and Mean Correlations for Attitude and Teacher-Student Interaction Scales

The figures for the Attitude and Teacher-Student Interaction scales are outlined in Table 4.4. The mean averages for the scales range from the lowest, Student Responsibility/ Freedom at 2.47, to the highest, which is Leadership at 4.46 out of a possible 5. The Student Responsibility/ Freedom scale has yielded interesting responses in contrast to the other scales, and will be discussed further in Section 4.8.

TABLE 4.3 - SCALE MEAN, STANDARD DEVIATION AND INTERNAL CONSISTENCY FOR THE SCALES OF STEM CEC.

Scale	No of Items	Mean	S D	CV %	Alpha Reliability	Mean Correlation	Eta^2
Care	10	4.15	0.63	15.18	0.87	0.65***	0.25
Control	8	4.30	0.55	12.79	0.77	0.56***	0.12
Clarity	9	4.02	0.70	17.41	0.87	0.67***	0.20
Challenge	9	4.10	0.64	15.61	0.83	0.66***	0.23
Motivation	9	4.15	0.71	17.11	0.88	0.61***	0.25
Consultation	8	3.85	0.74	19.22	0.82	0.62***	0.24
Consolidation	12	3.90	0.71	18.21	0.88	0.67***	0.37
Collaboration	9	4.11	0.61	14.84	0.84	0.44***	0.22
Average		4.07	0.66	16.30	0.85	0.61	0.24

*$p<0.05$, **$p<0.01$, ***$p<0.001$ N= Students=100, Classes=4

The Coefficients of Variation (CV), which act as a ratio for the mean and standard deviation, are generally low, ranging from 13.23 to 39.27. These figures indicate the standard deviation in relation to the mean, indicating that the spread of data around the mean indicates some central tendencies with data points being fairly close to the average across most scales other than Student Responsibility/Freedom.

The mean correlations for the Teacher-Student Interactions scales range from 0.44 to 0.72, with three of the scales indicating significance. Attitude to STEM and Helpful/Friendly indicate a statistical significance at $p < 0.001$, and Understanding at $p < 0.01$. Similar to the Emotions scales, the correlations highlight a medium strength positive correlation between the variables.

The alpha reliability figures range from 0.74 to 0.97, indicating that the items within the scales appear to consistently measure the same concept. Student Responsibility/ Freedom was indicated at the lowest value, with the Attitude to STEM scale at the highest. Similar to the Emotions scales, Cronbach's alpha figures indicate strong reliability for the Attitudes scales. This indicates that the collected results should be able to be reproduced.

The Eta^2 values refer to the correlational effect size of the data, which is the percentage variance accounted for within the research design. Within the data, the effect sizes represented by Eta^2 range from 0.16 through to 0.34, which are considered small. This data allows for further insight into Research Question 2, where the questionnaire was utilised to determine student perceptions of their interactions with their teacher. Overall, a reasonably positive but mixed perception was given by the students. While three out of the four scales (Leadership, Helpful/Friendly, and Understanding) were rated highly, Student Responsibility/Freedom reduced the overall mean average.

TABLE 4.4 - SCALE MEAN, STANDARD DEVIATION, INTERNAL CONSISTENCY (CRONBACH ALPHA RELIABILITY) AND ABILITY TO DIFFERENTIATE BETWEEN CLASSROOMS (ANOVA RESULTS) FOR ATTITUDE TO STEM AND SCALES OF TEACHER-STUDENT INTERACTIONS

Scale	No of Items	Mean	S D	CV %	Alpha Reliability	Mean Correlation	Eta^2
Attitude to STEM	10	4.08	0.96	23.53	0.97	0.44***	0.31
Leadership	5	4.46	0.59	13.23	0.78	0.68	0.16
Helpful/Friendly	5	4.28	0.73	17.06	0.80	0.72**	0.22
Understanding	4	4.28	0.87	20.33	0.88	0.70**	0.27*
Student Responsibility /Freedom	4	2.47	0.97	39.27	0.74	0.46	0.34**
Average		3.91	0.82	22.68	0.83	0.57	0.23

*p<0.05, ***p*<0.01, ****p*<0.001 *N*= Students=100, Classes=4

4.8 Analysis of Associations Between Emotions Scales, and Attitude Scale and Teacher-Student Interactions Scales

The analysis of associations between the questionnaire and Attitude scales are shown below within Table 4.5. Correlations, as reported as Pearson's r, are indicated with high levels of significance for four out of five attitude-environment associations: Attitude to STEM, Leadership, Helpful/Friendly and Understanding, which have a majority of correlations between the Emotions scales indicating $p < 0.001$. Out of the 32 r correlations within the attitude-environment associations, two correlations indicated significance at $p < 0.01$, one correlation indicated at $p < 0.05$, and the rest indicating significance at $p < 0.001$. This shows that the Emotions scales do provide some statistically significant impact on most of the attitude-environment associations.

It is interesting to note that the scale Student Responsibility/Freedom indicates a contrast from the other scales. Within this scale only one value was statistically significant, which was Motivation indicated at $p < 0.05$. As opposed to the other scales, it is also the only scale with negative correlations, however slight. The positive correlations in this scale are also very close to 0, indicating a potential lack of relationship. The researcher theorises that this may be an indication that primary-aged students do not value high levels of freedom, and that in fact this scale may contribute negatively towards a positive STEM CEC as suggested by the values. This will be explored further through Chapter 5 – Qualitative Analysis and Chapter 6 – Discussion.

The coefficient of multiple correlation (R), as indicated in Table 4.5, uses the linear model to make predictions for the outcomes of the dependent variable (Field, 2018). It is used to determine the quality of the prediction, and is reported between 0 and 1. Values closer to one indicate perfect multiple correlations. Due to the Student Responsibility/ Freedom scale, once again there is a large range present within these figures. They range from 0.07 (Student Responsibility/ Freedom) through to 0.62 (Attitude Towards STEM and Leadership) with values 0.59 (Helpful-Friendly) and 0.57 (Understanding) falling within the range. The Eta^2 correlational effect size values indicate a range from a small to medium, with Leadership having the smallest impact (0.16) and Student Responsibility/Freedom having the largest (0.34).

TABLE 4.5 - ASSOCIATIONS BETWEEN STEM CEC, ATTITUDE SCALES AND TEACHER-STUDENT INTERACTION SCALES IN TERMS OF SIMPLE CORRELATIONS (R), MULTIPLE CORRELATION (R) AND STANDARDISED REGRESSION COEFFICIENT (β)

	Attitude-Environment Associations									
Scale	Attitude Towards STEM		Leadership		Helpful - Friendly		Understanding		Student Responsibility/ Freedom	
	r	B	*R*	β	*r*	β	*r*	β	*r*	β
Care	0.32**	-0.35*	0.74***	0.42***	0.67***	0.32**	0.71***	0.43***	0.05	0.06
Control	0.48***	0.25*	0.66***	0.12	0.49***	-0.14	0.44***	-0.11	-0.04	-0.27*
Clarity	0.44***	0.07	0.65***	-0.11	0.65***	-0.05	0.65***	-0.09	0.07	0.01
Challenge	0.43***	0.01	0.67*** 7	0.02	0.68***	0.19	0.63***	0.02	0.01	-0.34
Motivation	0.48***	0.16	0.80***	0.54***	0.71***	0.42***	0.59***	0.24*	0.02*	0.63***
Consultation	0.42***	0.05	0.51***	-0.09	0.52***	-0.15	0.62***	0.01	-0.001	-0.09
Consolidation	0.51***	0.30	0.62***	0.15	0.65***	0.30*	0.72***	0.49***	0.09	0.26
Collaboration	0.46***	0.24*	0.32**	-0.17*	0.36***	-0.05	0.25*	-0.24**	-0.12	-0.28*
R		0.62***		0.62***		0.59***		0.57***		0.07
R^2		0.38***		0.38***		0.35***		0.33***		0.01

p*<0.05,*p*<0.01,****p*<0.001 *N*= Students=100,Classes=4

The coefficient of determination (R^2) indicates a goodness of fit measure, also reported between 0 and 1. It represents the amount of variance within the outcome (Field, 2018) and judges model competence (Sahay, 2016). Multiplying this number by 100 gives a percentage: the closer to 100%, the better the goodness of fit. However, when studying human behaviours, high values of R^2 aren't always expected. Frost (2019) explains that when predicting human behaviour, typical values will fall under 50% due to the unpredictability of people, and that this is acceptable. The R^2 values range from 0.01 (Student Responsibility/ Freedom) to 0.38 (Attitude Towards STEM and Leadership), with values 0.35 (Helpful-Friendly) and 0.33 (Understanding) between. Once again there is a significant difference with the Student Responsibility/Freedom scale, which continues to build on the idea that this scale does not impact positively on student attitudes to STEM, which will be explored further withing Chapter 6 – Discussion, and through the semi-structured focus groups as explored in Chapter 5. The other four scales fall into the criteria for goodness of fit within human behaviour predictions, with 50% being noted as a higher value. This data assists with answering Research Question 1 and 2, by analysing the associations between CEC, Teacher-Student Interactions and student Attitude to STEM.

4.9 Analysis of Associations Between Classrooms and Classroom Emotional Climate Scales

Classroom associations are outlined within Table 4.6. Between the four classrooms there were not a large number of statistically significant differences. The scale means between the group were all reasonably close, with Class 2 indicating the highest positive response to their SLE at 4.32, and Class 1 indicating the lowest positive response at 3.86 out of a possible 5. The standard deviations also do not vary significantly between classes, ranging from 0.78 (Class 3) to 0.61 (Class 2). These figures all indicate positive responses to their SLE experiences on average, which will be explored further within Chapter 6 – Discussion.

There were three statistically significant differences between the four classrooms groups. These were indicated within Control, which was statistically significant at $p < 0.001$, and Motivation, which was also statistically significant at $p < 0.001$, and finally Consolidation, which was statistically significant at $p < 0.05$. The differences between the classes ranged from 5.81 to 1.21, with an average difference of 1.88. As t is close to 0, it indicates that there are minimal differences between the perceptions of the students within each classroom.

Overall Class 2 reported having the highest positive response to their SLE through the quantitative data. They had a particularly high response to the Control within their classroom (4.57), and a lower response to how Consultation is used within their learning space (4.14).

Alternatively, Class 1 reported the lowest response to their SLE through the data (3.86), even though it is still positive. This class responded the most positively to the Collaboration within their classroom (4.11), but reported lower levels of Consultation (3.59), Consolidation (3.60) and Motivation (3.67).

4.10 Analysis of Associations Between Gender and Classroom Emotional Climate Scales

Overall, there were not many significant differences reported between the genders as indicated below within Table 4.7. The scale mean between males and females were very similar at 4.02 (males) and 4.11 (females) out of a possible 5, respectively. The standard deviations are fairly low, as they are close to 0 in comparison to the scale. The differences between males and females don’t overly vary at 0.74 (males) and 0.65 (females) respectively. Overall, females within this dataset have a more positive perception of their SLE, but both genders indicated a positive response. Interestingly, even though females report higher overall, the males indicate a stronger positive attitude towards STEM than the females. Other than Attitude to STEM, the males only indicated higher perceptions of Consultation and Consolidation,

TABLE 4.6 - ITEM MEAN, ITEM STANDARD DEVIATION AND ABILITY TO DIFFERENTIATE BETWEEN CLASSES (ANOVA RESULTS) FOR CLASS LEVEL DIFFERENCES ON THE SCALES OF STEM CEC AND ATTITUDE TO STEM

Scale	Mean				S D				Difference
	1	2	3	4	1	2	3	4	t
Care	3.88	4.37	4.11	4.20	0.66	0.62	0.56	0.63	2.40
Control	4.00	4.57	4.17	4.41	0.55	0.40	0.62	0.45	5.65***
Clarity	3.86	4.28	3.97	3.96	0.72	0.63	0.79	0.65	1.56
Challenge	4.00	4.31	4.02	4.06	0.54	0.58	0.75	0.64	1.21
Motivation	3.67	4.36	4.40	4.08	0.75	0.50	0.71	0.67	5.81***
Consultation	3.59	4.14	3.69	3.96	0.64	0.72	0.84	0.63	2.91
Consolidation	3.60	4.16	3.83	3.97	0.61	0.73	0.79	0.61	2.61*
Collaboration	4.11	4.33	3.97	4.07	0.56	0.50	0.73	0.59	1.60
Attitude to STEM	4.04	4.33	3.79	4.18	0.71	0.78	1.22	0.93	1.57
Average	3.86	4.32	3.99	4.10	0.64	0.61	0.78	0.64	1.88

*$p<0.05$, **$p<0.01$, ***$p<0.001$ *N*=Total 100 Students, Male=46, Female=54

though the differences were not significant. Females reported higher perceived values across all the other scales.

The data indicated only two statistically significant differences (t) between the male and female groups: Control (5.94) and Motivation (7.20). Each of these scales were both reported at $p < 0.01$. This was similar to the differences of scales reported between the classrooms, indicating that Control and Motivation show significant differences in a range of contexts.

The t value ranged from 0.07 to 7.20, with an average difference of 2.02 between the genders. With a low t value indicating a lack of difference between the two groups, it can be assumed that there were not significant differences across the data, other than for Control and Motivation.

The effect size r reflects the relationships of a model between -1 to 1, with weaker relationships being more scattered (Field, 2018). While the reporting of these numbers is debated by researchers, generally 0.10 is a small effect size, 0.3 indicates a medium effect size, and over 0.5 is a large effect size (Field, 2018). The effect sizes r as reported within Table 4.7 indicate small effect sizes, which is consistent with the differences reported within t. The average effect size is 0.10, ranging from 0.26 (Control) to 0.01 (Clarity and Consultation). This data is used to answer part b of Research Question 1, and highlights minimal differences between the genders for both CEC and Attitude to STEM.

TABLE 4.7 – ITEM MEAN, ITEM STANDARD DEVIATION AND GENDER DIFFERNCES ON THE SCALES OF STEM CEC AND ATTITUDE TO STEM

Scale	Mean		S D		Difference	
	Male	Female	Male	Female	t	Effect Size r
Care	4.06	4.22	0.66	0.60	0.44	0.13
Control	4.14	4.43	0.63	0.43	5.94**	0.26
Clarity	4.01	4.03	0.72	0.70	0.10	0.01
Challenge	4.02	4.16	0.75	0.53	2.51	0.11
Motivation	4.04	4.24	0.87	0.54	7.20**	0.14
Consultation	3.86	3.85	0.69	0.78	0.37	0.01
Consolidation	3.96	3.85	0.66	0.75	0.07	0.08
Collaboration	4.03	4.18	0.63	0.59	1.19	0.12
Attitude to STEM	4.14	4.03	1.01	0.92	0.33	0.06
Average	4.02	4.11	0.74	0.65	2.02	0.10

$^{**}p<0.01$ *N*=Total 100 Students, Male=46, Female=54

4.11 Analysis of Gender Between Teacher-Student Interaction Scales

Table 4.8 outlines gender differences between associations of the Teacher-Student Interactions scales. Similar to the gender differences between Emotions scales, there were minimal differences between the male and female's students' attitudes. Only two of the scales, Leadership (4.61) and Student Responsibility/Freedom (4.09), were indicated for significance at p < 0.05. For each of the scale differences, effect sizes are reported as being small. Females reported experiencing higher amounts of Leadership and Helpful/Friendly, while males reported higher levels of Understanding and Student/Responsibility Freedom. This data is used to answer part b of Research Question 2, and highlights two differences between the genders which are highlighted as significant.

TABLE 4.8 – ITEM MEAN, ITEM STANDARD DEVIATION AND GENDER DIFFERNCES ON THE SCALES OF TEACHER-STUDENT INTERACTION

Scale	Mean		S D		Difference	
	Male	Female	Male	Female	t	Effect Size r
Leadership	4.38	4.53	0.68	0.49	4.61*	0.13
Helpful/Friendly	4.16	4.37	0.82	0.64	3.78	0.14
Understanding	4.30	4.25	0.74	0.98	2.55	0.03
Student Responsibility/ Freedom	2.51	2.43	1.12	0.84	4.09*	0.04
Average	3.84	3.90	0.84	0.74	3.76	0.09

*p<0.05 *N*=Total 100 Students, Male=46, Female=54

4.12 Analysis of Attitude Towards Continued Engagement with STEM

Additional correlations were calculated between three specific questionnaire items and two of the scales to determine their impact on a student's attitude towards continuing to pursue STEM education in the future. *Item 82: These lessons make me interested in studying a STEM subject in the future*; *Item 83: I would choose to do this STEM subject even if I didn't have to;* and *Item 84: I feel confident about doing STEM projects in class*, were correlated against *Items 1-74* (Classroom Emotional Climate) and *Items 85-102* (Teacher-Student Interactions), as shown below in Table 4.9. These items were specifically selected to look closer at student perceptions of continuing to study STEM education, and the confidence they have developed through their SLEs.

One point that can be drawn from the data is that the CEC of the respondent's classroom is close to having a large effect size (0.48) on their perception of studying STEM within their future educational careers. This is also indicated at having a significance at $p < 0.001$. The Teacher-Student Interactions were not indicated as having high significance; however, this scale is considered to almost have a medium effect size (0.27) on the item. This shows that within this particular context, the CEC of the SLE impacts positively on the respondent's interest in pursuing STEM education, making this an important factor in engagement with STEM education for these students.

Furthering this, CEC had a large effect size (0.52) on the student's perceptions of selecting STEM disciplines as optional subjects, and the significance is indicated at $p < 0.001$. This is positive when reflecting on the construct of the STEM Pipeline, where students continue to follow a trajectory of learning through the STEM disciplines, potentially leading them to pursuing STEM occupations. The Teacher-Student Interactions scale has had a greater effect on this item at 0.37, which is considered a medium size. Significance is also indicated at $p < 0.001$, reflecting the probability of this data potentially occurring again in future contexts.

Additionally, Item 84 reflected student confidence about completing STEM projects within their classrooms. Out of the three specific items, CEC had the greatest impact at 0.54, which is considered a large effect size. This figure was also indicated at $p > 0.001$. Teacher-Student Interaction also indicated at this significance level, but had a lower effect size at 0.27.

TABLE 4.9 – CORRELATIONS BETWEEN SELECTED ITEMS OF CEC WITH ATTITUDE TO STEM AND QTI

	Classroom Emotion Climate	Teacher-Student Interactions
Item 82: These lessons make me interested in studying a STEM subject in the future.	0.48***	0.27
Item 83: I would choose to do this STEM subject even if I didn't have to.	0.52***	0.37***
Item 84: I feel confident about doing STEM projects in class.	0.54***	0.27***

****p*<0.001 *N*=Total 100 Students, Male=46, Female=54

4.13 Summary of Associations: Emotions

The results from the scales that make up the Emotions scales of the questionnaire are reported on within Table 4.3, which include Care, Control, Clarity, Challenge, Motivation, Consultation, Consolidation and Collaboration. Each of these scales are statistically significant at $p < 0.001$. The reliability of these scales averaged at 0.84, indicating a relatively high and acceptable score for this data. Overall, the mean average of the responses was 4.07 out of a possible 5, indicating relatively high responses to the questionnaire. The average alpha reliability was also above the acceptable figure at 0.85, and the mean correlations averaged at 0.61, with each figure being statistically significant at $p < 0.001$.

4.14 Summary of Associations: Attitude-Environment Associations

The results from the Attitudes and Teacher-Student Interaction scales section of the questionnaire are reported on within Table 4.4, which include Attitude to STEM, Leadership, Helpful/Friendly, Understanding and Student Responsibility/Freedom. Two of these scales have been indicated at being statistically significant at $p < 0.001$ (Attitude to STEM and Helpful/Friendly), and one scale has been indicated at being statistically significant at $p < 0.01$ (Understanding). Leadership and Student Responsibility/Freedom were not indicated as being statistically significant. The reliability of these scales averaged at 0.83, indicating a relatively high and acceptable score for this data. The mean correlations averaged at 0.57, slightly lower than the Emotions scales.

4.15 Summary of Associations: Attitudes Towards STEM

With a specific focus on the Attitudes Towards STEM section of the questionnaire, which is reported on within Table 4.4, this scale was indicated as statistically significant at $p < 0.001$. The alpha reliability of this scale was also very high at 0.97, indicating a strong reliability. The scale mean score was reported at 4.08 out of 5, which represents a strong positive attitude towards STEM within the data; however, the CV% is relatively high in comparison to the other scales at 23.53, indicating more of a spread of this data around the mean. This may have resulted from a number of outlier responses where students indicated a negative attitude towards STEM, which was not consistent with the average of the sample.

4.16 Summary of Associations: Classroom Differences

The results from the Emotions associations between the classroom differences are reported on within Table 4.6, which include Care, Control, Clarity, Challenge, Motivation, Consultation, Consolidation, Collaboration and Attitude to STEM. Two scales are indicated as statistically significant at $p < 0.001$, which are Control and Motivation. The reported difference for these scales are 5.65 and 5.81 respectively, with the other scales showing more minor differences between the responses. The average t value is 1.88, indicating that there are generally not major differences between the classroom responses. The mean averages ranged from 4.32 at the highest, to 3.86 at the lowest. Overall, the responses from students about their SLEs were positive across the four classrooms, with fairly minor differences between the classrooms.

4.17 Summary of Associations: Gender Differences

The results from the Emotions associations between the gender differences are reported on within Table 4.7, which include Care, Control, Clarity, Challenge, Motivation, Consultation, Consolidation, Collaboration and Attitude to STEM. Only two of these scales are indicated as statistically significant at $p < 0.01$, which are Control and Motivation. These two scales reported a difference of 5.94 and 7.20 respectively between the genders, with the other scales showing only minor differences between responses. The effect size *r* for all scales are also reported on a being very small, ranging from 0.01 to 0.26. Based on this data, responses between the genders are fairly similar, with the average Emotions scale mean for males being 4.02, and for females being 4.11. While this indicates a more positive response to the learning environment from the females, they interestingly report a less positive attitude towards STEM, with males indicating 4.14, and females indicating 4.03 out of a possible 5. Overall however, both genders indicate a strongly positive attitude towards STEM education. Potential reasons for these differences will be discussed within Chapter 6 – Discussion.

4.18 Summary and Key Findings

To summarise, the respondents from the four classes overall indicated positive emotions that they associated with their SLE. They gave an average score of 4.07 out of a possible 5 as the mean across the Emotions scales. Between the classes and the genders, their responses did not differ significantly. One potential may be the collaborative nature of the teachers who implemented similar, if not the same, projects within their classrooms. Another reason may be the quality of the SLE, which was one of the reasons that the sample school was selected to determine their strengths for engaging their students within the STEM disciplines.

Similar results were indicated across the Attitudes and Teacher-Student Interactions scales, where overall the respondents indicated an average mean score of 3.91 out of a possible 5. The range within these figures is larger, with

Leadership indicated at 4.46 and Student Responsibility/Freedom indicated at a low 2.47, which would be impacting the average score across the scales. The Student Responsibility/Freedom scale is an interesting construct to consider, and leads to several theories explored within Chapter 6 – Discussion. Through the research, it has been indicated that students don't necessarily see responsibility and freedom as positives within their learning environments, and this can lead to uncertainty and unproductivity. The researcher considers that children may find a certain level of responsibility and freedom to be engaging, but a lack of teacher input and control to be negative. This relationship can be explored further within Table 4.5 which outlines the associations between the Emotions, Attitudes, and Teacher-Student Interactions scales.

Overall it was indicated that the students had a positive attitude towards their SLEs and STEM education at the sample school. They indicated an overall 4.08 out of a possible 5 for their attitude towards STEM, which reflects positive perceptions. The data shows that the quality of the Emotions and Teacher-Student Interaction Scales have an impact on a student's attitude toward these disciplines, and therefore indicates that the quality of a SLE may directly impact a student's decision to pursue further STEM education.

4.19 Chapter Conclusion

This chapter presented the quantitative results gathered through the implementation of the questionnaire instrument. It outlined an overview of the results, data preparation and demographic, validation of the questionnaire, analysis and tabulated results, and summaries of the associations. The next chapter will present the qualitative results that were gathered through semi-structured focus groups.

Chapter 5: Qualitative Results

5.1 Chapter Introduction

This chapter will outline the results from the qualitative data collection. It discusses a key summary of the findings; introduces the thematic analysis process that was applied to the data, including the coding and themes, and presents a summary of each theme and the overall qualitative results.

5.2 Overview of Results

The data from the semi-structured interviews formed a bigger picture of the respondents' current experiences within their SLEs, some of their attitudes and emotions based on these experiences, and their perceived preferred ideas for further improving the SLEs within their school context.

Overall the students outlined a range of positive aspects within their SLEs that they were experiencing, and were able to articulate some of the impact that this was having on their attitudes towards STEM. Student freedom, peer collaboration, problem solving, communication, time, STEM learning and preferred environments were all concepts explored by the respondents through the questions, which in turn became the themes of the data set. Across these themes the students outlined specific and general experiences that occurred within their SLEs, and completed their semi-structured interviews by discussing their ideas for improving engagement and interest within their school context. A number of ideas were presented, including hands on opportunities such as through experiments and building; a range of spaces for the physical environment where they transition for different types of learning; additional choice relating to selecting groups and teams, curriculum learning and options for presenting their knowledge; types of engaging technologies for making and testing; and opportunities for peer collaboration beyond the constraints of their regular classroom.

A more detailed definition of each theme will be elaborated on within this chapter, with specific examples from the semi-structured interviews included. A final summary of each theme will also be presented towards the end of the chapter, with an overall summary of results.

5.3 Participants

The semi-structured interviews comprised of twelve students in total who were purposively selected based on their responses to the questionnaire. Table 5.1 shows the breakdown of the criteria for selection. A mix of respondents to ensure representativeness was necessary to gain a perspective from a range of students, who had indicated a different emotions towards STEM education. Additionally, a mix of genders was also necessary for representativeness, which is reflected in the table.

TABLE 5.1 – PURPOSIVE SAMPLING FOR QUALITATIVE FOCUS GROUPS BASED ON QUANTITATIVE RESULTS

Gender	N	Attitude Towards STEM		Motivated to Pursue STEM			
Male	5	Positive (≥ 4)	3	Indicated	3	Not Indicated	0
		Negative (2 ≤)	1	Indicated	0	Not Indicated	1
		Undecided (2 > <4)	1	Indicated	0	Not Indicated	1
Female	7	Positive (≥ 4)	3	Indicated	3	Not Indicated	0
		Negative (2 ≤)	2	Indicated	0	Not Indicated	2
		Undecided (2 > <4)	2	Indicated	0	Not Indicated	2

The students were asked to respond to five guiding questions, and then to describe their ideal STEM Learning Environment [See Appendix B].

5.4 Qualitative Data Preparation

The qualitative data from the semi-structured interviews were transcribed using the professional service TransciptionPuppy. The three interviews were separately transcribed verbatim using timestamping to improve readability. Several readings of the transcripts were then undertaken by the researcher, seeking patterns within the data. According to Saldana (2016), these patterns are regular occurrences or repetitions within the data that appear at least three times. As these initial patterns were considered, a colour coding strategy was designed in preparation for the initial coding of the data.

5.5 Initial Coding

According to Braun and Clarke (2006), thematic analysis is the process of identification, analysis, organisation and description of themes within a data set. The codification process was the first step within the identification stage to begin determining the potential themes of the interviews. The coding of data is a process of systematically classifying data in order to categorize it (Saldana, 2016). The coding of the semi-structured interviews began with several readthroughs of the data for the researcher to become familiar with the responses. After this, initial codes were created that reflected the key repetitive concepts within the interviews. The data was worked through systematically, with each area of the transcript being given an equal amount of attention to ensure accuracy and subjectivity. The codes appeared to naturally derive from the questions within the semi-structured interviews, with only a few codes not coming directly from the questions. These are outlined within the Table 5.2.

Saldana (2016) states that coding is cyclical, and usually the first attempts at creating codes to describe the data are not perfect. Braun and Clarke (2006) also state that codes and themes are often revisited several times to reflect on the categories and refine the process of analysing the data. Therefore, the initial codes were reviewed several times by the researcher, and then further developed through a peer reflection process.

TABLE 5.2 – INITIAL CODING OF THE QUALITATIVE DATA

Code	Sub-Categories
1. Student Freedom	a. Boundaries
	b. Choice
	c. Time
2. Peer Collaboration	a. Grouping
3. Problem Solving	a. Teacher Support
	b. Peer Support
4. Trial and Error	a. Opportunities
5. Communication	a. Noise
6. STEM Learning Environment	a. Female Perspectives
7. Time	a. Limitations
8. Hands On Learning	a. Building
	b. Designing

5.6 Developing Themes

After the initial coding of the data, the researcher then began to develop themes that captured groups of ideas within the data. Braun and Clarke (2012) describe this process as sculpting, as there are many different variations that can be created through this analysis process. Themes were developed by looking for overlaps within the initial codes and patterns that were emerging that related to the research questions.

The sub-category of Time within Student Freedom was moved into the Time theme as a natural fit. The Trial and Error code was collapsed into a sub-category within Problem Solving, which allowed for the condensing and refinement of the problem solving data. The sub-category of Teacher Control was also developed within the theme of Communication, as this was an evident repeating pattern within the responses. The sub-categories of STEM Learning were redeveloped from female perspective, which was less evident within the data set, and were developed into Emotions and Understanding/Misconceptions. The final initial theme of Hands On learning was turned into a sub-category, and the new theme of Preferred Environments was added. This then led to the development of the sub-themes Environment, Choice, Technology and Peer Collaboration, which all centred around students perceived preferred choices for their SLE.

5.7 Reviewing Potential Themes

Braun and Clarke (2012) advocate that novice researchers should review their themes to ensure that they are reflective of the message from the data set, provide relevant information for the research questions, have boundaries and are defined. Each theme was considered for its importance, which has been outlined below in conjunction with the theme definitions through sections 5.8-5.14. The peer reflection process, as advocated by Braun and Clarke (2006), allowed for the refinement of the themes that ensured greater accuracy for the illustration of the data narrative. It also assisted in developing the themes in alignment of the research questions, with the sub-categories creating boundaries of each theme to carefully interpret the responses of the participants. The final themes developed from the qualitative data through the peer reflection process are outlined below in Table 5.3.

A table was then developed where the data from the qualitative interviews were assigned to a theme. This started with physical copies of the transcript being colour-coded prior to a peer reflection session to discuss the initial readings. It was decided that each item would only be assigned to one category, when possible, unless a comment fit a theme, but was also important information for the Preferred Environments theme. The theme selected for the data would be the closest fit. This decision was made to facilitate an ease of transparency and analysis.

TABLE 5.3 – QUALITATIVE DATA THEMES

Theme	Sub-Category
1. Student Freedom	1. Boundaries
	2. Choice
2. Peer Collaboration	1. Grouping
3. Problem Solving	1. Teacher Support
	2. Peer Support
	3. Trial and Error
4. Communication	1. Noise
	2. Teacher Control
5. STEM Learning Environments	1. Emotions
	2. Understanding/ Misconceptions
6. Time	1. Limitations
7. Preferred Environments	1. Hands On
	2. Environment
	3. Choice
	4. Technology
	5. Peer Collaboration

Each item was then assigned a code based on its position within the table. The first number reflected the number of the theme, the second number reflected the number of the sub-category within the theme, the third number was the interview number, and the final number was the number of the item within the list. An example of this is *Item 2.1.1.5: Yeah. He gave everyone a letter and then he pairs letters up randomly and then you are that person's partner*. It is described as being 2 (Peer Collaboration), 1 (Grouping), 1 (Interview 1) and 5 (5th comment). A comparison can then be made to *Item 3.1.3.8: Normally I'd go up to them and ask for help and yeah, and doesn't say, doesn't um, helps us but doesn't say the answer*; 3 (Problem Solving), 1 (Teacher Support), 3 (Interview 3) and 8 (8th comment). This code system will be used to identify and illustrate the narrative from the data analysis process. Table 5.4 outlines the frequency breakdown of each theme and sub-category.

TABLE 5.4 – QUALITATIVE THEME FREQUENCY OF RESPONDENTS

Theme	Sub-Category	Frequency Total	Grand Total
Student Freedom	Boundaries	12	
	Choice	6	18
Peer Collaboration	Grouping	29	29
Problem Solving	Teacher Support	31	
	Peer Support	2	
	Trial and Error	18	51
Communication	Noise	5	
	Teacher Control	11	16
Time	Limitations	7	7
STEM Learning	Emotions	13	
	Understanding/ Misconceptions	12	25
Preferred Environments	Hands-On	5	
	Environment	1	
	Choice	7	
	Technology	8	
	Peer Collaboration	5	26

5.8 Student Freedom

The first theme that was drawn from the semi-structured interview was *Student Freedom*, with sub-categories of *Boundaries* (indicated 12 times) and *Choice* (indicated 6 times). Student Freedom has some links with the *Consultation* portion of the STEM Questionnaire on Classroom Emotional Climate (STEM CEC), which outlines student choice in *Item Q53 – My teacher gives me options about the tasks I complete*, and the *Challenge* portion in *Item Q36 – My teacher gives me enough time to finish STEM tasks.* It also connects to the *Teacher-Student* Interactions section of the questionnaire, specifically *Q99-Q102.* These four items make up the *Student Responsibility/* Freedom scale of the quantitative data. This theme was indicated a total of 18 times by the respondents across the three semi-structured interviews.

5.8.1 Boundaries

The respondents discussed boundaries in two distinct ways. Firstly, they talked about the teacher setting boundaries so that the learning would progress productively. They had an understanding that boundaries are an important part of their learning, and that within these boundaries they were then given choice. Interview *I*tem *1.1.3.1: But we had pretty much as much fun as we liked, and teacher only said, "let me set boundaries so we didn't have thing exploding or not actually [going] right",* illustrating an acceptance of boundaries from their teacher. The same child then responded to a question about how they felt about this within the context of their learning, answering within *Item 1.1.3.3: Very fun.* The following items illustrate another segment of an interview about student freedom:

1.1.1.1: We got a bit of freedom for what we choose and, like, what we do with it.
1.1.1.2: -maybe add on if we want to.
1.1.1.3: -we sort of had to stay within boundaries.
1.1.1.5: Um, with our teacher sometimes she lets us choose, and sometimes she just picks randomly.

Interviewer: Do you like it when she chooses for you or do you like to choose?
1.1.1.7: I don't really care.

The final item was an interesting addition to the conversation, with the student indicating that they were indifferent to some of the choice provided by their teacher.

The second way that the respondents discussed boundaries related to choice when constricted by time. This interpretation centred around prioritising the balance of learning and the creation of boundaries by the teacher to ensure this. The following items illustrate a segment of the interview that reflects this theme:

1.1.2.1: She says, go ahead and try it.
1.1.2.2: -she normally kind of looks at it and sees if. Because it might take too much time for us to do it. And then we'll be behind something else.
1.1.2.3: And she will consider all that before she says [yes or no].
1.1.2.4: - we had to select a topic off a piece of paper.

This final segment outlines an important boundary for the students in Item 1.1.2.4. It shows the boundaries of the choices that students are given: while they may have the opportunity for choice, it can be constricted to a set of choices already made by their teacher to support their progress or curriculum focus.

5.8.2 Choice

Choice as the second sub-category within the *Student Freedom* theme, and was only indicated within two of the three interviews. One child explained their opportunities for choice when they were trying to solve an issue within a project: *1.2.2.1: And when they weren't really working properly [a project], um and we asked her if we could try like, put more than one alka seltzer on board, change levels of water. And she said we could do that.*

1.2.1.1: We got some freedom to what – who we choose for a character.
1.2.1.2: - sometimes we get to (choose) a partner.
Interviewer: So, he gave, so he said, "Okay choose. You can have this many sort of a thing and you, you can choose.

Within these segments of the responses, the respondents outline some of the aspects where they feel freedom to make choices about their learning, and the opportunities given to them by their teacher to make choices within their SLEs.

5.9 Peer Collaboration

Peer collaboration was the third most frequent theme to be discussed across the three interviews, with 29 items from the respondents being recorded. This theme connects to the *Collaboration* section with the STEM CEC questionnaire, relating to items *Q66-74*. It was all centred around the sub-category of *Grouping*, which encompasses concepts of team and cooperative work. One of the key concepts within this theme was the respondent's views on the formation of groups. The following excerpts of the interviews reflect this discussion:

5.9.1 Grouping

Interviewer: Do you prefer working with random people or choosing who you work it?
2.1.1.10: Oh, it would be choosing.
2.1.1.11: Choosing, yeah.
2.1.1.12: I prefer choosing.

This small segment from the first interview simply reflects the respondents' attitudes towards having the opportunity to determine their own learning groups. The formation of learning groups was frequently discussed within the interviews, and reflected an important concept discussed by the respondents. This will also later be discussed within Section 5.14 – Preferred Environments.

2.1.2.8: Sometimes our teacher picks our groups. If you do not like that. But sometimes she just lets us cause um –
Interviewer: So, do you think that is most of the time? She lets you choose?
2.1.2.10: Yeah.
2.1.2.11: Um, yeah, she – [teacher] gives us relative, like, um. In our groups, we can really choose who we want. But yeah, she normally says there has to be like, a split gender. 'Cause otherwise, you just have whole groups of all girls and whole groups of all boys.
Interviewer: And what would you prefer?
2.1.2.13: Um, I like the split. It gives different perspectives normally.
Interviewer: Perspectives coming from the?
2.1.2.15: I would probably prefer to have an all-girl group but I think you do work better when you have like, different genders.

It is interesting to note *Item 2.1.2.13* and *Item 2.1.2.15*, the statements from the students regarding perspectives for learning. The first respondent indicated a positive attitude towards mixed-gender grouping, as it created a wider variety of perspectives, while the second indicated that while they preferred a single gender group, they recognised that they were more productive when working in a team of both genders.

Interviewer: How much freedom do you feel your teacher gives you when forming learning groups?
2.1.3.2: Kind of medium. I mean, sometimes they let us pick our groups and sometimes they just pick the groups for us, um which is a little bit hard especially when you get paired with random people. But, we were doing scripts on um, how the thing was, and she gave us lots of freedom, except she picked the character and the person we're working with.
Interviewer: So you would say you got a lot of freedom?
2.1.3.4: Yeah. A lot of freedom on that task.
2.1.3.5: I'd say our teacher actually pairs us up with people that we'll work well with so there's some kids in my class who can't work with their friends. So [teacher] says, "No, you can't go together". But otherwise, she just lets us pick

who we want in most tasks – a few tasks we have got to go to a boy/girl and something specific but.

Interviewer: So I, would I be right in saying that um this collaboration works differently at different times. Sometimes you have to select your partners, sometimes teacher picks the partners.

2.1.3.7: Sometimes she just advises us who to go with.

2.1.3.8: Yeah. With that so, our teacher tries to make us if we choose our own groups, try and choose someone that you work well with and not choose someone who you're gonna be silly with the whole time and muck around with and not do much work, and sometimes, um, she chooses our groups 'cos we'd be – like sometimes some of it you're working with a friend, sometimes you can muck around a bit, or you're not researching or doing any of that.

2.1.3.9: And sometimes in class he makes um, us letters, and there's like ABCD and all that, and the letter he has, he put some randomly up on the board and the pair, um, whatever letter you are, you're with that.

Within this segment of the third semi-structured interview, the respondents discussed the amount of freedom they felt they had in connection to the formation of learning teams. They outlined a range of scenarios where they had varying levels of freedom, based on teacher choices about behaviour and learning context. The respondents also mention some autonomy and teacher support within *Item 2.1.3.8*, and at other times higher levels of teacher control.

5.10 Problem Solving

The theme of *Problem Solving* was the most frequently indicated at 51 items. It was broken into three sub-categories: *Teacher Support* (indicated 31 times), *Peer Support* (indicated 2 times) and *Trial and Error* (indicated 18 times). It connects to several sections within the quantitative questionnaire; Control (Q12, Q16 and Q18), Challenge (Q31, Q32, Q35), Consultation (Q48, Q52, Q53), Consolidation (Q60, Q61, Q63, Q64), and Collaboration (Q66 - Q74). The theme was centred around support opportunities for solving problems from both peer and teachers, and opportunities for making and correcting mistakes.

5.10.1 Teacher Support

The respondents outlined teacher support in connection to solving problems across all three semi-structured interviews. They illustrated the variety of ways that they feel supported by a teacher when attempting a problem that they have found difficult, or needed assistance to proceed further. The following segments from the three interviews depict some of the attitudes:

3.1.1.2: Or he will help us. A little bit. Yeah.
3.1.1.3: Yeah. Or if they cannot figure [it] out. Just, the teacher will come and help us.
3.1.1.4: -even if you do not understand it, you have a small group on the mat. And try and talk, teach them, uh, easier way to [do] the work.
3.1.1.5: -you can get other friends down or the teacher might just let it try and, try and let it [work] out itself, and if you still cannot get it, she will come down and help.
3.1.1.6: They [the teacher] give us a sudden urge to like try to find another idea and go around the problem and find a new solution.
Interviewer: Great. And how does that make you guys feel?
3.1.1.10: Um, better because we know we have something to work with.

Within this segment, the respondents discuss that the teacher acts as a support during opportunities for problem solving. They also touch on the idea that the teacher acts as a guide for peer support also, which will be discussed further when exploring that sub-category. *Item 3.1.1.6* conveys that this style of support has assisted these students within engagement and resilience, motivating them to try new styles of problem solving or to continue when they are finding the problem difficult. *Item 3.1.1.10* also explains that this style of support allows these students to feel safe to take risks, as they know they will experience some form of support to solve their problem.

Interviewer: So you tried something different to solve the problem?
3.1.2.2: Yeah. [inaudible] 'cause if you don't succeed, she still sees you after.

Interviewer: What does your teacher do when you encounter a problem that frustrates you?
3.1.2.4: Um, so, um, our teacher, um, sometimes helps us [inaudible]. She describes the problem really well so we can understand it.
Interviewer: So she describes it in the same way or a little different?
3.1.2.8: A little different, so it is easier to understand.
3.1.2.10: So she gives us options like you could, you could go this way around it, or, and she helps explain, like. If we are stuck on, like, a question, then she will explain it better. That make sense?
3.1.2.11: She has different ways to explain it. So, if you don't get one way, then she'll tell us another way.
3.1.2.12: Well, she [inaudible] tried a different way. See if it works. If it does not, maybe keep on trying until you succeed.

This segment from the second semi-structured interview further outlined the respondent's views of teacher support during problem solving. *Item 3.1.2.12* explains that this student feels that their teacher wants them to continue attempting a problem until they are successful, and the preceding comments show that the students feel particularly supported by their educators.

3.1.3.2: Uh we're always trying, we do it no matter whether we find it hard and we just keep going.
3.1.3.5: Uh, she either tells us to just leave that one, go to the rest or she may help us understand it.
3.1.3.6: It really depends on um, the question they ask.
3.1.3.7: -like if we get stuck, she'd try to help us but she won't tell us the answer so we can still try and work it out ourselves but we still like, start to understand the question.
3.1.3.8: Normally I'd do up to them and ask for help and yeah, and doesn't say, doesn't um, helps us but doesn't say the answer.

Similar to the other two interviews, the respondents within this group also felt supported to approach their teachers for assistance when necessary, with the knowledge that they would receive support as needed.

5.10.2 Peer Support

Only a small segment of a single interview mentioned preferences specifically about peer support, indicating a simple preference for peer support over teacher assistance:

Interviewer: Do you prefer having one of your peer's help or the teacher?
3.2.1.2: Our peers.
3.2.1.3: Peers.

5.10.3 Trial and Error

The sub-category trial and error was mostly indicated within two of the semi-structured interviews. The segments illustrate the problem solving process that the respondents go through when they face difficulty and need to find solutions to an issue:

3.3.1.1: Like, I cannot give up so I can revise how it could be better and what can you – you can improve.
Interviewer: How does it make you feel when you do that?
3.3.1.3: Uh, happy I guess.
Interviewer: Makes you happy?
3.3.1.5: Makes us more inspired, so it can like, make more, uh, ideas and better ideas.
3.3.1.6: Ah yeah. Just giving advice.
3.3.1.7: Just like you are [inaudible], some actual help.
3.3.1.8: Yeah, that you help you and use the result to generate ideas.

3.3.3.6: Mine, the [inaudible] robot, it took me a few tries and [student name] is the witness of when I try to get it dancing, it fell over because the balance wasn't right.
Interviewer: Okay. Sometimes you're doing similar activity in [your] classroom and it's not working out. How does your teacher feel like?
3.3.3.8: Um, well she helps us but if she doesn't know, we just keep trying.

3.3.3.9: We um keep trying and trying if and if, like, we can't get it, then she'll just say, um, she'll basically say, "you don't have to do it if you're just struggling too much". And she'll help us if she can help us.

Interviewer: And roughly, how many opportunities do you get to test one – another idea?

3.3.3.11: Um, like probably five, six. So quite a few opportunities to test out.

3.3.3.12: I think until we get so frustrated that you just can't.

Interviewer: Okay. But you've done twenty times and got to try too, isn't it?

3.3.3.14: -she often likes us to just try our own strategies.

3.3.3.15: Unless it's like a test for that strategy – a certain strategy. But if an idea doesn't work she often says you have two options. Well, I do this. I have two options. You're trying to get a strategy right, use another strategy and get it done quicker. So both work.

The first segment illustrates how the opportunities for problem solving presented to these respondents allowed them to feel more inspired and safe to take risks when generating ideas. One of the students also indicated that this allowed them to generate better ideas when only advice was given by the teacher. The second segment discussed opportunities for testing a variety of items, with the respondents feeling they usually had approximately 5-6 opportunities to use a range of strategies to solve a problem. They also brought up the idea of frustration, and the teacher giving them the option to stop if necessary.

5.11 Communication

The theme *Communication* was indicated 16 times across the three semi-structured interviews, and it broken into the two sub-categories of Noise (indicated 5 times) and Teacher Control (indicated 11 times), related to communication. It connects to the section *Control* (Q11-18) within the STEM CEC questionnaire. The theme was centred around limitations on noise levels, and the way that communication was controlled by the teachers.

5.11.1 Noise

An interesting addition to the semi-structured interview was only experienced within the first group of respondents. The sub-category *Noise* was developed to communicate the attitudes of the respondents towards how peer-to-peer communication was managed within their classrooms. The following segment illustrates this discussion:

4.1.1.1: They seem to limit us to communication, that if we are talking too much, and about the relevant stuff, they make us be quiet.
Interviewer: So about [this], I will just clarify. So relevant things? So, even if you are talking about the project, you are still asked to quiet down a little?
4.1.1.3: Yeah.
Interviewer: How does it make you feel when your conversation is limited?
4.1.1.6: Well, it sort of limits us because if we get stuck to [the] wall, we cannot ask anyone. And it is much better talking to people because then, you can enjoy the task a bit more.
Interviewer: Okay, yes. That is more enjoyable and you can help you – help yourself more if there are problems. How do you guys feel? Similar or different?
4.1.1.8: Uh, probably the same.

This above segment is an interesting contrast to previous discussions about peer and teacher support within the classroom. The students appeared to feel, though they were able to seek support, limited within their capacity to communicate with others when completing their projects. This will be explored further within Chapter 6 – Discussion.

5.11.2 Teacher Control

Teacher control, related to communication, was indicated within all three of the interviews, but the most valuable data was collected within interview two and three. It centred around items that focussed on the presenting and communicating of ideas, and the way these processes were structured by the teachers. Within the second semi-structured interview, the respondents were discussing the different ways that they share their learning:

Interviewer: Okay, so did you have to present it?
4.2.2.2: Yeah, at the end. We did, right? Like what we discovered on a, on the computer.
Interviewer? So you did write it down on a computer? And where did you share that?
4.2.2.4: Um, we printed it off and gave it to our teacher.
4.2.2.5: We made posters of it. So we collected data, and we've made posters with that data.
4.2.2.6: Also, we also presented [it] see? Like with our scripts, we're presenting it doing like drama and stuff. So the teacher can see how well we're working together –
Interviewer: But you presented your iMovie?
4.2.2.8: Yeah. My, my iMovie was in a group.
Interviewer: So that is another way that you communicate. That is awesome. That is really interesting.

The students outlined several formal opportunities that they were given to communicate their team solutions, some of which involved technology and others that did not. The third data set differed from the second, and focussed closer on teacher support of student emotions during these opportunities for sharing their ideas and presenting their learning:

Interviewer: Uh, how does your teacher make you feel when you're presenting your ideas?
4.2.3.2: Um, really depends if she just randomly calls you out 'coz you're not really playing attention or if you put your hand up, you often feel pretty confident 'coz she yells at anyone if they laugh at your idea. So you always know even though it's not the right one, [the teacher] understands that you make mistakes.
4.2.3.3: Our [inaudible] teachers [inaudible] like other [inaudible] she said it's a no put down zone and every time we answer questions, we feel more – we

feel comfortable that nobody will laugh at us and that the teacher respects whatever idea we come up with.

The second set of the data discusses more of how the teacher controls the learning environment to ensure that the students feel safe and secure to share their ideas, knowing that, if they are wrong, they will be respected by both the teacher and their peers. The teachers therefore control these opportunities for communication through behaviour management strategies to create a cohesive and safe learning environment.

5.12 Time

The fifth theme, *Time*, related to limitations placed on students, was indicated a total of 7 times within two of the interviews. This connects to the *Challenge (Q28-36)* section of the STEM CEC questionnaire, where a balance is made between the time it takes to solve a challenging task, and the amount of time available to spend on a task. It was only given one sub-category, *Limitations*, and is particularly interesting due to the problematic nature of time within education organisations. Due to curriculum requirements, within classrooms time can be an issue due to balancing opportunities for trial and error, and the ensuring the comprehensive teaching of the curriculum. It is interesting to note student perspective on time:

4.1.1.1: And I, um, did not quite get it done.
Interviewer: Time is really [an] important thing, is it not? Do you feel like you have enough time to do your projects?
4.1.1.3: No, we have enough time because we do it like quite often. But sometimes we could use a little more time.
4.1.1.4: After they [the teachers] are spreading it out and keep it in one group during the day.
Interviewer: Oh. So, you have it over a day rather than spread over weeks?
4.1.1.6: Yeah.
Interviewer: Oh okay. So, it felt for you, rushed?
4.1.1.8: Yeah.

4.1.1.9: We finished it now, but not one is actually finished their site [project].

There was a mix of feelings about time within this group, with one of the respondents claiming that they were given enough time, but still conceding that no one had finished the website they were creating for their project. An interesting note that also came from this conversation, was that the students were advocating for the projects to be completed within longer sessions, such as a day, as opposed to breaking up the learning across many weeks. The second snippet was an important part of a conversation summarising the ideas of a respondent:

Interviewer: Okay, so you are gonna keep going til you succeed? But then you said earlier, it depends on how long it takes you.
4.1.2.2: Yeah.

In contrast to the parts of the interviews where the students discussed opportunities for trial and error, they also indicated that there were limitations to these opportunities. This is, of course, a natural concept within a classroom, where, as mentioned earlier, curriculum expectations mean that limitations must be placed on time to ensure expectations are met. It would be interesting to further explore primary-aged student perspectives on the concept of time, and how these may relate, or differ, from the organisational expectations of classrooms.

5.13 STEM Learning

The *STEM Learning* theme was broken into two sub-categories: *Emotions* (indicated 13 times) and *Understanding/Misconceptions* (indicated 12 times). The first sub-category outlined emotional responses to STEM learning opportunities, and then the second provides some insight into the respondent's understandings of STEM education. The leading question, '*Describe a STEM learning environment that excites you,'* does not relate to any particular segment of the associated questionnaire, and rather prompts students to consider perceived improvements to any or all segments.

5.13.1 Emotions

The *Emotions* sub-category related specifically to the way that STEM learning opportunities made students feel. These ranged from discussions about technology to general enjoyment:

Interviewer: Technology? What, what kinds of technology excite you?
6.1.1.6: Like yeah, big epic stream on Minecraft. I do not know.

6.1.2.1: I just feel it was fun without doing it. I have don't it before. It is fun [STEM projects].
Interviewer: Were they cool?
6.1.2.3: Yeah, mine [robot] fell over a million times though.

Interviewer: Do you do STEM at home and stuff?
6.1.3.2: Yeah.
6.1.3.3: By the way, since then I've built another robot. It's a spider robot and I found my robot cockroach and I built a robot cricket, and I hid them on my Mum's pillow, and I activated them 'cos they were solar-powered and it had a battery, then Mum got scared [laughs].
Interviewer: That's funny. So that means you enjoy working in STEM. Is that right?
6.1.3.5: Yeah. I have another one that does this go-dancing, that's all it does.

6.1.3.8: I just think it's fun to build robots and stuff.
Interviewer: Yes. It is fun, but at the same time you have to think and you have to be innovative.
6.1.3.10: I'm – I've started trying to learn java programming after I got um, a little bit good at code.
Interviewer: Wonderful!
6.1.3.12: So now I can code like really simple games or animations in java.
Interviewer: So it was fun?
6.1.3.14: Very fun.
6.1.3.15: I find it fun to learn all new stuff about science and math and tech.

The previous excerpts from the interviews illustrate situations where the respondents discussed how a variety of elements of STEM learning are enjoyable and engaging. Technology is discussed fairly frequently within the responses, and is depicted in a positive manner.

5.13.2 Understanding/Misconceptions

It was interesting to note, that while the respondents from this study indicated positive attitudes towards their SLEs and STEM education, they found it difficult to articulate what STEM actually means. The following excerpts highlight misconceptions and understandings indicated by the students:

Interviewer: Okay, my first question, so STEM involves innovation. Now, first of all, you don't know what STEM is? Do you remember what STEM is?
6.2.2.2: I do STEM. I do the club.
Interviewer: Tell me what STEM is then.
6 2.2.4: So, it is basically, it is kind of like, ugh. They work, STEM kind of works with technology. And you, like, why I start to make things turn on like a light. Turn on, like, you know that this, the city whatever. Okay, I am finding it hard to describe it, but-
Interviewer: Okay.
6.2.2.6: They –
Interviewer: So you use STEM in a, in, in your school? Okay, so do you remember what it stands for?
6.2.2.9: It stands for Science, Technology, English and Maths.
6.2.2.10: Yeah.
Interviewer: E is for English, do you think?
6.2.2.12: I do not know. That is the one thing –
6.2.2.13: This is the one I am not really sure.
6.2.2.14: Yeah, same with me.

Misconceptions about STEM education with students is an interesting concept to consider when measuring their attitudes towards the subject. While these students found it difficult to explain specifically what STEM means within this context, they were able to describe a range of learning experiences that they had been involved in which reflected quality STEM education. Furthering this, as previously mentioned, the sample school does not refer to these programs as 'STEM'. Rather, they sometimes refer to Solutions Fluency or other types of integrated learning. It would be interesting to explore further into whether or not it matters that these experiences are labelled as STEM to children, or if being exposed to these quality SLEs creates positive perceptions.

5.14 Preferred Environments

The *Preferred Environments* theme was broken into five sub-categories: Hands On (indicated 5 times), Environment (indicated 1 times), Choice (indicated 7 times), Technology (indicated 8 times) and Peer Collaboration (indicated 5 times). Each of the sub-categories varied in their connection to preferred environments, but developed a more comprehensive picture of what students prefer their SLEs to encompass.

5.14.1 Hands On

The sub-category of Hands-On describes experiences within SLEs where students have opportunities for building, or learning by doing. This ranged from examples of activities to associated emotions connected to these activities:

Interviewer But would you like to do things? What would you like to do for yourself? You would like to do hands-on things?
7.1.2.2: Yes and experiments.
Interviewer: Anything else you'd like to put in and do in your STEM classrooms?
7.1.2.4: Um, chemical reactions.
Interviewer: Chemical reactions? Okay.
7.1.2.6: Although you would have to have a, uh, a grown-up who knows exactly what he or she is doing. Otherwise you could put the classroom on fire or something rash.

Interviewer: So, anything else you would like to share about your learning environments? Yeah?
7.1.2.8: Maybe. Like designing things and then structure them and make them.
7.2.2.9: You could actually get more out doing this thing than just like watching videos or writing stuff down.

The first set of items is interesting as the respondent automatically brings teacher control into the preferred environment. They articulate that they understand the concept of danger and needing an adult to scaffold learning experiences. The second set of items indicates that one of the respondents does not connect as well to watching videos and taking notes, and would rather have opportunities to learn from hands-on experiences, which they appear to believe is a more effective way to learn.

5.14.2 Environment

The Environment sub-category outlines any respondent comment that applies to the physical learning environments that the students experience. While it only has one comment from a respondent, it was kept as a sub-category because physical environments, while not the focus of this study, are an important construct for quality STEM education:

7.2.1.1: Like different ideas, like [inaudible], a lounge area. I do not know. A gaming area.
Interviewer: Different spaces that you could go into.

5.14.3 Choice

The sub-category of Choice includes any comments from respondents that indicate preferences for being given options within their SLE. It ranges from selecting peers to work with through to curriculum adjustments/presentation ideas. It is interesting to consider how students discuss being given choices, especially when considering the quantitative data collected about Student Responsibility/Freedom.

7.3.1.1: Probably choosing [teams] because you know how the person thinks and you know how they do.
7.3.1.2: Um, with our teacher sometimes she lets us choose, and sometimes she just picks randomly.
7.3.1.3: I prefer choosing.

Interviewer: Is there something that you think would help you enjoy it [STEM] even more than you do?
7.3.1.5: Just our opinions on what the project would be?
Interviewer: Oh, okay, so having a bit more choice in what we are doing.
7.3.1.7: Yeah.
7.3.1.8: Variety definitely helps, and like, if you, say, we are gonna do a script, we should be able to like, choose what the script should be on. Like if it was on HASS, we would choose if it was on HASS or like, in a science project. So, it can be linked to, any other subjects.
7.3.1.9: Yeah, that would be great [choice].

In the above excerpts, the respondents suggest that they prefer selecting their own teams. They also provide information that their teacher lets them make this choice at times, and at other times the choice is random. It would be interesting to gain further information about *when* the teacher decides to let them select their teams, and whether or not when she selects teams if they are actually random. In the second segment, the respondents discuss having more choice around the curriculum and presentation opportunities. Again, these concepts relate to the Student Responsibility/Freedom scale of the questionnaire, so it is interesting to see the responses to the questions about choice and if they align with the quantitative data. This will be discussed further within Chapter 6 – Discussion.

5.14.4 Technology

The sub-category of Technology includes comments from the respondents that include their preferences to technology within their SLEs.

7.4.1.1: [inaudible] technology.
Interviewer: Technology? What, what kinds of technology excite you?
7.4.1.3: Like yeah, big like epic stream on Minecraft. I do not know.

Interviewer: Okay, so if we gave you an opportunity to do STEM. So, Science, Technology, Engineering, Math, like your STEM Club. If we gave you an opportunity to do that, what would it look like in your classroom? If I said to you, you can do anything we want, what would it look like?
7.4.2.2: Micro:bits.
7.4.2.3: You can program them to, um. You attach wires. You could turn light on, and you could make it do all sorts of things.
Interviewer: So learning about microbots and Micro:bits.
7.4.2.5: And we did bee bots.
Interviewer: Were they fun?
7.4.2.7: Yeah really fun.
Interviewer: So, that was your most exciting – So, you like to do more really cool interesting things like?
7.4.2.9: Yeah, and like making it and testing it.
Interviewer: So, beebots, making and testing – and experiments!

Within this sub-category, the respondents outlined several specific pieces of technology they felt were engaging when participating within STEM education. To further this conversation, it would be interesting to learn how the students would want these technologies implemented, and how they feel they could be used to enrich their STEM learning experiences.

5.14.5 Peer Collaboration

The final sub-category of perceived Preferred Environments is Peer Collaboration. This category includes comments made by students about their preferred way of working within an SLE with their peers. This is in contrast to Peer Collaboration as its own theme, which has a focus on how students are *currently* grouped and collaborate with each other. This sub-category is dedicated to items from within the qualitative data that suggest preferred options for peer collaboration.

7.5.1.1: I feel like just chatting with other people. Let us, like, chat and work with them. Maybe be in groups to collaborate.
Interviewer: Okay. So, collaborating, talking, being with others.
7.5.1.3: Um, probably the same. The, or say, a bigger learning space.
7.5.1.4: And loads more people to collaborate with and [inaudible] help sometimes.
Interviewer: So, sort of a more spread-out learning space, um, more people and working with different genders. Do you, when you choose your groups, going back to groups. Do you choose mixed-group gender groups often? Or you seem to stick to…
7.5.1.6: Yeah.
7.5.1.7: Unless it is like, not enough people.

The comments within this section outline that the respondents would prefer their learning environment to extend beyond the classroom to where they have additional space and people to collaborate with. These comments link with the item in the Environment sub-category, where the respondent was talking about specific types of spaces that they would choose to work within.

5.15 Thematic Analysis Process

Braun and Clarke (2012) describe thematic analysis as being a flexible, accessible and increasingly popular method used for qualitative data analysis. This process was used by the researcher to focus on finding meaning across a data set, and to make sense of any collective meaning or experiences had by the respondents (Braun & Clarke, 2012).

Themes are derived to capture important information within the data that relate to the research questions (Braun & Clarke, 2012). The thematic analysis process applied to the qualitative data was deductive, as the researcher framed questions for the semi-structured interviews with the preconceived idea that this would help guide specific concepts, codes and themes to assist in the analysis. These concepts were related to the research questions and the quantitative questionnaire so that further information could be gathered and compared to these results.

5.16 Summary of Theme 1 – Student Freedom

The key information derived from the Student Freedom theme were the sub-categories of Boundaries and Choice within SLEs. This information links with the Consultation scales of the questionnaire, and is centred around student's perceptions of the boundaries their teacher sets for them, and the autonomy they have experienced around those boundaries.

The respondents were able to articulate that they were constrained by particular boundaries when undertaking STEM educative experiences, but within those boundaries they had opportunities for autonomy. Specifically, one comment made by a respondent suggests that they do get freedom of choice, though that choice may be related to a specific menu of options pre-chosen by the teacher. It can be speculated that this is to ensure that students adhere to the requirements of the task, assessment or curriculum structured by the teachers.

Student Freedom is an interesting theme to consider when making comparisons between the data collected within the semi-structured interviews and the quantitative data. The data reported within the questionnaires reflected a more negative view of freedom, and indicated a possibility that students didn't find too much freedom to be valuable. In comparison to the qualitative responses, there appears to be certain types of freedom that the students find positive, and these will be explored further withing Chapter 6 – Discussion.

5.17 Summary of Theme 2 – Peer Collaboration

The Peer Collaboration theme has a focus on the respondent's comments related to their formation of groups and teams when completing projects. The items within this theme discuss different ways that their teacher forms their groups, or the ways that they are able to form their own.

The respondents commented that, at times, they have advocacy, and other times their teacher selects their group. The respondents believe that sometimes the teachers give them criteria, such as mixed gender, or students the teachers knows they will be productive with, and other times it can be completely randomised, such as random letter pairing. An interesting comment made by a female respondent within this theme is that they would prefer working in an all-girl group; however, they also note that split gender groups give 'different perspectives' and that they are more productive when they are mixed.

With the collaborative nature of the workforce continuing to more and more prominent, the skills required to work with peers are increasingly more essential. It would be interesting to explore further the balance between having students develop to skills needed to work with people they might not usually choose to, which can be a reality in the workplace, and having the skills to select people that they identify they would be able to be productive with. The scenarios outlined by the students appeared to give them varying amounts of freedom with these choices, which is reflective of the balance between the two concepts. These strategies will be discussed further within Chapter 6 – Discussion.

5.18 Summary of Theme 3 – Problem Solving

The theme of Problem Solving was the most frequently indicated out of all the themes, and was broken into three sub-categories: Teacher Support, Peer Support, and Trial and Error. The questions that elicited answers for this particularly theme were heavily connected to a number of scales from the quantitative questionnaire. Items within this theme were specifically focussed on teacher and peer supported problem solving, and opportunities to attempt problems using a variety of strategies.

Teacher Support is the first sub-category of Problem Solving, and it illustrates the behaviours of the teacher when the students felt unable to proceed. Within the responses, the students commented that they felt supported by their teachers, as they know they would assist them or explain the problem a different way when they felt frustrated. One respondent also commented that their teacher doesn't tell them the answer, but supports them in different ways to find it themselves. The students spoke positively about this type of support. There was only a small comment made about peer support specifically, where the respondents commented that they preferred the help of their peers over their teacher. Interestingly, they spoke more about being supported by their teacher; however, due to the collaborative nature of their projects, it could be assumed that they would first have access to each other before approaching their teacher for assistance. The third sub-category is Trial and Error, where the students highlighted that they had opportunities for trialling a range of approaches, and that they were also taught new approaches from their teacher that they could then put into practice. One respondent commented that they possibly get five or six opportunities to test a particular idea, and another commented that they continue until they get frustrated. Again, the respondents spoke positively about these strategies for trial and error, and the way that their teachers supported them through this process.

Problem solving processes are often centred around developing and refining essential STEM skills and capabilities, making them an integral aspect of SLEs. Implications for developing these skills within this theme will be explored further within Chapter 6 – Discussion.

5.19 Summary of Theme 4 – Communication

Communication was the fourth theme drawn from the responses to the semi-structured interview questions, and was broken into two sub-categories: Noise and Teacher Control. This was purposefully not grouped within peer collaboration, at is focussed specifically on the learning environment, and the teacher's preferences for that learning environment. It also centred around current opportunities for the communication of student understanding, and the way that this is determined by the teacher. This connects with comments made within the Preferred Environments theme, about student desire to have more choice in the way that they communicate their learning to others.

Within the sub-category Noise, the students discussed how they felt their communication was limited even when they believed they were discussing relevant information about their projects. Specifically, one respondent commented that they [the teachers] ‘make us be quiet’. The respondents also indicated that they felt that this limited their progress, as because when they felt ‘stuck’ and couldn’t proceed, they didn’t feel like they could communicate with others for help. They also noted that they felt a task was more enjoyable when they were able to communicate. It would be interesting to know students’ perceptions of the word ‘quiet’, whether this is referring to them needing to be silent, or if the teacher is merely managing the volume of the classroom, where students are asked to communicate using softer voices. The second sub-category, Teacher Control, focussed on processes implemented by the teacher to support students with communicating their ideas and knowledge. There were two key idea groups within this sub-category: one conversation focussed on methods for presenting, and another focussed on how students are made to feel when presenting. Students outlined a list of ways that they are asked to present their ideas, though they commented that this was presented specifically to the teacher, and made little comment on whether they presented to each other. They then highlighted the process of sharing information within discussions, and methods used by the teacher such as random cold calling and developing confidence through peer-to-peer respect.

Communication and student advocacy are both key concepts that students discussed within the Preferred Environments theme, making them an important element of student perceived preferred environments for SLEs. These concepts will be discussed further withing Chapter 6 – Discussion, and will be connected to some of the ideas the respondents had for improving STEM education within their context.

5.20 Summary of Theme 5 – Time

The Time theme only contains one sub-category: Limitations. It was decided to be kept as a theme based on its important nature within the educational sector and the influence that it has on all learning experiences. This sub-category focussed on respondent comments about limitations to their attempts for problem-solving, or any time constraints for completing or finishing projects.

Within the Limitations sub-category, the respondents discussed feeling differently about time. One individual said they were not able to complete their work in the given time, while another felt that they had enough time, but then noted they could use a little more time. They then commented that they felt rushed by the time expectations, and one respondent believed that no one had actually finished this particular project and they were not going to work on it any further. Additionally, one student acknowledged that they wanted to keep attempting a problem until they succeeded, but would only be able to continue trialling solutions within the given time.

Time is a very interesting concept to consider within education, as it is not always something that is completely within the control of the educator due to curriculum and school legislative requirements. It is interesting to explore students' conceptions about time, and whether they have an understanding of the constraints placed upon their educators which they need to balance each day. As time is an important factor when solving problems and performing trial and error based approaches, this theme will be analysed in further detail within Chapter 6 – Discussion.

5.21 Summary of Theme 6 – STEM Learning

The STEM Learning theme that was constructed through the responses to the semi-structured interviews was broken into two sub-categories: Emotions and Understandings/Misconceptions. These sub-categories focussed on the current feelings and understandings of the respondents within their SLEs.

The first sub-category highlighted important information about how the respondents felt when experiencing STEM education within their SLEs, and even with the mix of students selected from the quantitative interviews, the overall emotions towards STEM was positive. Additionally, these comments often included information about technology; however, it was specifically coded within this theme due to its focus on how that technology made the respondents feel, as opposed to the types of technology they would like to use within their SLEs. The Understandings/Misconceptions sub-category showed that even though the students are being immersed in quality STEM education, they find it difficult to articulate exactly what STEM means. They were able to articulate some aspects of what it may look like, but would not explain what the acronym stands for.

The concepts highlighted through the STEM Learning theme share some interesting insights into the ways that students are made to feel during the their STEM education within SLEs, or when participating within similar experiences beyond their classrooms. This important information can be viewed as evidence that, typically, quality experiences with STEM education is engaging and seen to be positive by the respondents. Furthering this, an interesting concept was explored about students understanding of the term STEM, as to why the respondents were not able to articulate its meaning, even when participating in something as focussed as a STEM Club. Further information will be explored withing Chapter 6 – Discussion, where potential reasons for these responses will be presented.

5.22 Summary of Theme 7 – Preferred Environments

The question that led to the Preferred Environments theme of the qualitative data was designed as an opportunity for students to consider perceived preferred learning environments, which can be taken on as potential ways to engage students within STEM education. The key information derived from this theme related to a range of sub-categories: Hands-On, Environment, Choice, Technology and Peer Collaboration. These all focussed on what students would *prefer* within their SLEs, rather than what they are currently experiencing.

The respondents outlined several concepts that they felt would improve their classroom's SLE. The first concept included additional opportunities for students to learn through the use of 'hands on' methods, within which a student commented that it was a more effective way to learn. Another segment advised that utilising a range of spaces to learn in, such as areas specific to building or gaming, could improve engagement. This is an interesting concept, and something that is not always possible for schools due to resource management and space issues. Choice relating to peer collaboration was also discussed as a means for improving student advocacy. The respondents indicated a desire to be able to select their teams as opposed to their teacher selecting them at random, which was the indicated perceived way that their teacher grouped them. They also added comments about being given additional freedom with the curriculum and how they communicate their learning. They specifically brought up the concept of integration, by saying that sometimes they wanted to combine different ideas from other curriculum areas, such as the Humanities and Social Sciences, and Science together. With the integrated approach of the learning programs at the sample school, it is interesting to see the respondents seeking additional opportunities for these methods. Technology was another area where the respondents expressed a range of specific preferences for robotics and online programs, including the use of collaborative Minecraft, Micro:bits and Bee-Bots. The final sub-category of the Preferred Environment theme was Peer Collaboration, where the respondents discussed preferred learning spaces where they have room to collaborate with a range of peers beyond their own classroom space. Specifically, they noted it would be beneficial to work with students from the opposite gender within these spaces, even though they commented earlier that they typically paired up with students of the same gender normally, unless told differently.

Some illuminating concepts were drawn through the Preferred Environments theme, which have the potential to be considered for improving student's perceptions of their SLEs. The respondents were able to verbalise a range of perceived preferences for their SLEs, and some reasons for why these would be effective approaches when implementing STEM education. A more in-depth analysis will be presented within Chapter 6 – Discussion, and Chapter 7 – Conclusion, where potential reasons for these preferences, and implications of these preferences will be discussed in further detail.

5.23 Summary of Results

Overall the respondents indicated a range of opinions and emotions about their SLE that gave critical information about the current experiences they are having, and how they feel about these, as well as potential opportunities to improve SLEs within their context. Firstly, the respondents were able to indicate that boundaries were present within their SLE; however, they also felt that they had some freedom within these boundaries that were structured by their teacher. They could comment on their own advocacy at times when being given opportunities to collaborate with others, but are also experiencing teacher structure at other times during the formation of groups and teams. The students were particularly vocal about problem solving and expressed that they felt very supported during this process by knowing that their teachers and peers were there to support them when they felt frustrated. Comments were also made about explicit and guided opportunities for trial and error, where they felt they were given several opportunities to test ways of doing things. Communication was also a concept that the respondents discussed, with interesting comments about how they felt they were not always allowed to speak with each other even if their conversations were on task. It also included the communication in terms of presenting their learning, where the students eluded to this being quite closely controlled by their teacher. The respondents also outlined the issue of time within SLEs, and how they felt they were not always given opportunities to complete their learning projects. Overall the students communicated positive emotions towards their STEM experiences, and often discussed using technology when speaking of opportunities that excited them or that they had enjoyed.

The Preferred Environments theme was developed as a means for discovering some aspects of the respondents' perceived preferred SLEs. Within this concept, the students outlined more opportunities for hands on learning, where they would have opportunities to build and conduct experiments. Interesting, a respondent commented that when you have experiences that are hands on, you learn more, which was met with agreement from his peers. The students also described more environmental structures that they felt would be engaging, such as rooms specific to building or gaming where they could be more immersed within their environment. An important concept that they outlined was greater opportunities for choice, where they would prefer more autonomy when selecting teams, defining their own curriculum and choosing how they would like to present the information that they have gathered. Furthering this, technology played a part within the responses, where the respondents outlined several types of technology that they would like to implement, and that using these types of resources are engaging and fun. Finally, they also discussed peer collaboration, and that they would like to extend this learning approach beyond the walls of their classroom, where they have greater choice to work with others beyond their own class by accessing different learning spaces.

The qualitative data allowed for a more 'human' insight that enriched the quantitative data through the narrative of the students. The combining of these two types of information created a detailed picture of the way that these students view their STEM Learning Environment, and how they made connections with the different items within the questionnaire. Naturally, the students discussed questionnaire aspects within the semi-structured focus groups, and gave their voice to the quantitative information that they had shared. Additionally, the positive comments also coincided with the positive data that was collected through the questionnaire, and helped to create a stronger sense of validity within the data. This was due to the opportunities given to elaborate on these perceptions, rather than them potentially being biased by wanting to impress their teacher. Overall, the combination of the qualitative and quantitative data combined to demonstrate student perceptions of their quality STEM Learning Environment, and how these positive characteristics impacted their Attitude to STEM education.

5.24 Chapter Summary

This chapter outlined the results from the qualitative data collection through the use of semi-structured focus groups. It initially outlined the participants and context, before describing the thematic analysis process which was applied to the data to create codes and then themes. The chapter then outlined each of the themes derived from the transcript data, gave examples of the related quantitative questions and examples from the transcripts to create a more holistic understanding of each theme. Finally, the chapter outlined a summary of each theme and the overall results from the qualitative research.

Chapter 6: Discussion

6.1 Introduction

This chapter will present a discussion that combines the findings from both the quantitative and qualitative data. It will be presented within the context of the literature review, reflecting on parallels and conflicts that arise from the data. Findings for the research questions will be outlined and an overall summary will be presented.

6.2 Findings in Context of Literature Review

Defining a STEM learning environment within a regular primary school classroom, as opposed to a specialist subject environment, included challenges where teachers and students needed to define the parameters of when this type of learning was occurring, and when it wasn't. This was reflected at times within the students' responses, where they were able to discuss at length the types of tasks and experiences that were reflective of the criteria, but were not always able to define exactly what was meant by STEM. As previously mentioned, this was also possibly due to this integrated learning style being referred to by the pedagogical model through which it was being implemented, such as 'solutions fluency'; however, when students have the same teacher across a range of curriculum subjects, it can be difficult for them to determine subject 'boundaries' if they are not being explicitly defined. As previously stated, an exact definition for STEM education has been long debated, and still remains an issue as to its specific meaning within education (Barkatsas et al., 2018; Blackley & Howell, 2015; Rosicka, 2016; Timms et al., 2018). This research project has referred to STEM education as the full, or partial, integration of concepts from the four related disciplines within the context of problems that require the application of skills and knowledge. This definition has been frequently referred to within literature, including Nadelson and Seifert (2017), who also add that through this integrated approach, students develop essential skills required for their future careers.

The learning experiences described by the respondents are reflective of the integrated approach to STEM education, and while the teachers don't necessarily refer to these experiences as STEM to the students, the learning environment is reflective of the aspects required for engagement with these disciplines. Prior to the quantitative data collection, the students were asked to think about STEM experiences that they had been involved in, and to consider the SLEs when answering their questions. The respondents were able to articulate a range of STEM learning experiences, such as tasks that required technologies, like website building to showcase integrated learning, Minecraft Education, and the use of applications on iPads and laptops. Additionally, they outlined several unplugged engineering projects that involved the physical design competencies. Furthering this, students were also involved within a school STEM club, and the Western Power Circuit Breakers program where they needed to design a sustainable city and power it using Micro:bit technology. The latter opportunity also showcased integral links to industry, where students were exposed to real-world STEM learning opportunities and potential career prospects.

Honey et al., (2014) state that one of the key goals of integrated STEM learning programs is the development of 21st Century competences. Opportunities for students to make decisions, solve problems and have agency with their learning, assists in the crucial development of these employability skills. These skills include a wide variety of abilities which amalgamate intrapersonal, interpersonal and cognitive characteristics (Honey et al., 2014). According to the World Economic Forum (2020), Analytical Thinking and Innovation rate 1st for the Top 15 Skills for 2025, and that Creativity, Originality and Initiative rate fifth. Students who are not being given opportunities to develop these skills in an environment where they have agency to make their own choices, or think for themselves, will have little explicit opportunity to develop these traits. The Office of the Chief Scientist (2012) stated that these skills should become a focus within primary and secondary education to begin the engagement process. The respondents were able to articulate their experiences in the development of a range of these skills, reflecting the quality nature of their SLE. The follow sections discuss the research findings within the context of the literature review by outlining the current research and the associations or conflicts made with the collected respondent data.

6.3 Findings for Research Question 1

How do upper-primary student perceptions of the emotional climate of their STEM Learning Environment impact attitudes towards STEM?

a. What do students perceive to be preferred emotional climate of a classroom?

Classroom Emotional Climate (CEC) is a construct within the field of learning environments, and measures how an educator promotes comfort and positive emotions within their classroom (Brackett et al., 2011). A positive CEC includes an educator who is aware of student needs; shows care and concern; listens to their perspectives and actively acts upon them; and creates a cooperative environment between peers (Hamre & Pianta, 2007). Classrooms within which students experience a positive CEC are indicative of greater academic success and engagement (Reyes et al., 2012). The concept of the STEM Pipeline outlines how engagement may lead students to continue pursuing STEM education through primary, secondary and then post-schooling, such as University or TAFE studies, and needs to be seriously considered from the earliest learning experiences of a child (Murphy et al., 2019). Understanding the factors that may result in students engaging, or disengaging, are essential in building a more STEM competent workforce (Timms et al., 2018, Watt, 2016; Watt et al., 2012). If CEC has a significant effect on engagement, then it is important to understand its impact within SLEs from the perspectives of students, to determine the ways that will enhance the 'flow' of the pipeline.

This research project measured the students' perceptions of their CEC within their classroom SLE. The positive data collected from the respondents is indicative of their perception of a quality SLE. The data highlighted that the students' positive perceptions of their CEC within their SLEs had significant impact on their attitude towards STEM. The correlations *r* ranged from 0.32 – 0.51, with all but one reported to be significant at $p < 0.001$. This shows that the positive CEC was having a positive impact on their attitude towards STEM.

The students indicated that their highest perceived preferred CECs on a Likert 5 Point scale, includes environments of high teacher Control (average 4.30), Care (average 4.15), Motivation (average 4.15), Collaboration (average 4.11), Challenge (average 4.10), and Clarity (average 4.02). They also indicated reasonably high amounts of Consolidation (average 3.90) and Consultation (average 3.85). These scales of CEC had an overall mean correlation of 0.61, with all scales statistically significant at $p < 0.001$, indicating their effect on the students' attitudes towards STEM education, (average 4.08). Attitude to STEM had a highly positive response at 4.08, however; it did have one of the larger standard deviations at 0.96, and coefficient of variation at 23.53. This indicates that responses from students had a larger range across the data set. While this may be the case, there could be other contributing factors, which are beyond the scope of this study, that may be causing such a wide range of perceptions, such as family life views and prior personal experiences.

Considering the Key Findings (Sections 6.3 – 6.8), the students built on these responses by outlining their desire to work collaboratively with each other whenever possible, and to be given opportunities to select the students that they would be working with. They also outlined that while they valued the teacher controlling the behavioural side of the SLE, that they wanted greater choice and consultation with the curriculum and presentation elements of their STEM education. The respondents also highlighted that their teachers' use of problem-solving approaches were motivational, and that their balance of challenge and care promoted success as much as it did productive struggle, which is the concept within education where students are challenged enough to make mistakes and grow, but not so challenged that they disengage. Within this context, the students indicated that they were experiencing a positive SLE, which appears to have had a positive impact on their attitudes towards STEM, as theorised within Figure 1.1.

b. Do any variations in perception, or attitude towards STEM, exist between genders?

Females continue to be underrepresented within STEM careers (Marginson et al., 2013), and their contributions are critical to bridging the STEM skills shortage gap currently being experienced within Australia (Office of the Chief Scientist, 2014; 2013). Research suggests that positive early childhood exposure to STEM can affect a female's motivation to pursue STEM careers (Marginson, 2013; Timms et al., 2018). The Commonwealth of Australia (2019) also believes that quality foundational STEM education is the only way to inspire girls to pursue these careers. The context of this study was selected to see how a school, known for implementing quality STEM learning, impacts their students' perceptions of their STEM learning environment. In order to seek differences in perception between genders, comparisons were made within the quantitative data.

It is interesting to note that female perceptions of STEM within the context of this study did not vary greatly from that of the males. Only two differences were statistically significant when considering the t-test between two groups, which were Control and Motivation at $p < 0.01$. Females reported much higher levels of control within their SLEs, and this particular scale also had the highest effect size r of 0.26. Females also reported higher levels of motivation than the males. Across each of the CEC scales, the girls reported higher mean scores other than Consultation (3.86 male; to 3.85 female) and Consolidation (3.96 male; to 3.85 female). Interestingly, even with these factors, the males still reported a slightly more positive attitude to STEM (4.14 male; to 4.03 female). This is an interesting finding, and within this context may indicate that there are other factors impacting perceptions of STEM education.

6.4 Findings for Research Question 2

How do upper-primary student perceptions of their relationship with their teacher impact attitude towards STEM?

a. What do students perceive to be preferred teacher interpersonal behaviour?

Teacher-student relationships are an integral element within learning environment research. Classroom interactions have a strong influence on a child's development (Hamre & Pianta, 2007), therefore measuring student perceptions of these relationships is essential to determining indicators of positive relationships and student motivators. The Office of the Chief Scientist (2013) states that teachers who are inspirational to their students are crucial to nurturing their students' love of STEM, which will influence their study and career decisions. De Loof et al., (2019) state that motivational teachers directly influence the engagement of their students, and these factors may influence their perceptions of their relationship with their teacher, and impact their attitude towards STEM.

This research project measured the students perceptions of their teacher-student relationships within their classroom SLE. The positive data collected from the respondents is indicative of their perception of a quality SLE. The data highlighted that the students' positive perceptions of their teacher-student interactions within their SLEs had statistically significant impact on their attitude towards STEM, except for the Student Responsibility/Freedom scale. The correlations *r* ranged from 0.46 – 0.72, with Helpful/Friendly indicating $p < 0.001$, and Understanding indicating $p < 0.01$. Interestingly, the Leadership scale, while highly rated within this context, did not have significant mean correlations, indicating that this scale may not impact the students' perceptions of their SLEs. While these scales had less of a significant impact than the Emotions scales on the students' perceptions of their attitude towards STEM education, they still provided valuable insight into their impacts.

The Attitude scales related less highly than the Emotions scales, however; this would be the impact of the Student Responsibility/Freedom scale being rated low by the students. The students indicated that their perceived preferred preference for teacher interpersonal behaviour were high levels of Leadership (average 4.46), Helpfulness/Friendliness (average 4.28) and Understanding (average 4.28). They also indicated that they preferred not to have high levels of Student Responsibility and Freedom (average 2.47), which was seen as a pattern throughout the data, and appears to have negative impacts on student perceptions of their SLEs. This included behaviours such as letting students 'fool around' in class and tolerating higher level of negative student behaviours. While this is the case, this scale also had the highest standard deviation at 0.97, and the highest coefficient of variation at 39.27. This highlights a spread within this data set, which indicates that the students had mixed perceptions about the Student Responsibility/Freedom scale.

Bringing this into the context of the Key Findings (Sections 6.3 – 6.8), the respondents highlighted that they preferred when their teachers supported them with their learning, and that this particular scale (Student Responsibility/Freedom) was balanced out with the Challenge scale to allow students to take safe risks. The combination of these two scales creates an environment where students are positioned to problem solve and collaborate, but know that their teachers will reliably support them when they need it. Additionally, they also indicated a preference for teachers who were understanding, showing behaviours such as being willing to clarify concepts, and who will listen to students rather than jump to conclusions. Overall, other than their preferences for less student responsibility and freedom, specifically in terms of behaviour, the students indicated that their relationships with their teachers were positive, and this appears to have positively impacted their perceptions of their SLE, as theorised within Figure 1.1.

b. Do any variations in perception, or attitude towards STEM, exist between genders?

Similar to research question 1b, there were minimal differences between the students' perceptions of their interactions with their teacher, and their attitude towards STEM. Overall the females had a slightly higher mean average of 3.90 to 3.84, with both figures lower than the mean averages for the Emotions scales. Looking at each scale individually however, there was a 50:50 split between higher reported values. The males perceived higher levels of Understanding and Student Responsibility/Freedom, and the females perceived higher levels of Leadership and Helpful/Friendly from their teachers. The Leadership and Student Responsibility/Freedom scales were both indicated as being significant at $p < 0.05$. Males reported a slightly more positive attitude towards STEM, at 4.14 to 4.03, but differences were not statistically significant. Overall the differences between the genders were not overly significant, and overall indicated positive responses to their Attitudes to STEM and their interactions with their teachers. Potentially, this is due to the quality nature of the SLE within which they are experiencing their STEM education.

6.5 Findings for Research Question 3

What are the characteristics of a STEM Learning Environment?

6.5.1 Key Finding 1 – Student Freedom within Integrated STEM Learning Environments

One of the most significant key findings from this research was the students' perceptions of their freedom within their SLEs. Student freedom, or agency, plays a critical role in the development of these abilities due to students being given the opportunity to make decisions, solve problems, think flexibly and work autonomously. This finding specifically links to Items Q11-18 (Control), Item Q53 (Consultation), Items Q99-102 (Teacher-Student Interactions) of the questionnaire; and most closely with interview Question 2: *STEM involves collaboration. How much freedom do you feel your teacher gives you when forming learning groups?*; and Question 6: D*escribe a STEM learning environment that excites you*.

Firstly, students noted a range of elements that they associated with negatively, and these were primarily related to behavioural control of the classroom. Students did not respond well to classroom environments where the teacher allowed students to act inappropriately, or within environments where students were able to influence teacher behaviour too greatly. Their preference was that their teacher had control over the behaviour in the classroom, and that students were supported to make appropriate choices to engage positively with their learning. Within this concept, the students also indicated that they liked to be acknowledged for their good behaviours, and liked environments where their teacher was treated with respect. The respondents did not seek high levels of student freedom within this aspect of choice, and in fact, preferred well-structured learning environments.

While students saw freedom within behavioural and learning structures as negative, they associated positively with opportunities where they perceived they were being given choice or agency related to the curriculum. One of these ideas was related to choice when determining more specific aspects of their learning goals. While the teacher may set a task where students are learning about a general idea, the students indicated that they would like to have choice in what they would experience related to the more general idea. One particular focus group also discussed having opportunities to link these ideas to other curriculum areas, indicating a desire for further integration of content not always associated with STEM education. This form of freedom can be a subtle shift within SLEs, where students are still learning about the intended curriculum, but have the opportunity to delve deeper into related concepts that specifically interest them. This concept also relates to the idea of communicating through their choice of medium, where students are given opportunities to express their knowledge through a process that makes sense to them, e.g.: film, speech, informational or creative writing, Stop Motion technology, or through designing a solution. It would be interesting to delve deeper into student perceptions of this area of freedom, and look closer at their preferences for curriculum related agency.

6.5.2 Key Finding 2 – Peer Collaboration

Peer collaboration is another interesting concept that emerged through the research. This also links strongly with the development of STEM employability skills, as it develops a range of abilities and attributes required for the development of productive and cohesive teams. While collaboration skills are not specifically outlined by the World Economic Forum (2020), Leadership and Social Influence ranks 6th, Emotional Intelligence ranks 11th, and Persuasion and Negotiation ranks 15th for top skills required by 2025, which are closely related and required for effective collaboration. Honey et al., (2014) specifically include collaboration as an essential employability skill, and communication skills are frequently referred to as being of high importance (Office of the Chief Scientist, 2015).

Within the questionnaire, students were asked to identify their perceptions of a range of statements using the Likert 5 Point scale. Examples of these questions include, *Q68*: *I work with other students on STEM projects in this class*, and *Q74: I sort out our disagreements about the project within the group.* Students indicated that they were frequently given opportunities to practice these skills, with an overall mean average of 4.11 out of 5. There were also minimal differences between gender perceptions of this competency, with girls indicating only a slightly higher response to the items. Within the semi-structured interviews, peer collaboration was a common theme with 29 respondent comments relating to it. Primarily, these comments formed a narrative about group formations within the context, and student's preferences for how this is achieved. The students outlined that there were several ways that groups were formed during their STEM learning experiences: teacher-chosen, student-chosen and random.

Students related positively to being given the choice of selecting other students to work with; however they also noted that they understood why their teachers frequently selected groups for them, as they knew they were more productive when this occurred. Interestingly, one student commented that while she preferred single-sex groups, she knew that she would work better with mixed-genders, and that there would be a greater variety of perspectives. They were less positive about random groupings, as they noted that sometimes they were paired with other students that they didn't get along with. One idea discussed by the respondents was that at times their teacher *advised* them on who they should group with, and would give parameters, such as requiring a mix of genders.

The varying amounts of freedom within this mix of contexts may in fact set students up for success. At times, they are able to work with whom they choose, which can create safety for risk taking; other times they are given a team, which is more reflective of a real-world environment, where you do not usually get to select who you work alongside of. The fact that students have an understanding of why their teacher gives them these different options is also positive, as they are able to rationalise and adapt to different learning environments, rather than only practising collaboration in one particular way. As this skill is becoming increasingly more essential within the work place, it is positive that the students within this context identify positively with this construct.

6.5.3 Key Finding 3 – Problem Solving

The World Economic Forum (2020) identifies Complex Problem-Solving as the 3rd Top Skill for 2025; with Critical Thinking and Analysis 4th; Reasoning, Problem-Solving and Ideation 10th; and Troubleshooting and User Experience 12th, as related skillsets. Additionally, The Foundation for Young Australians (2017) names problem solving as a key enterprise skill. They outline that the demand for problem solving has risen by 26% within early career advertisements between 2012 and 2015 (The Foundation for Young Australians, 2017). One of the key arguments behind the development of 21st Century competencies is the need for workers who can adapt to unknown future working conditions, with the capacity to be flexible and solve problems as they occur (Caplan et al., 2016; Honey et al., 2014; Marginson et al., 2013; Margot & Kettler, 2019; Nadelson & Seifert, 2017; Stobaugh, 2019; Timms et al., 2018). Nadelson and Seifert (2017) refer to quality integrated STEM practice as the combination of concepts from a range of disciplines, presented within the context of a *problem*. This highlights the ability to solve problems as a critical skill needed to be developed through this interdisciplinary approach. Unfortunately, an international test, Program for International Student Assessment (PISA) found that approximately 1 in 3 Australian fifteen-year-olds demonstrated low proficiency in problem solving (The Foundation for Young Australians, 2017). With this skill being so critical, and in such high demand, it is essential that research determines effect ways to teach and measure this concept effectively within schools.

Within the questionnaire, students were asked to rate this concept within a range of items related to the Challenge scale. For example, *Q31: My teacher encourages me to keep going when the work is hard; Q32: My teacher wants me to use my thinking skills, not just memorise things;* and *Q35: I'm encouraged to correct my mistakes.* The mean average for this scale was reported as 4.10 out of a possible 5, and a mean correlation of 0.66 with significance indicated at $p < 0.001$. Females felt slightly more challenged within this learning environment, but again there were minimal differences between the genders. Within the semi-structured interviews, Problem Solving has the highest frequency of items, at a total of 51. The category was broken into three sub-categories: *Teacher Support, Peer Support,* and *Trial and Error.*

Within this context, the students articulated that they felt supported during problem solving processes. Teacher support was discussed by the respondents across all three of the semi-structured interviews, and outlined a narrative where the teachers of this context were well equip at supporting the students through complex problem-solving tasks. They indicated that their teachers were skilled at balancing support and challenge which scaffolded student goal achievement. One respondent even outlined the sudden 'urge' their teacher gave them to seek new ways of finding ideas and solutions, which shows the motivational nature of the SLE. The students also built upon the idea that they knew their teacher would support them if they needed it, and that they would do so by giving them hints and prompts, rather than just giving the answer to their problem. These instructional qualities may be what support students within their SLEs to continue developing a more flexible approach to problem solving, where they are required to trial a range of approaches within an environment that has been developed for them to take safe risks.

A smaller segment of the interviews mentioned Peer Support, and it was indicated by the students that they preferred to seek assistance from their peers when possible. This preference may link with the highly collaborative nature of the SLEs within this context, where students have the capacity to work effectively together, and therefore seek solutions from each other rather than their teacher; however, they also know that if necessary, that they can seek support from an adult if these attempts aren't successful. This may be an important idea to consider for quality SLEs, where students are supported to solve complex problems together to continue developing this essential workplace skill.

Furthering the idea of Problem Solving is the sub-category of Trial and Error, the students highlighted their opportunities for getting opportunities for iteration and the development of multiple solutions to a problem. They discussed that their teachers supported them to trial their own ideas, but were available for support as outlined above. They also outlined that being given these opportunities made them feel happy during these learning experiences, and that multiple opportunities for success allowed them to improve.

The theme of Problem Solving was a clear finding through both the qualitative and quantitative data. It was significant in its impact on attitudes towards STEM, and was the most commonly discussed theme within the semi-structured interviews. It is clear that the respondents felt that this concept was important within their SLE, and that their teachers were providing them with ample opportunities to take supported risks that valued the choices of the students, and allowed them to solve problems cooperatively and collaboratively when required. As problem solving is one of the most highly rated competencies for the work force, it is important to reflect on the student's perceptions of their experiences within this learning environment context.

6.5.4 Key Finding 4 – Communication

There is little value in gaining knowledge if not for the point of communicating it with others, which is heavily reflected within the practices of the research community. While communication skills are not specifically stated within the World Economic Forum's (2020) Top 15 Skills for 2025, they may fall under the category of Social Influence, which are skills related to connecting with others. The Foundation for Young Australians (2017) specifically lists communications as essential enterprise skills as a powerful predictor of long-term success. As mentioned previously, The Office of the Chief Scientist (2015) also states that communication is a highly valued competency required for 21st Century workers.

Within this key finding, the focus of this type of communication is less linked to a child's ability to verbally communicate, but rather the opportunities they are given for communication, and communication as the presentation of knowledge. Within the questionnaire, this relates closely to several items, such as *Q50: My teacher wants me to share my thoughts; Q51: I speak up and share my ideas about the class work; and Q53: My teacher gives me options about the tasks I complete.* During the semi-structured interviews, the theme of Communication was highlighted 16 times, and split into sub-categories *Noise* and *Teacher Control*.

Noise, as a sub-category, relates predominantly to the control over the learning environment within which students are communicating with each other. It is interesting to note that within the responses, there were conflicting opinions that seemed to also conflict slightly with the student's perceptions of their peer collaboration. While at other points within the interview, the students discussed freedom in their ability to collaborate and consult with one another, however a respondent added that their communication was in fact limited, and that if they were talking 'too much', even if it was about 'relevant stuff', that the teachers made them be quiet. The respondent also added that when this happened, it made them feel limited in their problem solving approaches, and that they enjoyed being able to communicate more freely. This was agreed with by the other children within the group. It is interesting to consider this perspective, and difficult to measure exactly the context from where these opinions would have developed. The teachers within this study were rated as having high amounts of control over their environments, which was seen as a positive thing by the students. Due to the strong belief of the students that they had agency and freedom to collaborate with their peers, it could be speculated that the teachers within these environments were managing the noise to ensure that there was continued control within the classrooms, where students would continue to be safe and productive from the perspective of an educator. However, a child's perception is their reality, and therefore it would be interesting to further consider appropriate noise levels within an SLE, and the balance of teacher control and student communication that is most conducive to success and productivity.

The other sub-category within Communication is *Teacher Control*, and relates primarily to the teacher's decisions about how students will communicate their knowledge beyond their teams. This relates closely to the dimension of Consultation within the questionnaire, and the level to which the teacher controls a student's agency. Typically, the students reported that they were given guidelines as to how they would present their knowledge to their peers, and this was usually utilising the same methods across the groups. They listed particular types of communication styles that usually incorporated a type of technology: typed reports; posters; movies, using iMovie; performances; websites, using Wix; and more casual verbal opportunities to communicate. They also remarked that within these boundaries, that they felt safe to communicate, as their teachers had created an environment where students were not afraid to give answers that weren't quite correct.

The demand for presentation and communication skills in early-career jobs between 2012 and 2015 rose by 25% and 12% respectively (The Foundation for Young Australians, 2017). Additionally, The Foundation for Young Australians (2017) outlines that, when compared to similar earlier-career job advertisements, advertisements that specifically seek presentation skills pay $8853 more than those that do not. This reflects the essential nature of these skills, and the demand highlights scarcity within the industry (The Foundation for Young Australians, 2017).

Within the context of this research project, the respondents outlined that while they were given opportunities to collaborate and solve problems with their peers, their ability to verbally communicated was controlled in some way by their teacher. They also highlighted a range of opportunities to develop multiple forms of presentation and communication styles. The students appeared to be accepting of this, and enjoyed participating in a range of projects. It would be interesting to see how greater agency and choice for presenting would impact the skills of children within SLEs, and if given the choice, if students would present in a single style that they preferred each time, or if they would still choose to attempt a range of communication styles.

6.5.5 Key Finding 4 – Time

Time is a critical construct within every classroom, and the balance of ensuring the timely delivery of all mandated curriculum concepts, versus giving students additional opportunities to work on the same concept, is a dilemma for teachers.

Within the questionnaire, time was related to several items, including: *Q36: My teacher gives me enough time to finish STEM tasks, Q54: My teacher takes time to summarise what I learn each day*, and *Q81: STEM projects are a good use of time.* Within the semi-structured interviews, time was a theme that was discussed the least at only 7 times; however, it created an important picture that is relevant to classrooms. The students seemed to be genuinely confused about whether or not they were being presented with enough time to complete their tasks. They responded that they did spent quite a lot of time on their projects, but they could have really used more. They discussed the idea that no students actually got to finish their website, as they ran out of time.

Interestingly, one student identified that the projects were ‘spread out’ over weeks, as in the projects were being fit around other curriculum concepts.

They were interested in having projects like these confined to a day or two, rather than spreading them out over a term or part of a term. This is an interesting concept, and depending on the type of learning experience the students are having, could be an interesting concept to be considered by educators. While they would need to collapse regular time tables for the allocated project, it would mean that there would be less packing and resetting time to complete other areas of the curriculum around the project, potentially acting as a time saver. On the other hand, being engaged in the same task for long periods of time can be taxing on a student's ability to focus and be productive. Additionally, some students require consistency, and rely upon routines at school.

The final comment relating to time highlighted how this concept impacts all areas of STEM learning experiences. A respondent indicated that while they were given opportunities for trial and error, and frequently were able to trial multiple attempts, this was limited to the amount of time the project was given by the teacher, and if they hadn't solved their issue in this time frame, they weren't able to. Again, this is a regular issue within classrooms, as unlimited time cannot be allocated to a particular project when the mandatory curriculum must be implemented, but an interesting thought to consider regardless.

Time is an immense factor across schools and classrooms, and was an important theme that was drawn through the research. The students seemed aware of the limitations within this area, and while they were understanding, noted that it made them feel rushed. Within this context, the students were interested in projects which spanned days, rather than were broken up into shorter sessions over weeks.

a. What do students perceive to be their preferred STEM Learning Environment Characteristics?

Throughout the research, learning environments have been referred to as the psychosocial and emotional dimensions of a classroom, which can be identified from the perspective of an educator or a student. Through over four decades of research, Fraser (2012) proposed the importance of measuring the perceptions of students, who spend a significant amount of time in classrooms and can make comparisons between their experiences. While this field has been extensively researched, STEM Learning Environments (SLEs) are relatively new spaces where currently little research has been conducted (Fraser et al., 2020). Hackling et al., (2014) explain that attitudes towards STEM education will not change until primary aged students are immersed within quality learning environments.

Student perceptions have been the focus of this research project, as a child's view of their world is their reality. Murphy et al., (2019) define the term 'STEM disposition' as a student's attitudes and thoughts towards STEM achievement and career preferences. Findings suggest that attitude fluidity means that even after negative experiences with the STEM disciplines, that further positive experiences may reengage students with negative attitudes, and that this happening from an early age is integral (Murphy et al., 2019). This key finding relates specifically to ideas that the students had to improve their SLEs.

The data relating to this finding was predominantly collected within the semi-structured interview, and mostly related to the statement: *Describe a STEM learning environment that excites you.* The theme, which had a frequency of 26 items within the data, was broken into five sub-categories: *Hands-On, Environment, Choice, Technology* and *Peer Collaboration*.

Hands On related to any recommendations that the respondents had relating to learning being more of a physical experience. They shared a desire for more experiments and building opportunities, rather than always creating presentations. One student stated that being involved in that type of learning was more effective than, 'just like, watching videos or writing stuff down'.

A smaller sub-category was that of *Environment*, which relates to changes students would like within their physical environment. A range of areas that students could access for different motivations was discussed, such as lounge areas and gaming rooms. This is an interesting concept, as some schools utilise laboratory or Makerspaces to inspire, motivate and support their students. Going beyond the walls of the classroom, within this context students are seeking more flexible areas to utilise in ways that support the type of learning that they are undertaking, which is an interesting concept for schools.

The third sub-category was *Choice*, which outlined their preference for agency within their SLEs. One of the areas that the students were seeking further agency was with their choice of teams. While within the Peer Collaboration theme, they outlined a range of ways that they were grouped, and the reasons why their teacher did this, they still advocated for being able to choose who they would work it. Their justification was that you could work with people that you already know how they think, and the way that they work. Some positives for this is that students may be more receptive to taking risks, or may build on each other's ideas with more confidence. Additionally, they may perceive the task as more enjoyable if they are working with people that they have personally chosen. However, there are a number of negatives that are also important to consider when giving agency in this way. Firstly, some students may feel 'unwanted' when they are not sought out by their peers, causing feelings of isolation. Adding to this, if certain friends are left out, and others are included, it may cause issues within friendship groups. Students with lower maturity levels may also be more likely to team up with their friends, and this may lead to unproductive behaviours as they seek to just have 'fun' with each other. Furthering this, selecting people to work with doesn't necessarily reflect real-world realities, where you do not always get given an option of who you get to work with, and if you haven't had practice learning with a range of people, this may present as challenging. It is clear that within this particular SLE context, that the teachers measure and determine opportunities for this type of agency: sometimes it needs to be teacher choice, sometimes random, and other times students get the opportunity to select their teams.

Another element of choice within the student preferred SLE is curriculum-related. The respondents commented on having more options and opinions about the projects that they will be completing. They went as far as to talk about variety, and that if the teacher wants them to create a 'script' about something, that they should then be able to determine what it will be on. Furthering this, they stated that they wanted further integration of content within their projects, and if they wanted to bring in more humanities subjects into their science project, that they should be able to. The Organisation for Economic Co-operation and Development (OECD) (2019) outlines that student agency develops a child's capacity to reflect, act responsibly to create change, and to play active roles within their learning, which typically builds greater motivation to develop and learn. While agency needs to be negotiated to assure that schools are meeting the requirements of their teaching and learning, it is clear that within this context the students are seeking more options to pursue learning that is purposeful and relevant to their lives. A potential way to implement this is through teacher judgement: to know which students can act more autonomously, and to give additional support to those who need it during opportunities for choice. Providing students with the tools that they require to be successful is an aim of education, and learning environments that develop a child's ability to co-construct and evaluate the teaching and learning process are extremely valuable (OECD, 2019). It is interesting to consider more open-ended opportunities for students within SLEs to successfully determine appropriate learning choices and presentation styles, that fit within the requirements of their school curriculum, to both allow educators to achieve their targets and assess effectively, and for the students to have more of a say within their learning.

Another perceived preferred choice within the respondent's SLEs was the idea of having more access to technologies. They specifically listed Minecraft, Micro:bits, bee bots, and more opportunities for making and testing. Making connections between this preference and industry, the demand for digital literacy has risen 212% within early career jobs between 2012 and 2015, with jobs listing these skills paying an additional $8 648 on average per year (The Foundation for Young Australians, 2017). In 2015, ICT support and test engineers ranked 3rd for the most common occupations requesting digital literacy; with web developer listing 4th, and software and applications programmers listing 8th (The Foundation for Young Australians, 2017). Grant and Basye (2014) explain that the use of digital technologies allows students to have greater control and ownership over their learning; foster the growth of a large range of 21st Century skills; and improve engagement and autonomy. While resourcing these technologies can be a barrier for schools, the Government of Western Australia (2021) outlined within a budget report that $87.6 million is being used to upgrade school STEM facilities; 136 public schools are having classrooms upgraded into science laboratories for STEM education, including the provision of resources; and that an additional 282 primary schools will also receive grants to enhance their resourcing specific to these disciplines. Not only does this reflect the government's drive to advance our STEM narrative, but also provides some support for schools to implement this approach. The rising demand for these skills make them a critical component for the development of 21st Century capabilities, with the added bonus that they increase student engagement, and that they are perceived by students as an important element within their SLEs.

The final sub-category within preferred environments is *Peer Collaboration*, which specifically looks at student's preferences for working with their peers during STEM education. This is different from the theme Peer Collaboration, which is discussed in Section 6.5.2. It focuses more on *how* students prefer to work together. Within this sub-category, the respondents outlined that they would like to work among bigger learning spaces, where they have a larger variety of people to collaborate with, specifically including a mix of genders. This indicates a desire for the SLE to extend beyond the classroom, utilising larger available spaces and potentially networking with other classrooms, parents and community members, to expand the boundaries of who they are able to collaborate with. A positive that could come from implementing this type of change is further connections to real-world relevance through the use of experts beyond the school. Students would have the opportunity to engage with people directly who are working within relevant fields to potentially engage them with wanting to pursue STEM careers, or give them insights into job possibilities.

Students' perceptions of their SLEs are a valuable insight into quality practice and engagement. A focus on younger elementary student perspectives is a growing trend, and that challenges to motivation in upper-primary classrooms as an issue as this is possibly where students begin disengaging with the STEM disciplines (Wiebe et al., 2018). Positive self-perceptions within these environments are crucial to building engagement with STEM (Murphy et al., 2019). Taking into consideration the perspectives of the students within their learning environments will attempt to improve their perceptions of these learning areas, and hopefully continue to build momentum for our STEM workforce and the future of Australia's economic success.

6.6 Summary and Overall Discussion of Research Findings

Overall, the respondents within this context indicated that their SLE was a positive environment, and that they were experiencing high quality STEM education. This was evident within their responses to the questionnaires, the semi-structured interviews, and their attitudes towards STEM education. They were also able to articulate a range of perceived preferred environmental factors and teacher interpersonal behaviours that may potentially improve their SLE from their perspective.

One of the key findings outlined that greater freedom for consultation with curriculum and presentation styles would be preferred, however; strong behavioural control by the teacher was still highly preferred. They also discussed having more autonomy to select who they were able to work with, and showed preference for consulting their peers first, before approaching their teacher. While this was the preferred approach, they were also be able to describe why, at times, it was important that their teacher selected who they worked with. The respondents also outlined problem solving as a preferred environmental factor within their SLE. They described this approach to be well-balanced, so that they were challenged enough to be motivated, but knew that they could approach their teacher to discuss solutions if necessary. They were also motivated by having opportunities to trial a range of solutions to problems, and being given opportunities to 'fail upwards' until they found a way succeed. The respondents also noted within their learning environments, that at times, their teacher would control the amount of communication they had with their peers. This comment was interesting, based upon the other collaborative factors that the students described, however; they highlighted that they wanted more opportunities to communicate freely, as this was a part of the communication and problem-solving process. Furthering this, they described seeking different ways of communicating the knowledge that they had developed, linking in with further freedom in their comments about selected presentation formats. Furthering this, the students acknowledged that time could be an issue within SLEs, and even though they had opportunities to trial different approaches to problem-solving, they didn't always get to complete their projects due to time constraints.

Additionally, the students were asked specifically what their ideal preferred SLE would incorporate. They outlined a range of conditions that they perceived to be the preferred SLE for STEM education. Firstly, students were seeking more opportunities to complete hands on projects and experiments. They also outlined an interest in having different and flexible spaces around the school for different types of working scenarios, such as Makerspaces, laboratories, and comfortable rooms for collaboration. Additionally, they reiterated their desire to have more choice in their collaboration partnerships, curriculum and presentation formats. This was something that the students indicated frequently within the data, across the different interview groups. Another perceived preferred condition was the use of more technologies, such as Minecraft, bee bots and Micro:bits. Each of these ideas were discussed as 'even better ifs', and were all interesting additions to the picture that the students were creating through the data.

Within the Emotions scales, there were not many significant differences between the genders. Only Control and Motivation were scales reported at having significance at $p < 0.01$, with females reporting higher values within their SLEs. While the females reported higher values across most of the Emotions scales, the males actually indicated a slightly more positive attitude to STEM education, which is an interesting result. The Attitudes scale reported no significant differences between the genders, and the Teacher-Student

Interactions reported only Leadership and Student Responsibility/Freedom as being significant at $p < 0.05$.

it is clear that the Emotions, Attitudes and Teacher-Student Interactions scales have had a positive impact on the respondents' attitudes towards STEM, which was theorised in Figure 1.1. There were many positive contributing factors within the learning environment and the relationships with their teachers that improved their perception of their SLEs within this particular context which have been highlighted through the reported data.

6.7 Chapter Summary

This chapter presented the discussion that combined the quantitative and qualitative results from the questionnaire and semi-structured focus groups within the context of the literature review. It outlined each of the key findings that emerged through the research, including possible further applications of these concepts. These findings also included the perceived preferred SLEs from the perspectives of the respondents, and ideas for potentially improving STEM education within the context of this study. Additionally, the findings for each of the research questions were presented from the results of the data. Finally, an overall summary and discussion was presented.

The next chapter will include the conclusions of the research, including a summary of the research findings; the limitations of the study; potential applications of the study for educators; and a final conclusion.

Chapter 7: Conclusions

7.1 Introduction

This chapter will include the final conclusions and summaries as presented in the previous chapters. It will outline a final summary of the research findings, discuss the limitations of the study, and present further applications of the study for educators. Finally, the chapter will finish with an overall conclusion to the study.

7.2 Summary of Research Findings

This project sought to determine ways that students' perceptions of their STEM Learning Environment and their interactions with their teacher impacted their attitude towards STEM education. Through the use of a quantitative questionnaire, and qualitative semi-structured interviews, this project collected the perspectives of 100 Year 5 students within an independent private school north of Perth, Western Australia. IBM SPSS Statistics Management software was used with the quantitative data to determine correlations between student perceptions of their learning environment, and their indication of their motivation to pursue further STEM education. Thematic analysis was applied to the qualitative data to develop themes, and create a more holistic picture of from the perspective of the respondent within their SLE.

The quantitative data showed that students had relatively high positive perceptions of their SLEs, STEM education, and their interactions with their teacher. There were minimal differences between the perceptions of male and female participants, and only a few scales were indicated as being significant. The mean average for both genders for Attitude to STEM was reported as being over 4 out of a possible 5. There were also minimal differences between the classrooms, which may result from the teachers working collaboratively to implement their projects.

The qualitative data created a more detailed picture, where the students outlined their thoughts and feelings about their current experiences, and how this impacted their attitude towards STEM, including Student Freedom, Peer Collaboration, Problem Solving, Communication, Time and STEM Learning. These findings were categorised again into a number of sub-headings, which are outlined in Table 5.3. Additionally, they outlined a range of perceived preferred environmental factors, such as Hands On Learning, Physical Environment, Choice, Technology and Peer Collaboration.

7.3 Contributions of the Study

This study has made contributions to the field of learning environment research, specifically within the context of STEM Learning Environments in upper-primary classrooms. Due to enrolments and performance within Australian STEM education declining (Timms et al., 2018), it is imperative that research continues to determine how to reverse this trend. As students determine their career trajectories at an early age, the importance of quality STEM education within upper-primary classrooms is essential (Tytler et al., 2008). This study has aspired to play a small part in seeking how learning environment research, and teacher-student interactions may impact student attitude towards STEM education, and to further seek perceived preferred perceptions of what they believe will create further engagement within these contexts.

7.4 Limitations of the Study

The researcher acknowledges that there are limitations to this study. One of the limitations of this study is the sample size used for this research project, and the use of a single context. Additionally, there are further limitations around the use of the questionnaire instrument, which are discussed in greater detail below.

7.4.1 Case Study

Case studies have the capacity to provide unique examples of the perceptions of humans within real life situations, and can create a clear picture that goes beyond theories or principles (Cohen et al., 2018). They also present more unique features that may get lost within large data samples (Cohen et al., 2018); however, there are also limitations to case studies. Firstly, results may not always be generalisable, and can be subjective (Cohen et al., 2018). As recommended by Punch and Oancea (2014), explicit boundaries of the research project were developed through the use of research questions to ensure a focus for the data collection. Additionally, a focus on similarities between environments was also a focus, as Punch and Oancea (2014) outline how this allows for more connections between similar contexts. As there are many similarities between educational environments, the results have some generalisability to other contexts, as long as the user reflects on the limitations.

7.4.2 Sample

One of the key limitations of this study is the sample size and context. While it is an appropriate size for the scope of this case study, there are limitations that need to be considered when applying the results of this research to other contexts. The larger the sample, the higher the level of precision that is attainable within a study. Furthering the sample size limitation, the use of a single school creates a specific context for within which the data is applicable. It is important to consider this when considering the findings within other contexts, including rural, lower socioeconomic status, single gender and government schools. Further studies within the upper-primary school age across a range of contexts would assist in the development of further data creating a larger representation of the population. Due to the case study nature of this research project, the findings from the data are contextualised to the sample and care should be taken when applying them to differing contexts.

Limitations were also placed on the time allocated with the respondents due to COVID-19 and the strain this placed upon educational institutions with time and outside organisation visitations. The semi-structured interviews were only able to be conducted on one particular day, as was agreed upon by the teaching staff, as to not interrupt further learning time. Due to the students being at home for a significant proportion of the year during online learning, the teachers felt under pressure to address the curriculum gaps that had developed and therefore felt under too much strain to lose additional teaching time.

7.4.3 Instrument

Another limitation is the instrument, which, while being developed through extensive testing by experts of the learning environment field, would benefit from further validation to determine if reductions to items within scales are applicable due to its length. Additionally, a range of reading levels are expected across primary-aged classrooms, and therefore students may misinterpret questions. While the researcher put in measures to prevent this, including reading each item to the participants and accepting questions if students had them, it is still difficult to determine if those measures were 100% effective for all students within the study.

Further limitations exist around the nature of the questionnaire. Responses may be altered due to student concern over the sensitivity of items, and the trust that their teachers will not have access to the results. They may also want to please their teacher, and give responses that they think would make their teacher happy. Trust was difficult to build as the focus of this project was to minimise disruptions to the class. The researcher spent a short amount of time prior to the students answering the questions explaining the project, discussing their own Year 5 classroom to create positive connections, and outlining how their responses would be kept private.

7.5 Application of the Study for Educators

While it is very important to consider the limitations of this research project, and to consider the context of the study, several applications can be drawn for educators. As integrated STEM education continues to be a focus for international governments and education systems, quality practice should be a focus for schools.

Therefore, this researcher recommends the use of student perceptions as a way of measuring quality STEM education, which could be used to provide essential information to educators about their strengths and areas for development. This data could inform future professional development to support educators through their journey with STEM education, to develop further abilities, confidence and positive attitudes towards these disciplines and teaching pedagogies.

7.5.1 Integrated STEM Education

Nadelson and Seifert (2017) explain that integrated STEM education should be the amalgamation of concepts and content from the separate disciplines, where real-world problems are presented, through which students can practice their knowledge and skills. It is through this style of education that students have the opportunity to experience learning that extends beyond the classroom, and gives opportunities to connect authentically with real-world applications and industry professionals (Rosicka, 2016; Timms et al., 2018). It is also then through these experiences that students develop 21st Century competencies that are essential to their careers, and Australia's economic success (Honey et al., 2014; Marginson et al., 2013; Nadelson & Seifert, 2017; Timms et al., 2018).

One of the findings from the data was that the respondents were seeking more opportunities to naturally integrate content where they believed it connected to other areas of the curriculum. It is interesting to consider that, within this context, primary-aged children are seeking to make these connections within their learning, and that they believe further integration is reflective of an effective SLE. Additionally, the respondents discussed at length how they preferred to solve integrated problems with their peers, and that opportunities to complete this with others gave them additional perspectives to come up with solutions to issues.

Educators may consider how they may be implementing their STEM education within their SLE, and if it meets the criteria of integrated practice that develops 21^{st} Century competencies. This researcher is not suggesting that the separate disciplines of STEM should always be taught through integration, rather that this pedagogical approach can be utilised to form real-world problems where the students can bring together their explicit knowledge and skills to solve problems authentically.

7.5.2 Preferred STEM Learning Environments

A child's perception is their reality, and therefore taking into consideration their thoughts and feelings is an important way of determining the effectiveness of a learning environment. The use of questionnaires for determining the perceptions of students within their learning environments is common practice within research, and a large number of extensively validated questionnaires which measure these perceptions are available (Fraser, 2012). Educators may consider how they would be able to reflect on these methods to capture the perceptions of the students within their own SLEs, as to consider their perceived preferred environments to aim towards positive attitudes to STEM education. While taking into consideration, the perceived preferred environments from this study could be beneficial, dependent on school context. Furthering this, educators may wish to consider how they can seek these ideas from their own students.

7.5.3 Student Freedom/Responsibility

The key findings from this case study could be considered within other SLEs based on student perceptions. Firstly, considerations about behavioural control within SLEs could be identified, as often students are given greater amounts of behavioural freedom during STEM education than traditional explicit learning. Potentially, educators should consider which behavioural freedoms add to the productivity of the learning, and which actually create negative conditions within SLEs. Boundaries could be set for, or with, students, to ensure that they still feel adequately supported and managed to be successful within their environment. Additional to this, considerations could be made about choice within the SLEs, where students have greater opportunity to integrate content, define specific content within a scope to research or solve problems within, and/or be able to select their methods of communicating their findings. This could be as structured as a ‘menu’, where students select options from a pre-determined list, or less structured where they negotiate their presentation styles with their teacher.

7.5.4 Opportunities for Authentic Failure

One of the key findings from the data was the way that students viewed problem solving, and the opportunities they were given to trial a range of solutions to an issue. They highlighted an essential balance that the teachers had developed within their SLEs. Firstly, the students were given opportunities to interact with problems that had real-world contexts. This allowed them to see connections between their learning, and possibilities that could be relevant to industry. Furthering this, the authenticity created motivation as the problems were actually relatable to the students. Secondly, the problems were difficult enough that the students needed to trial several solutions, and simply did not find the correct answer the first time. While this may create a sense of frustration in children, it was evident that several systems were in place to ensure that this frustration turned to motivation, and became productivity.

One of these systems was the use of collaboration between the students, even between groups of students that weren’t working together. They outlined the many opportunities that they had to interact with their peers to try and find solutions prior to needing help from an adult. Teacher support was another stage of this system however; students explained that they could always discuss their ideas with their teacher, and that they would give them a ‘push in the right direction’. This is an important detail. The teachers didn’t simply give them the answer, but supported them towards the solution. These factors within the learning environment supported these students to experience a very authentic failure in a safe environment where they were not afraid to get things wrong.

Rosicka (2016) highlights the importance of children being given opportunities to experience authentic failure, as this teaches them the essential concept of reflection, leading to growth mindset approaches to solving problems. Immersing students within this type of learning also develops a range of critical 21st Century skills, including some of the key competencies as explained by the World Economic Forum (2020), such as: Complex Problem-Solving; Critical Thinking and Analysis; Reasoning, Problem-Solving and Ideation; and Troubleshooting and User Experience. Educators may wish to consider how their use of authentic problems is positioning their students to work collaboratively to develop these essential competencies, and ways that they could create further connections to real-world experiences and industry.

7.6 Recommendations for Further Research

This study contributes to the field of Learning Environment research, within the specific context of STEM Learning Environments in upper-primary aged classrooms, indicating its specific and limited nature. From a reflection on the findings, the researcher recommends that further research be conducted to develop a larger sample size from a range of contexts. This would include seeking schools from the independent private, private, and public sectors; across a range of socio-economic contexts; and in rural and metropolitan settings to determine how these factors impact upon the SLE's capacity to impact student attitude towards STEM education.

The researcher also recommends for further research to seek the perceived preferred perceptions of primary-aged students within SLEs of varying contexts, to determine characteristics which may improve the quality of these environments, and potentially raise the engagement and achievement of students studying STEM education. While little difference was indicated between genders within this study, further insight into potential differences between male and female perceptions beyond this context may also enrich the quality and impact of STEM Learning Environments.

7.7 Conclusion

This final chapter provided a summary of the thesis, and outlined a summary of the key findings. The contributions of the study were also outlined, explaining where this project sat within the gap in the literature. Limitations of the study were then identified, along with a range of potential applications of the findings for educators. Finally, suggestions were made for future research.

This thesis has provided new information about how STEM Learning Environments and interactions with teachers impact upper-primary student perceptions of STEM education. It has demonstrated correlations between positive SLEs, positive teacher-student relationships, and positive attitudes to STEM education, as theorised. Finally, this study has also sought out the perceived preferred perceptions of a STEM learning environment from the respondents, and outlined several findings for how these students believe they could be further engaged within their environments.

It is important to note, reflecting on the limitations, that this study has reflected the views of a small population of students, and therefore, while their perspectives are valuable, it does not suggest that all students would echo these perspectives. Every school and every classroom teaches very different individuals, and therefore it would be astute for educators to discover the preferences within their own classrooms to make decisions about their SLEs. It has been the aspiration of this research project to play a small part in determining what is reflective of a quality SLE, and how we can best engage our students to immerse themselves positively within STEM learning contexts, and hopefully pursue passionate and successful careers within these fields.

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Appendix A

Questionnaire on Classroom Emotional Climate

The following questionnaire asks for your view of Classroom Emotional Climate.

The questionnaire has 103 sentences about how you feel in this class, particularly when you do STEM (Solutions Fluency) projects. Examples of STEM projects are: building solar cars, planning a project to solve a pollution problem, designing a computer program to solve a problem, designing a new product, robotics or other projects you might have done.

What STEM (Solutions Fluency) project are you doing currently (or have you just completed)?

How many hours per week do you think you do STEM (Solutions Fluency) projects?_________________

Do you identify as a male or female? (circle one)

As you complete this questionnaire, think about your experience in the classroom as you did this STEM (Solutions Fluency) project.

For each sentence, circle the number corresponding to how often you feel that something happens. For example:

	Almost Never		Sometimes		Almost Always
I like the way the teacher treats me when I need help.	1	2	3	4	5

If you **almost always** like the way your teacher treats you when you ask for help**, circle the 5.** If you **almost never** like the way they treat you when you ask for help, **circle the 1**. You also can choose the numbers 2, 3 and 4 which are in between. If you want to change your answer, cross it out and circle a new number. Thank you for your cooperation.

Name: __________________________ Date: ____________________

Room Number: ___________________ Teacher: _________________

CARE **In this class:**		Never				Always
1	I like the way my teacher treats me when I need help.	1	2	3	4	5
2	My teacher is nice to me when I ask questions.	1	2	3	4	5
3	My teacher makes me feel that s/he really cares about me.	1	2	3	4	5
4	My teacher helps me if I am confused.	1	2	3	4	5
5	My teacher encourages me to do my best.	1	2	3	4	5
6	My teacher seems to know if something is bothering me.	1	2	3	4	5
7	My teacher gives me time to explain my ideas.	1	2	3	4	5
8	My teacher tries to understand how I feel.	1	2	3	4	5
9	My teacher makes me feel safe to try new things.	1	2	3	4	5
10	My teacher treats me with respect.	1	2	3	4	5
CONTROL In this class:		Never				Always
11	I behave well when the teacher is explaining things to the class.	1	2	3	4	5
12	I behave well when working in small groups.	1	2	3	4	5
13	My teacher controls my behaviour without raising his/her voice.	1	2	3	4	5
14	I behave the way my teacher wants me to.	1	2	3	4	5
15	I treat the teacher with respect.	1	2	3	4	5
16	My teacher makes sure that I stay busy and don't waste time.	1	2	3	4	5
17	My teacher acknowledges my good behaviour.	1	2	3	4	5
18	My teacher makes sure that I contribute to the group project.	1	2	3	4	5
CLARITY During STEM projects in this class:		Never				Always
19	My teacher breaks up the work into easy steps for me.	1	2	3	4	5
20	My teacher explains difficult things to me clearly.	1	2	3	4	5
21	I understand what I am supposed to be learning.	1	2	3	4	5
22	My teacher knows when I understand and when I do not.	1	2	3	4	5
23	My teacher shows me how to find project materials around the classroom.	1	2	3	4	5
24	If I don't understand something, my teacher explains it another way.	1	2	3	4	5
25	My teacher checks I understand my learning goals.	1	2	3	4	5
26	My teacher uses a variety of teaching methods to make things clear to me.	1	2	3	4	5
27	I know what I should be doing and learning.	1	2	3	4	5
CHALLENGE During STEM projects:		Never				Always
28	My teacher asks questions that make me think hard.	1	2	3	4	5
29	My teacher helps me find challenging STEM projects	1	2	3	4	5
30	My teacher accepts nothing less than my full effort.	1	2	3	4	5
31	My teacher encourages me to keep going when the work is hard.	1	2	3	4	5
32	My teacher wants me to use my thinking skills, not just memorise things.	1	2	3	4	5

33	My teacher asks me to explain answers I give –why I think what I think.	1	2	3	4	5
34	I learn a lot every lesson.	1	2	3	4	5
35	I'm encouraged to correct my mistakes.	1	2	3	4	5
36	My teacher gives me enough time to finish STEM tasks	1	2	3	4	5
MOTIVATION During STEM projects:		Never				Always
37	I stay focused in this class.	1	2	3	4	5
38	My teacher makes my learning enjoyable.	1	2	3	4	5
39	My teacher makes my lessons interesting.	1	2	3	4	5
40	I like the ways I learn.	1	2	3	4	5
41	The questions in this class make me want to find out the answers.	1	2	3	4	5
42	My project makes me want to learn.	1	2	3	4	5
43	My project is interesting.	1	2	3	4	5
44	My project is enjoyable.	1	2	3	4	5
45	How the classroom looks makes me motivated.	1	2	3	4	5
CONSULTATION During STEM projects in this class:		Never				Always
46	My teacher asks me whether I understand.	1	2	3	4	5
47	My teacher asks me questions whether I put up my hand or not.	1	2	3	4	5
48	I feel comfortable asking my teacher for help.	1	2	3	4	5
49	My teacher tells me what I am learning and why.	1	2	3	4	5
50	My teacher wants me to share my thoughts.	1	2	3	4	5
51	I speak up and share my ideas about the class work.	1	2	3	4	5
52	I work together with my peers to solve problems.	1	2	3	4	5
53	My teacher gives me options about the tasks I complete.	1	2	3	4	5
CONSOLIDATION During STEM projects in this class:		Never				Always
54	My teacher takes time to summarise what I learn each day.	1	2	3	4	5
55	My teacher checks to make sure I understand what s/he is teaching.	1	2	3	4	5
56	I get helpful comments to let me know what I did wrong on assignments.	1	2	3	4	5
57	The comments that I get on my work help me understand how to improve.	1	2	3	4	5
58	My teacher speaks to me in class about how to improve.	1	2	3	4	5
59	My teacher reminds me of what we learned earlier.	1	2	3	4	5
60	My teacher points me in the right direction to get further help.	1	2	3	4	5
61	My teacher gives me feedback on the work I do.	1	2	3	4	5
62	My teacher shows me how to do difficult problems on the board.	1	2	3	4	5
63	I receive feedback from peers about my project.	1	2	3	4	5
64	I ask the teacher for help.	1	2	3	4	5
65	I evaluate my own work.	1	2	3	4	5

COLLABORATION		Never				Always
66	I cooperate with other students in my group when doing STEM projects.	1	2	3	4	5
67	When I work in a group doing a STEM project, I work as a team.	1	2	3	4	5
68	I work with other students on STEM projects in this class.	1	2	3	4	5
69	I learn from other students in my STEM group.	1	2	3	4	5
70	Students in my group work with me to reach the goals of our STEM project.	1	2	3	4	5
71	I work well with other group members when doing STEM projects.	1	2	3	4	5
72	I help other group members who are having trouble doing STEM projects.	1	2	3	4	5
73	I ask for help from other students.	1	2	3	4	5
74	I sort out our disagreements about the project within our group.	1	2	3	4	5
ATTITUDE TO STEM		Never				Always
75	I look forward to STEM projects	1	2	3	4	5
76	STEM projects are fun.	1	2	3	4	5
77	I like doing STEM projects.	1	2	3	4	5
78	STEM projects are exciting.	1	2	3	4	5
79	Subjects that are related to STEM are some of the most interesting ones.	1	2	3	4	5
80	I enjoy lessons that are part of STEM projects.	1	2	3	4	5
81	STEM projects are a good use of time.	1	2	3	4	5
82	These lessons make me interested in studying a STEM subject in the future.	1	2	3	4	5
83	I would choose to do this STEM subject even if I didn't have to	1	2	3	4	5
84	I feel confident about doing STEM projects in class.	1	2	3	4	5
The following questions are about teacher-student interactions in your class. They ask you to consider what you think about the teacher you had/have while doing the STEM project you identified before.						
TEACHER-STUDENT INTERACTIONS		Never				Always
85	This teacher is a good leader	1	2	3	4	5
86	This teacher acts confidently	1	2	3	4	5
87	This teacher is respected	1	2	3	4	5
88	This teacher holds our attention	1	2	3	4	5
89	This teacher is someone you can depend on	1	2	3	4	5
90	This teacher has a sense of humour	1	2	3	4	5
91	This teacher’s class is pleasant	1	2	3	4	5
92	This teacher can take a joke	1	2	3	4	5
93	This teacher is reliable	1	2	3	4	5
94	This teacher is patient	1	2	3	4	5
95	This teacher is understanding	1	2	3	4	5
96	This teacher is easy-going	1	2	3	4	5

97	This teacher is willing to clarify things	1	2	3	4	5
98	This teacher listens to students	1	2	3	4	5
99	This teacher lets students fool around in class	1	2	3	4	5
100	This teacher lets students get away with a lot	1	2	3	4	5
101	This teacher tolerates a lot of student behaviour	1	2	3	4	5
102	This teacher can be influenced by us	1	2	3	4	5

103. Is there anything else that you would like to share with us about your STEM (Solutions Fluency) experience?

Appendix B

Semi-Structured Focus Group Questions

1. STEM involves innovation. What does your teacher do when you ask to try something new to solve a problem?

2. STEM involves collaboration. How much freedom do you feel your teacher gives you when forming learning groups?

3. STEM involves problem-solving. What does your teacher do when you encounter a problem that frustrates you?

4. a. STEM involves trial and error. How does your teacher make you feel when your idea doesn't work?
   b. How many opportunities do you get to test another idea?

5. STEM involves communication. How does your teacher make you feel when you present your ideas?

Describe a STEM learning environment that excites you.