

**Primary Teachers' Knowledge of Inquiry-Based Learning  
and Learner Autonomy in Science**

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## **Dedication**

This thesis is dedicated to the people who have supported my education throughout  
my life.

Thank you for your unending support!

## Abstract

Primary Teachers hold the key to the development of the complex raft of knowledge, skills, and attitudes for a scientifically literate community when they facilitate learning in science. That makes these teachers crucial for contemporary society in the Industrial Revolution 4.0, especially due to the declining interest and enrolments in STEM-related courses and the declining performance in science in international tests in Australia.

Inquiry-based learning (IBL) has become synonymous with primary science education, but the reality for students of teacher facilitation of IBL in primary science classrooms is under-researched. This thesis addresses this gap by providing and analysing rich classroom stories of student engagement with teacher-facilitated IBL. It therefore presents knowledge of teacher beliefs, understandings and practices around IBL, and the evident outcomes for students including the skills and extent of autonomy that they develop through IBL. This focus addresses a gap in the literature linking IBL and learner autonomy (LA), especially the link between IBL, learner autonomy supported, and learner autonomy demonstrated.

Building on a social constructivist paradigm, this qualitative multiple case study investigated learner autonomy demonstrated (LAD) in IBL in a science classroom in a metropolitan Catholic school in Adelaide. The data were gathered through participant observations and interviews involving two teachers of the same Year 4 students on different days of the week. The rich observation data was transformed into research vignettes depicting classroom interactions, and three vignettes were selected to epitomise each teacher's approach to IBL. The vignettes and interviews were probed using qualitative content analysis.

There was a complex relationship between teacher knowledge of IBL and the nature of IBL facilitated in science classrooms. Additionally, teachers facilitated structured and guided inquiry which constrained the nature of learner autonomy demonstrated (LAD) by students. Students demonstrated a lower level of autonomy, called *compliant autonomy*, despite active engagement in learning activities. Principal factors that promoted *compliant autonomy*

included teacher utilisation of directives/hints which students complied with, teacher-prescribed instructions, and teacher-limited knowledge of IBL and LA. The study found, however, that LAD was fluid and non-linear in nature. These findings show that LAD emerges, plateaus or submerges due to the interaction between students and the teacher's instruction, peers, and learning tasks.

The findings are significant as they illuminate the impact of teacher IBL knowledge on the nature of IBL and learner autonomy supported and learner autonomy demonstrated. The findings illuminate a complex system of teacher knowledge of IBL and LA, how they relate to IBL and LA facilitated by teachers, and learner autonomy demonstrated by students. The ways the two teachers facilitated student learning autonomy influenced how the same students engaged at varying levels in IBL. These findings are therefore significant for pre-service and in-service teachers of science.

## **Declaration of Originality**

I, Nemwel Aming'a, certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint award of this degree.

I give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library Search and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

I acknowledge the support I have received for my research through the provision of an Australian Government Research Training Program Scholarship.

Signature

Nemwel Aming'a

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# Table of Contents

Dedication .....	ii
Abstract .....	iii
Declaration of Originality .....	v
Acknowledgements .....	vi
Table of Contents .....	vii
List of Tables .....	xiv
List of Figures .....	xv
List of Abbreviations and Acronyms .....	xvi
Chapter 1 Introduction .....	1
1.1 Background to the Study .....	1
1.1.1 Australian Curriculum .....	2
1.1.2 Inquiry-Based Learning .....	2
1.1.3 Primary Connections .....	3
1.1.4 Declining Interest, Enrolment and Engagement in Science Learning .....	4
1.1.5 IBL in the Classroom .....	4
1.1.6 Learner Autonomy .....	5
1.2 Research Questions .....	7
1.2.1 Research Questions .....	7
1.2.2 Research Objectives .....	7
1.3 Significance of the Study .....	8
1.4 Key Concepts in the Study .....	9
1.5 Methodology .....	12
1.6 Reflexivity .....	13
1.9 Organization of Thesis .....	14

1.10 Conclusion .....	15
Chapter 2 Literature Review .....	17
2.1 Theoretical Framework .....	17
2.1.1 Constructivist theory .....	17
2.1.2 Constructivist Theory and IBL.....	20
2.1.3 Social Constructivism .....	21
2.1.4 Current Education Situation .....	22
2.2 Historical Development of Inquiry .....	22
2.2.1 Learning Cycle .....	22
2.2.2 Scientific Inquiry.....	23
2.3 Meaning of Inquiry.....	24
2.3.1 Alternative Definitions of Inquiry.....	25
2.4 IBL Models .....	26
2.5 Teacher Knowledge of Inquiry-Based Learning.....	27
2.5.1 Teachers' Understandings and Beliefs of IBL.....	27
2.5.2 Science Teachers' Knowledge of IBL .....	28
2.6 Nature of Inquiry-Based Learning .....	32
2.6.1 Structured Inquiry .....	32
2.6.2 Guided Inquiry .....	32
2.6.3 Open Inquiry .....	33
2.6.4 Review of Past Studies on Nature of IBL .....	33
2.7 Learner Autonomy .....	36
2.7.1 Definitions of LA .....	37
2.7.2 Benefits of LA.....	40
2.7.3 Misconceptions of LA.....	41
2.7.4 Role of Learner in LA .....	42
2.7.5 Role of the Teacher in LA.....	43
2.8 Teacher Autonomy Supportive Practices.....	44

2.9	Learner Autonomy Demonstrated .....	47
2.10	Relationship between IBL and LA .....	48
2.11	Contextual Factors .....	50
2.12	Conceptual Framework.....	51
Chapter 3	Research Design .....	53
3.1	Research Approach .....	53
3.1.1	Qualitative Case Study Design.....	53
3.2	Research Design.....	55
3.2.1	Case Study and Cross-Case Analysis Designs.....	56
3.2.2	Case Selection .....	56
3.2.3	Participant Selection.....	58
3.3	Data Collection.....	59
3.3.1	Participant Observations .....	59
3.3.2	Semi-Structured Interviews.....	62
3.4	Data Analysis .....	64
3.4.1	Qualitative Content Analysis .....	64
3.4.2	Interview Data Analysis Process.....	66
3.4.3	Observation Data Analysis Process.....	68
3.5	Rigour of Qualitative Research .....	71
3.5.1	Credibility.....	72
3.5.2	Transferability .....	74
3.5.3	Dependability .....	74
3.5.4	Confirmability .....	75
3.6	Ethical Considerations.....	76
3.6.1	Level of Risk .....	76
3.6.2	Measures to Minimise Risks .....	77
3.6.3	Confidentiality.....	77
3.6.4	Storage of Information .....	78

3.7	Limitations of the Study .....	78
3.8	Delimitations of the study .....	79
3.9	Conclusion.....	80
Chapter 4 Mrs Jasmine’s Inquiry-Based Learning Practices .....		82
4.1	Context .....	82
4.1.1	Mrs. Jasmines’ Educational and Teaching Background .....	82
4.1.2	Classroom Culture.....	83
4.1.3	Science Topics.....	83
4.2	Knowledge of Inquiry-Based Learning.....	84
4.2.1	Meaning of Inquiry-Based Learning .....	84
4.2.2	Teacher Role in IBL Lesson.....	86
4.2.3	Student Role in IBL Lessons.....	87
4.2.4	Role of Assessment in IBL Lessons.....	88
4.3	Teacher Knowledge of Learner Autonomy.....	89
4.3.1	Meaning of LA .....	89
4.3.2	Teacher Role in Promoting LA .....	90
4.3.3	Student Role in LA.....	92
4.3.4	Importance of LA in Science Learning .....	92
4.3.5	Factors Influencing Promotion of LA .....	93
4.4	Mrs Jasmine’s Research Vignettes.....	95
4.4.1	Teacher Autonomy Supportive Practices .....	110
4.4.2	Nature of Inquiry-Based Learning .....	126
4.5	Chapter Summary.....	138
Chapter 5 Mr Smith’s Inquiry-Based Learning Practices .....		140
5.1	Context .....	140
5.1.1	Mr. Smith’s Educational and Teaching Background .....	140
5.1.2	Classroom Culture.....	140
5.1.3	Science Topics.....	141

5.2	Knowledge about Inquiry-Based Learning .....	141
5.2.1	Meaning of Inquiry-Based Learning .....	142
5.2.2	Teacher Role in IBL Lesson.....	143
5.2.3	Student Role in IBL Lesson .....	144
5.2.4	Role of Assessment in IBL Lesson .....	145
5.3	Teacher Knowledge of Learner Autonomy.....	146
5.3.1	Meaning of LA .....	146
5.3.2	Teacher Role in Promoting LA .....	147
5.3.3	Student Role in LA.....	149
5.3.4	Importance of LA in Science Learning .....	150
5.3.5	Factors Influencing Promotion of LA .....	151
5.4	Mr Smith’s Research Vignettes.....	153
5.4.1	Teacher Autonomy Supportive Practices .....	169
5.4.2	Nature of Inquiry-Based Learning .....	183
5.5	Chapter Summary.....	195
Chapter 6	Cross-Case Analysis and Discussion.....	197
6.1	Context.....	200
6.1.1	Teacher Context .....	200
6.1.2	Classroom Context .....	201
6.1.3	Science Topics.....	203
6.1.4	Discussion on Context.....	204
6.2	Teacher Knowledge of Inquiry-Based Learning .....	205
6.2.1	Meaning of IBL.....	205
6.2.2	Teacher Role in IBL.....	206
6.2.3	Student Role in IBL.....	207
6.2.4	Role of Assessment in IBL.....	207
6.2.5	Discussion on Teacher Knowledge of IBL .....	207
6.3	Teacher Knowledge of LA .....	209
6.3.1	Meaning of LA .....	209

6.3.2	Teacher Role in Promoting LA .....	210
6.3.3	Student Role in LA.....	210
6.3.4	Importance of LA in Science Learning .....	210
6.3.5	Factors Influencing the Promotion of Learner Autonomy .....	211
6.3.6	Discussion on Teacher Knowledge of LA .....	212
6.4	Teacher Autonomy Supportive Practices .....	213
6.4.1	Organizational Autonomy Support .....	213
6.4.2	Procedural Autonomy Support.....	217
6.4.3	Cognitive Autonomy Support .....	221
6.4.4	Discussion on LAS and LAD.....	229
6.5	Nature of Inquiry-Based Learning .....	234
6.5.1	Embark and Clarify .....	234
6.5.2	Find and Generate .....	237
6.5.3	Evaluate and Reflect.....	238
6.5.4	Organise and Manage.....	241
6.5.5	Analyse and Synthesis.....	242
6.5.6	Communicate and Apply.....	244
6.6	Discussion on the Nature of IBL.....	246
6.6.1	Inquiry-Based Learning and Explicit Instruction (Complementary Teaching Approaches) .....	246
6.6.2	Relationship between Hands-On Inquiry Activities and Conceptual Understanding.....	251
6.6.3	Literacy (Free) Science Lessons: Complementary Teaching.....	253
6.6.4	Learner Autonomy Supported, Nature of IBL and Student Interest .....	254
6.6.5	ICT integration in teaching .....	255
6.7	Conclusion.....	257
Chapter 7	Conclusion .....	259
7.1	Summary of the Research .....	259
7.2	Contributions.....	262
7.3	Implications.....	265

7.4 Recommendations for Future Research .....	267
References .....	270
Appendices .....	290
Appendix A: Teacher Interview .....	291
Appendix B: Ethics Approval .....	293
Appendix C: CESA Approval .....	294
Appendix D: School recruitment email .....	295
Appendix E: Teacher Interview-Observation Participant Information Sheet .....	296
Appendix F: Teacher interview-classroom observation consent form .....	299
Appendix G: Parent/guardian-student participant information sheet .....	301
Appendix H: Student consent form .....	304
Appendix I: Parent/guardian consent form .....	306

## **List of Tables**

Table 3.1 Characteristics of case studies for this study .....	56
Table 3.2 Research Vignettes .....	61
Table 3.3 Research Objectives and Data Collection Methods.....	64
Table 3.4 <i>Analytical framework for science teachers' knowledge of IBL</i> .....	67
Table 3.5 Examples of Data Categorisation for LAS and LAD .....	69
Table 3.6 Learner autonomy demonstrated framework.....	70

## List of Figures

<i>Figure 2.1.</i> Conceptual Framework .....	52
Figure 6.1. Conceptual Framework .....	197
<i>Figure 6.2.</i> Main themes for the cross-case analysis and discussion.....	199
<i>Figure 6.3.</i> Billy's LAD in my straw musical instrument vignette .....	232
<i>Figure 6.4.</i> Lara's LAD in my straw musical instrument vignette .....	232
<i>Figure 6.5.</i> Billy's LAD in what is an ecosystem vignette .....	233
<i>Figure 6.6.</i> Complex interrelationship among factors influencing LAD.....	257

## List of Abbreviations and Acronyms

Abbreviation	In Full
AC	Australian Curriculum
ACARA	Australian Curriculum, Assessment and Reporting Authority
A $\int$ L	Assessment <i>for</i> Learning
AoL	Assessment <i>of</i> Learning
ATCP	Alternative Teacher Certification Program
BSCS	Biological Science Curriculum Study
CCT	Critical and Creative Thinking
EI	Explicit Instruction
EQUIP	Electronic Quality of Inquiry Protocol
F-10	Foundation to Year 10
IBL	Inquiry-Based Learning
ICT	Information Communication Technology
K-12	Kindergarten to 12th grade
LA	Learner Autonomy
LAD	Learner Autonomy Demonstrated
LAS	Learner Autonomy Supported
NGSS	New Generation Science Standards
NRC	National Research Council
NSES	National Science Education Standards
PC	Primary Connections
PD	Professional Development
PISA	Programme for International Student Assessment
PSETs	Preservice Elementary Teachers
QCA	Qualitative Content Analysis
QR	Quick Response
R-6	Reception/Primary School to Year 6
SAMR	Substitution Augmentation Modification Redefinition
SCIS	Science Curriculum Improvement Study
SDT	Self-Determination Theory
STEM	Science, Technology, Engineering, and Mathematics

<b>Abbreviation</b>	<b>In Full</b>
STEAM	Science, Technology, Engineering, Arts and Mathematics
TIMSS	Trends in International Mathematics and Science Study
UK	United Kingdom
USA	United States of America
USSR	Union of Soviet Socialist Republics
VET	Vocational Education and Training
ZPD	Zone of Proximal Development

# Chapter 1 Introduction

Australia is facing a well-documented decline in school student achievement and interest in science education. The decline in both student achievement and interest has drawn attention to the practices of primary teachers of science (Deehan, 2022; Prinsley & Johnston, 2015). The questioning of contemporary teacher science practices, and the decline of Australian science students' comparative international test results, has been exacerbated by a fall in student interest in science classes and a decrease student enrolment in STEM-related courses (Hobbs et al., 2021). This thesis reviews the use of science teacher practices to improve science teaching and student interest and engagement in the primary years' education. Previous research has investigated the impact of science teachers' pedagogical practices on learning outcomes but remains under-researched. This thesis investigates a specific pedagogical approach known as inquiry-based learning (IBL), commonly used for the teaching of science in primary school classrooms, to further inform the existing body of research and fill the current gap in the literature. A qualitative case study methodology is used to provide insights into the IBL practices and subsequent beliefs of two middle-year primary teachers teaching science in the same Year 4 classroom in a primary school in Adelaide, South Australia. The study investigates teacher autonomy supportive practices and how these practices influence learner autonomy (LA) and student interest in science learning. This chapter presents the background to the study, the research questions, the significance of the study, definitions of key concepts, methodology, reflexivity and a brief overview of the thesis structure.

## 1.1 Background to the Study

The ongoing concern to improve the quality of science teaching (ACARA, 2016, 2017; Goodrum et al., 2001; Hackling et al., 2007; Prinsley & Johnston, 2015) for countries to remain globally competitive (ACARA, 2016, 2017; Goodrum et al., 2001; Hackling et al., 2007; NRC,

2000, 2012; Prinsley & Johnston, 2015) has seen a growing global clamour for high quality learner engagement (Kelley & Knowles, 2016; Prinsley & Johnston, 2015). Governments across the globe recognize the importance of a quality science education programme to national development and the solving of current and emerging problems (Daphne et al., 2010; Hackling et al., 2007; Prinsley & Johnston, 2015). To improve the teaching of science, several government initiatives have been introduced in Australia, including the development and implementation of the Australian National Curriculum.

### ***1.1.1 Australian Curriculum***

Significant to the improvement of the teaching and learning of science in Australia were the outcomes generated by the 1989 Hobart Declaration on Schooling. The declaration agreed to establish a national curriculum agency, the Australian Curriculum Assessment and Reporting Authority (ACARA), and to develop the national Australian Curriculum (AC) (Spring, 1998).

The Australian Curriculum (AC), endorsed by all State and Territory education ministers, provided an exhaustive curriculum from the Foundation to Year 10 (ACARA, 2023c, 2023d). The AC comprises of a broad range of learning areas for science education in primary schools. The AC: Science is organized around three interrelated strands: science understanding, science as a human endeavour, and science inquiry skills (ACARA, 2016; Kidman, 2012). The AC suggests that learners engage in inquiry skills at all levels of schooling (Kidman, 2012). Learners are encouraged to identify problems, design and conduct investigations, gather and analyse data, and explain and summarise patterns (ACARA, 2016; Kidman, 2012).

### ***1.1.2 Inquiry-Based Learning***

The promotion of inquiry skills in the AC supports the use of IBL pedagogical approaches to the teaching of science, and has drastically changed the instructional practices found in school science (ACARA, 2016; Deehan, 2022). The adoption of IBL has been

promoted as a viable solution to enhance the quality of science teaching. It is argued that IBL fosters students' critical thinking and problem-solving skills. IBL is presumed to not only lead to better learning outcomes, but also generate student motivation and positive attitudes towards science (Attard et al., 2021; Furtak & Kunter, 2012). While primary teachers are in general not science specialists, and may be uncomfortable or ill-equipped for 'teaching science concepts' (Fitzgerald et al., 2019; McKenzie et al., 2008), the AC provides a framework to support the teaching of IBL, and facilitates students to engage more in self-learning, as teachers adopt a more facilitative role.

### **1.1.3 Primary Connections**

Central to improving the quality of primary science teachers has been the introduction of the Primary Connections (PC) resources introduced in 2004 (Hackling et al., 2007). The PC was created in conjunction with the Australian Academy of Science and is closely aligned to the science curriculum within the AC. The PC resources integrate teacher professional learning to enhance learning outcomes in science (Hackling et al., 2007). Despite the introduction of the PC, concerns remain about the quality of science teaching in primary schools (Deehan, 2022; Prinsley & Johnston, 2015).

The PC is composed of five phases known as the 5Es: engage, explore, explain, elaborate and evaluate (Bybee et al., 2006; Duran & Duran, 2004; Hackling et al., 2007) encouraging the use of IBL within the pedagogies used in a primary science classroom. Despite IBL being recognised in the AC and included within the PC resources, IBL remains under-researched in the primary science education context. The small amount of research that has been conducted suggests that IBL is rarely adopted and its effectiveness is inconsistent (Jerrim et al., 2019; Oliver et al., 2019).

#### **1.1.4 *Declining Interest, Enrolment and Engagement in Science Learning***

After more than a decade of AC-endorsed science inquiry and the emerging shift to learner-centred teaching approaches, Australian primary school science is deemed inadequate and ineffective (Deehan, 2022). These concerns are exacerbated by the declining performance in international tests such as the Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS), despite increased funding and a shift towards STEM specialist teachers (Prinsley & Johnston, 2015).

Inadequate and ineffective primary science education is seen by some as the major cause leading to the continued decline in science enrolments in senior high school, matched by a decline in tertiary enrolments in science related courses (Deehan, 2022; Kennedy et al., 2014). Some researchers have suggested that a possible reason is the lack of relevance in primary school science (Goodrum & Rennie, 2007; Tytler, 2007) which has been reflected in the declining TIMSS and PISA performance over the years (Deehan, 2022; Hackling et al., 2007). To address the problem of declining enrolments in science-related courses and declining PISA and TIMSS performance, several interventions have been put in place, and one such intervention to aid the AC has been the Primary Connections resources which promotes the use of investigative approaches to teaching such as IBL (Hackling et al., 2007).

#### **1.1.5 *IBL in the Classroom***

A body of research suggests IBL may support in addressing the issues associated with science education (Fittell, 2010; FitzGerald, 2016; Fitzgerald et al., 2019). Findings from these studies seek to support teachers, educators, policymakers and the scientific community to envision and understand the fundamental principles of IBL and its application in current science education contexts to promote student learning outcomes (Areepattamannil, 2012; Capps et al., 2016; Crawford & Capps, 2016; Engeln et al., 2013).

While there is no universally accepted definition for IBL (Bevins & Price, 2016), IBL has been defined as an instructional strategy in which the student is the centre of the learning

process as they assume ownership of their learning by generating, investigating and answering scientifically oriented questions (Caswell & LaBrie, 2017). This thesis adopts a working definition of IBL as an instructional practice that involves learners in essential features of inquiry (Capps & Crawford, 2013; NRC, 2000). Through engagement in essential features of inquiry, learners develop their critical thinking and problem solving, as well as their creative thinking abilities, as they investigate scientific phenomena (Daphne et al., 2010; NRC, 2000, 2012). These skills can support learners to lead productive lives thus supporting their countries both socially, politically, and economically (NRC, 2012).

Several scholars have suggested that IBL is largely effective in enhancing students' conceptual understanding (Kuhlthau et al., 2015; Schwartz, 2004). However, other studies have shown that IBL's effectiveness is inconsistent as it is associated with a negative relationship with academic achievement (Cairns, 2019; Cairns & Areepattamannil, 2019; Jerrim et al., 2019). A study by Cairns and Areepattamannil (2019) using PISA data revealed that IBL was significantly negatively related to science achievement. However, there was a positive relationship between IBL and dispositions towards science such as interest and enjoyment of science learning. Reid and Ali (2020) argued that while IBL and other student-centred teaching approaches are less effective for the acquisition of knowledge, they are effective for developing skills, attitudes and applications of understanding in new or different contexts.

#### **1.1.6 *Learner Autonomy***

Evidence suggests that IBL allows teachers to optimise the facilitation of learning in ways that engage learners in learning activities in an independent manner (NRC, 2012; Palincsar, 2013). IBL can be classified with reference to the amount of guidance provided to students, ranging from highly structured, closed inquiry to open inquiry (Çavas et al., 2013), and the amount of guidance fundamentally influences the extent of learner autonomy (LA) that students experience in IBL lessons. Learners, it is assumed, take an active role in the knowledge

construction process during open-ended IBL lessons in which teachers ensure students engage in planning and conducting their investigations (Capps & Crawford, 2013; Capps et al., 2016; Çavas et al., 2013; Palincsar, 2013). The way teachers facilitate IBL fundamentally influences how learners experience science learning and LA.

LA has been defined as a learner's sense of control over their learning (Roth et al., 2007). Learning environments that support LA may boost learner engagement and motivation (Reeve et al., 2004; Stefanou et al., 2004). IBL environments may present new opportunities for teachers to support LA, depending on the level of guidance that teachers provide during teaching.

Stefanou et al. (2004) proposed three types of autonomy support: organizational, procedural and cognitive autonomy. Whereas other researchers propose additional types of autonomy support: rationale and relevance, responsiveness and feedback, (Rogat et al., 2014), this current study utilized Stefanou et al.'s (2004) three types of autonomy support to analyse and categorise teacher autonomy supportive practices. Organizational, procedural and cognitive autonomy support have been used by other researchers and found to be suited to classroom settings (Furtak & Kunter, 2012; Sheffield, 2017).

Organizational autonomy support entails teacher instructional practices that include offering learners choice over environmental procedures such as development of rules, choosing seating arrangements or selecting group members (Rogat et al., 2014; Stefanou et al., 2004), essentially fostering the learners' sense of ownership of the learning environment. Procedural autonomy entails teacher instructional practices that provide learners with the choice of presentation of their learning, handling of classroom materials as well as discussing their wants (Stefanou et al., 2004). Cognitive autonomy support includes teacher practices that seek to motivate learners to generate diverse solutions, self-evaluate, monitor their learning, evaluate each other's work, participate in classroom discussions, ask and answer questions, and offer

their opinions and ideas (Rogat et al., 2014; Stefanou et al., 2004).

Some researchers argue that learners may benefit more from procedural and cognitive autonomy (Furtak & Kunter, 2012; Stefanou et al., 2004). While some publications provide evidence of autonomy supportive teaching (Furtak & Kunter, 2012; Rogat et al., 2014), there is a dearth of studies focusing on IBL in Primary Science, a context which offers a rich environment for the demonstration of LA. Moreover, few studies have investigated whether teacher knowledge of IBL and LA influences how teachers facilitate LA during science learning.

## **1.2 Research Questions**

The overall aim of the study was to determine how teacher knowledge of IBL influences the nature of IBL facilitated, and how LA is supported and demonstrated. This study sought to address the following research questions.

### ***1.2.1 Research Questions***

1. What are the effects of primary teachers' knowledge of IBL on the nature of IBL facilitated in science classrooms?
2. What are the teacher autonomy supportive practices employed in science classrooms?
3. How does the nature of the IBL facilitated influence the teacher autonomy supportive practices facilitated and the learner autonomy demonstrated by students?

### ***1.2.2 Research Objectives***

This study addressed the following research objectives.

- i) To determine how primary teachers' knowledge of IBL affects the nature of IBL facilitated in school science.
- ii) To establish teacher autonomy supportive practices employed in primary school science.
- iii) To characterise learner autonomy demonstrated in primary school science.

- iv) To determine how teachers' knowledge of IBL relates to teacher autonomy supportive practices and learner autonomy demonstrated in school science.

### **1.3 Significance of the Study**

This research extends the literature on IBL and LA by expanding the understanding of how primary teachers of science understand and facilitate IBL and LA. A novel and richer understanding acquired from analysing science teachers' knowledge and the practice of IBL and LA may inform in-service teachers' PD and pre-service teacher education.

This study contributes to a novel understanding and knowledge of IBL due to its naturalistic stance. Many studies on IBL have been conducted (Capps & Crawford, 2013; Fitzgerald et al., 2019; Fogleman et al., 2011), however, there is a scarcity of studies combining IBL and LA to determine how IBL influences the facilitation of LA. Due to this study's qualitative methodology, the study has provided insights into how teachers understand and facilitate IBL, as well as how the facilitation of IBL influences the LA experienced and demonstrated by students. These insights will inform intervention efforts geared towards enhancing the quality of science teaching in Australia. Hence, findings from this study will support ongoing governmental efforts to improve the quality of science education which is currently lagging in terms of STEM teaching (ACARA, 2016; Prinsley & Johnston, 2015).

This research contributes to knowledge and ideas for science teachers and other educational practitioners who endeavour to promote IBL and LA. The fine-grained case studies provide stories showing real classroom examples of how organizational, procedural, and cognitive aspects of autonomy support can be practised in an IBL environment. These cases may be helpful for primary teachers in school communities and during PD to discuss different approaches to IBL and the strengths and weaknesses of those approaches. The new insights may be valuable to policy makers and educational managers seeking to reform curriculum, teaching approaches and PDs to improve the quality of teaching and learning in school science.

These findings would be useful for both in-service and pre-service teacher education as they provide exemplars from early career and experienced teachers facilitating science learning. The exemplars could be used to demonstrate how teachers facilitate science using IBL and how they adopt teacher autonomy supportive practices.

This study modified and extended the learner autonomy demonstrated (LAD) framework that was first developed by Littlewood (1999) that comprised two levels: *reactive* and *proactive autonomy*. This model led subsequently to an additional level introduced by Trần (2019) known as *compliant autonomy* before *reactive autonomy*. The current study has added two further levels to describe LA: *underdrive* and *overdrive* before *compliant* and after *proactive autonomy* respectively. This newer version was influenced by classroom observation data and offers a clearer way of characterising the LAD not only in school science but also in other subjects.

The analysis of vignettes from two different teachers suggests that LAS whether high or low does not guarantee higher levels of LAD. The findings also showed that LAD is fluid, as it plateaus, sub-merges and emerges. Based on this finding that LAD is fluid, should teachers strike a balance on how they facilitate LAS to optimise student learning?

#### **1.4 Key Concepts in the Study**

This study focused on two key constructs: inquiry-based learning and learner autonomy.

*Inquiry-based learning* has been defined as students engaging in the five essential features of inquiry as detailed in NRC 2000 (Capps & Crawford, 2013). A simplified version of the essential features of inquiry is adapted for this study. The simplified essential features of inquiry are scientifically oriented questioning, data collection, data analysis, connecting evidence to scientific concepts and communicating findings.

*Explicit instruction* has been characterised as a teaching approach where teachers model, discuss, guide, use prompts and probing questions and offer feedback to foster conceptual understanding (Kruit et al., 2018). Rosenshine (1987) has listed skills teachers use when adopting explicit instruction such as beginning a lesson with the goals of the lesson, giving clear and detailed instructions, providing feedback and corrections among other skills that are compatible with IBL (Darling-Hammond et al., 2020). In this study, explicit instruction refers to teachers providing explicit support through modelling, guiding, prompting, questioning among other explicit instruction practices to foster conceptual understanding.

*Learner autonomy supported (LAS)* comprises teacher autonomy supportive and inhibitive practices, and has been categorised in three ways: organizational, procedural and cognitive autonomy. These three categories were further divided into low or high cognitive autonomy, depending on whether the teacher practices were autonomy supportive or controlling.

*Organizational autonomy support* entails teacher instructional practices that foster students' ownership of the learning environment, such as determining seating arrangements and developing classroom rules (Rogat et al., 2014; Stefanou et al., 2004).

*Procedural autonomy* entails teacher instructional practices that foster student ownership of the form of the learning output, such as learners' choice of presentation of their learning, and handling of classroom materials, as well as discussing their wants (Stefanou et al., 2004).

*Cognitive autonomy support* entails teacher instructional practices that foster student ownership of ideas, content and skills, including motivating students to generate multiple solutions, self-evaluate, monitor their own learning, and evaluate each other's work (Rogat et al., 2014; Stefanou et al., 2004).

*Learner autonomy demonstrated (LAD)* is defined as the extent to which students exercise control over their learning. *LAD* has been categorised into five categories: *Underdrive* describes students who do not take any actions or are off-task based on teacher instructions. *Compliant* describes students who adopt actions that closely follow teacher instructions. *Reactive* describes students who initiate some actions in order to follow teacher instructions (Trần, 2019). *Proactive* describes students who initiate significant actions in relation to teacher instructions or new activities in-line with the overall goal of the lesson (Trần, 2019). *Overdrive* describes student-initiated actions deviating from teacher instructions as well as the goal of the lesson, but are still learning oriented.

*Science or STEM?* Case study teachers used the terms Science and STEM interchangeably during the study period. STEM is an acronym that encompasses Science, Technology, Mathematics and Engineering. These four are a group of disciplines that are closely related and intertwined. STEM encompasses a broader spectrum of disciplines that work together to address real-world challenges and drive innovation (Timms et al., 2018). Science entails the study of the natural world and the application of the scientific method in the discovery of new knowledge (Chuy et al., 2010). Whereas Science is a single subject, STEM is a group of subjects including Science. This intertwining between Science and STEM may be the cause for their interchangeable use by teachers. It appears Mrs Jasmine and Mr Smith referred to Science as STEM and sometimes STEM as Science.

There was fungible use of the terms Science and STEM in the current study. The terms were used to mean the same thing even when the terms may not mean the same thing. However, when Mr Smith was teaching Science, he referred to the lesson as STEM and justified the use of ICTs to make PowerPoints as the technology side of things, and the learning about ecosystems as the Science side of things. He went on to explain that the lesson he was covering did not encompass Mathematics and Engineering. Implying that he was teaching STEM even

though he did not cover all the four components of STEM. Mrs Jasmine consistently referred to her lessons as STEM and sometimes during the interview as STEAM when she integrated Art into her teaching. Therefore, in this study, there might be fungible utilisation of STEM and Science to mean the teaching of science in the Year 4 class. The researcher makes an attempt to use the term Science throughout the thesis where possible. However, the acronym STEM is used when referred to directly by teachers.

### **1.5 Methodology**

The study adopted a qualitative case study approach to investigate how two middle year primary teachers understand and practice inquiry-based learning (IBL) and learner autonomy (LA). The two teachers were teaching science to the same Year 4 class in a Metropolitan Catholic school in Adelaide. The study utilised teacher interviews and classroom observations to gather data. Similarly, I took a qualitative approach to analyse and interpret data.

Qualitative inquiry facilitates the gathering of rich data from human research (Denzin & Lincoln, 1994; Denzin & Lincoln, 2018) than would quantitative methods (Creswell, 2013). An interpretive lens was used to investigate Year 4 science teaching and how teacher knowledge of IBL influences LA facilitated and demonstrated by students. The teachers, besides being a convenient sample, may display behaviour and interactions shared by the greater science education community (Creswell, 2013). Thus, this group and their interactions were significant to this study.

This study was conducted in a natural classroom setting as part of my doctoral research. Based on my previous primary school teaching experience, I was partly positioned as an insider as I have prior knowledge and experience in primary science teaching. However, due to my nationality and doctoral research position, I may be perceived as an outsider. This is because I am not a member of the group I was studying. Therefore, I adopted a dual observer stance, as an insider and outsider as described by Chhabra (Chhabra, 2020). Optimising on the

complementary benefits of adopting the dual perspectives, I took the observer as a participant and participant observer positions while gathering and analysing data (Kawulich, 2005). I drew on the benefits of both observer stances and positions to conduct rigorous research in collecting, analysing and interpreting data (Creswell, 2013).

The two teachers had varying teaching experiences as Mrs Jasmine was in her 25<sup>th</sup> year of Primary school teaching whereas Mr Smith was in his first year of teaching. Both teachers were not science specialist teachers but were teaching all the subjects to the Year 4 students. Additionally, both teachers reported that they were passionate about the teaching and learning of science.

## **1.6 Reflexivity**

My desire to conduct research in primary science education for my doctoral studies stems from my training and past experiences. Firstly, I have five years' experience teaching primary school science. Secondly, I completed research in primary science for my master's degree in education at the University of Nottingham. These past experiences coupled with my passion for teaching and improving the quality of science teaching in primary schools triggered my desire to conduct research in primary science teaching for my doctoral studies. Initially, I sought to investigate the influence of the recently implemented competency based curriculum in Kenya (Government of Kenya, 2017) on science teaching in Kenyan primary schools. However, as international borders were closed due to COVID-19, there was a change on the research site to Australia to facilitate access to research participants.

Undertaking my doctoral research in Australia, positioned me as an outsider. However, having taught science in primary schools meant I understood the complexities of teaching science in a primary school setting. Hence, I had some insider perspectives, thus adopting the dual perspectives as an insider and outsider (Chhabra, 2020). It is not uncommon for researchers to hold both insider and outsider positions (Chhabra, 2020). These experiences may

have impacted how I gathered, analysed and interpreted data. My previous primary school teaching experience implies that I may have empathized with the teacher's situation. Having conducted research in primary schools had the potential to influence my methods, the way I approached the research as well as how I collected, analysed and interpreted data. This dual perspective allowed me to perceive research findings from both the insider and outsider lens as I examined the broader educational landscape. However, coming from Kenya to Australia, may also have impacted how I recorded and interpreted data.

Therefore, adopting a qualitative approach to the study positions the researcher as a subjective investigator whose knowledge, beliefs and experiences may impact how data is gathered, analysed and interpreted (Denzin & Lincoln, 1994; Denzin & Lincoln, 2018). As an instrument in this research, I was aware that my presence may influence the teacher and student behaviour. Even though my easy going and continued engagement was meant to neutralise my presence as teachers and students got used to my presence (Creswell, 2013). To ensure transparency in how I was situated in gaining access to insider knowledge of the event of teaching, I provided research vignettes that detailed the events in the science classrooms. I consistently remained aware of my impact during the data collection, analysis and interpretation stages of the research process.

## **1.9 Organization of Thesis**

This thesis consists of seven chapters.

Chapter One – **The introduction** outlines the background of the study, the research questions, the research objectives, the significance of the study, the definition of key concepts, methodology, reflexivity and the organization of the thesis.

Chapter Two – **Literature Review** provides the theoretical framework for the study, a historical view of inquiry learning, and learner autonomy. The chapter then provides a further synthesis of the literature on IBL and LA in which the fundamental concepts around IBL and

LA are explored: teacher knowledge of IBL and LA, the nature of IBL, teacher autonomy supportive practices and the relationship between IBL and LA, contextual factors and conceptual framework.

Chapter Three - **Research Methodology** describes the qualitative case study design approach, and the data gathering and analysis methods. The chapter further details participant recruitment, data analysis methods, research quality, and ethical considerations. This study comprises two individual cases and data was gathered through teacher interviews and classroom observations.

Chapter Four - **Mrs Jasmine's IBL practices** and Chapter Five - **Mr Smith's IBL practices** mirror each other as they present the findings for the two case studies. The chapters outline the research findings based on the following themes: context, teacher knowledge of IBL, teacher knowledge of LA, teacher autonomy supportive practices including learner autonomy demonstrated, and nature of IBL.

Chapter Six - **Cross-case analysis and discussion** presents a cross-case analysis and discussion of the two individual cases. Overarching themes are presented and discussed: context, teacher knowledge of IBL, teacher knowledge of LA, teacher autonomy supportive practices including learner autonomy demonstrated, and the nature of IBL.

Chapter Seven - **Conclusion** presents the conclusions, contributions, and recommendations of the study.

## **1.10 Conclusion**

Despite strong endorsement for the adoption of IBL across the globe by various government policy documents, curriculum and research reports (ACARA, 2016; European Commission, 2007; NRC, 2012), IBL has been minimally adopted in school science, an endemic problem over the last five decades (Anderson, 2002; Bull et al., 2010; Fitzgerald et al., 2019; Orosz et al., 2023; Tosa, 2011; Welch, 1981). A number of studies indicate that

transmissive teaching approaches are largely adopted in school science (Anderson, 2002; Danaia et al., 2013; Tosa, 2011). In situations where IBL is adopted, it is highly structured and based on cook-book investigations where learners do not have opportunities to generate investigative questions as well as plan and conduct their own investigations (Capps & Crawford, 2013; Capps et al., 2016). If teachers are not teaching science as IBL, they may not provide learners with opportunities to understand scientific concepts through active participation in the knowledge construction process (Kuhlthau et al., 2015). The following chapter reviews the literature on IBL and LA, and provides a framework to investigate how teachers facilitate IBL and LA in the classroom.

## Chapter 2 Literature Review

This chapter provides a review of different areas of the research literature that develop and justify the need for the study: the theoretical framework for the study; historical development of inquiry; the meaning of inquiry; inquiry-based learning (IBL) models, teacher knowledge of IBL; the nature of IBL; learner autonomy (LA) including teacher autonomy supportive practices and learner autonomy demonstrated (LAD), relationship between IBL and LA, contextual factors and conceptual framework. This review demonstrates a need for further studies regarding teacher knowledge and the practice of IBL, as well as the facilitation of LA in school science.

### 2.1 Theoretical Framework

Inquiry-based learning (IBL) is grounded within the tenets of constructivist learning theory. A common theme embedded within both IBL and constructivism is the active participation of the learner in the learning process. This perspective includes a shift towards guidance and scaffolding, and a shift away from an authoritarian and transmissive nature of teaching (Driver, 1995; Treagust, 2013).

#### 2.1.1 *Constructivist theory*

Constructivism as a theory of learning was pioneered by theorists such as Dewey, Vygotsky and Piaget (Llewellyn, 2005) and describes how students construct knowledge (Henson, 2003). Piaget theorised that learners learn in stages based on age, while Vygotsky contended that knowledge is constructed through social interaction with knowledgeable peers and adults (Llewellyn, 2005; Vygotsky, 1999). Dewey theorized that direct experiences create the foundation for knowledge creation (Llewellyn, 2005).

Dewey's theorization that the foundation of knowledge creation emanates from students engagement with direct experiences formed the basis of the progressive education reform movement (Dewey, 1938; McCaughan, 2013). Within the progressive education

movement, learners actively interact with the environment as they learn (McCaughan, 2013). Dewey further argued that learners should be involved in the search for answers to solve real and authentic problems (Dewey, 1938).

Using authentic experiences in learning provides students with first hand experiences with scientific activities (Dewey, 1938). As such, teachers facilitate students' active linking of abstract science ideas with real life problems. This approach to teaching and learning marked a shift towards student-centred teaching (Henson, 2003), where learners are actively involved in the knowledge construction process (Savasci & Berlin, 2012).

Piaget (1954) in his seminal work on student learning contended that children learn in stages as they assimilate and accommodate new information. His work emphasised that the cognitive processes of analysing and interpreting lead to knowledge construction. Hence, teachers should avail learning opportunities that allow learners to integrate new knowledge with prior knowledge and experiences (Savasci & Berlin, 2012). For instance, when learners gather data for their science activities, they have the opportunity to integrate the data with their previous knowledge through the process of analysis and interpretation. Both Piaget and Dewey's approach to instruction focused on the students constructing knowledge for themselves (Gordon, 2009).

Piaget's ideas mirror those of Kuhn's scientific knowledge development. Kuhn posited that the development of scientific knowledge is non-linear as it alternates between normal and revolutionary phases (Kuhn, 1996). Kuhn explains that in the normal phase, the development of scientific knowledge is "continuous insofar as there is accumulation of puzzles solved" (Tsou, 2006, p. 211). This is similar to Piaget's. While in the revolutionary phase, the scientific knowledge development process is discontinuous and noncumulative. The revolutionary phase appears to contradict Piaget's theory that suggested that knowledge development is cumulative as learners integrate new information with prior knowledge to create new understandings

through the process of accommodation and assimilation.

Vygotsky posited that learners create knowledge when they interact with knowledgeable peers and adults (Vygotsky, 1978). Vygotsky indicated that learning began socially, then proceeded to psychological or cognitive (Gordon, 2009). When knowledgeable peers and adults in this case teachers support learners to learn, this is known as learning within the zone of proximal development (ZPD) (Henson, 2003). The ZPD is a zone where the concept being studied is difficult for the student to undertake independently. Therefore, the teacher or peers support the student to gain mastery. Thereafter, students can independently carry out the tasks (Gordon, 2009). In science classes, students can work with peers, teachers and researchers to investigate complex problems, with time, students will master the research skills and develop knowledge around the phenomena being investigated.

Dewey, Piaget, Vygotsky and Kuhn emphasised the crucial role of experiences in the knowledge construction process. Their ideas became the foundation of the constructivist theory where students actively construct their understanding (Zhang, 2016). This constructivist view has become synonymous with science learning and teaching and is a dominant theory in science education (Zhang, 2016).

Constructivists argue that students learn science when they engage in authentic activities like those performed by scientists (Orgill & Thomas, 2007). To develop scientific literacy skills, learners must actively engage in scientific activities as well as reflect on those activities (Haney et al., 2003). The constructivist views of learning became the major theory of education that was used to promote scientific inquiry in science classrooms across the globe, especially in US schools in the 1960's (Zhang, 2016). This has led to a range of instructional approaches that foster scientific inquiry to be developed and utilised in science teaching. Such strategies include inquiry-based learning, project-based learning and hands on learning approaches that allow students to construct their understanding (Zhang, 2016). These

approaches are being adopted in science classrooms using different models such as 5E (Bybee et al., 2006), and guided inquiry model (Magnusson et al., 2004) which have common features such as scientifically oriented questions, data collection, and data analysis.

### **2.1.2 *Constructivist Theory and IBL***

IBL is considered to sit within the parameters of constructivist learning theory and practices. In constructivist theory, students are participants who are, to some extent, autonomously and actively engaged in, and responsible for, their learning (Duffy & Raymer, 2010; Furtak & Kunter, 2012). The constructivism theories suggest that one possible mechanism underlying the potential success of IBL and other student-centred teaching approaches is that students are offered greater responsibility for their learning (Duffy & Raymer, 2010; Furtak & Kunter, 2012). This may engage learners in meaningful activities leading to better learning outcomes (Furtak & Kunter, 2012).

Constructivism theory, as it is broadly conceived, posits that learners should actively participate in the learning process (Driver, 1995). Learners construct new knowledge when they integrate new information into their prior knowledge while interacting with the environment (Driver, 1995; Rannikmäe et al., 2020). Therefore, teachers using IBL, according to constructivist ideals, should allow learners to engage in scientific practices, provide authentic problems for solving, and support learners to develop conceptual understanding of scientific concepts in increasingly more autonomous ways (Colburn, 2000; Driver, 1995).

Based on these perceived benefits of constructivist theories, constructivist ideals have informed science education reforms in many countries such as the USA (NRC, 1996, 2000, 2012), the United Kingdom (UK, 2015), and Australia (ACARA, 2015, 2016). Many studies have reported low adoption of learner-centred teaching approaches such as IBL in the USA and across developed economies (Crawford, 2014; Furtak & Kunter, 2012; Kim & Tan, 2011). The main challenge emanating from student-centred teaching approaches, such as IBL, stems

from the incomplete interpretation of the autonomy supported in these learning settings (Furtak & Kunter, 2012; Hardy et al., 2006).

### **2.1.3 Social Constructivism**

Social constructivist theories of learning suggest that knowledge should be actively and socially constructed through meaningful learning experiences that may contribute to the development of transferable knowledge (Bransford et al., 2000; Collins et al., 2001; Rannikmäe et al., 2020). Teachers are challenged to provide opportunities for learners to take more responsibility in their learning, activating students' prior knowledge, integrating student ideas into the learning process and providing opportunities for students to engage in meaningful discussions (Smith Iii et al., 1994). Evidence from experimental and quasi-experimental studies reveals that learning environments based on constructivist ideals promote learner engagement, culminating in better learning outcomes as well as desirable motivational development (Hardy et al., 2006; Scott et al., 2006). This is because teachers can guide students to a higher conceptual understanding through co-construction of meanings and understanding (Colburn, 2000; Hodson & Hodson, 1998; Rannikmäe et al., 2020).

Researchers such as Vygotsky (1978) postulate that learners create new knowledge by engaging with teachers and peers in a social environment. He further explained that teachers should offer learners adequate support to develop the ability to undertake tasks independently. This support is commonly known as scaffolding. Scaffolding is offered within the zone of proximal development (ZPD) to allow learners to develop and master a concept they currently have little or no knowledge about (Jones & Brader-Araje, 2002; Rannikmäe et al., 2020). Teachers must have the knowledge and experience to determine when to scaffold and when to fade support to ensure learners develop autonomy in carrying out specific tasks (Mestad & Kolstø, 2014).

### **2.1.4 Current Education Situation**

Despite the notions of constructivist theories influencing science education reforms across the globe, transmissive and explicit instruction teaching styles are prevalent in many science classrooms (Crawford, 2014). These teaching approaches differ from the tenets of social constructivist learning theories (Crawford, 2014; Darling-Hammond et al., 2020). Teachers assume the role of a transmitter with authority, devising learning activities and conveying knowledge in a systematic way to passive students (Straits & Wilke, 2007). Advocates of explicit instruction have criticised constructivist approaches to science teaching creating tension between constructivist teaching approaches and explicit instruction (Jonassen, 2009; Klahr, 2009; Rosenshine, 2009; Schwartz et al., 2009). The debate about which is a better teaching approach has been gaining momentum as researchers from both ends of the debate release findings showing the benefits and challenges of the teaching approaches (Oliver et al., 2019; Tobias, 2009; Tobias & Duffy, 2009).

Despite the ongoing debate around constructivist and teacher-centred teaching styles, Darling-Hammond et al. (2020) reported that both direct and constructivist teaching styles can be used in science teaching, allowing students to benefit from aspects of the different teaching styles. Other researchers have also supported the use of different instructional approaches together with inquiry-based learning in science classrooms (de Jong, 2019; de Jong et al., 2023; Denoël et al., 2017).

## **2.2 Historical Development of Inquiry**

### **2.2.1 Learning Cycle**

Inquiry has been part of the educational environment and education literature for the past 500 years (Crawford, 2014; Oliveira et al., 2013; Sawyer, 2005). Early use of IBL can be found in the Socratic methods of teaching used in the 15<sup>th</sup> century (Sawyer, 2005), and later in the scientific methods espoused by Dewey in the early 20<sup>th</sup> century (Barrow, 2006; Dewey, 1910, 1938).

The launching of Sputnik in the late 1950s led to the rekindling of inquiry-based practices in the USA (Barrow, 2006; Bybee et al., 2006), accelerated by numerous reforms initiated by concerns that the USA had fallen behind the USSR in the space race (Barrow, 2006). During the same time period, research into Dewey's ideas by researchers such as Karplus and Atkins led to the development of guided inquiry (Simpson, 2012). This further led to the coining of the term "learning cycle" by Karplus and Herbert. The learning cycle consisted of three phases: exploration, invention and discovery (Goldston et al., 2013). The teaching methods embraced within the learning cycle were used in the Science Curriculum Improvement Study (SCIS) project in the USA in the 1970s (Bybee et al., 2006). The Biological Science Curriculum Study (BSCS) conducted in the USA added two new stages to the beginning and end of the learning cycle in the 1980s: engagement and evaluation (Bybee et al., 2006). In Australia, this has evolved into what is commonly known as Primary Connections (PC) containing the 5E learning cycle comprising of engage, explore, explain, elaborate and evaluate phases (Bybee et al., 2006; Duran & Duran, 2004).

### **2.2.2 Scientific Inquiry**

During the post Sputnik period, as the learning cycle emerged, scientific inquiry began to appear in policy documents for K to 12 science education in the USA (Crawford, 2014). A series of National Science Education documents such as the NRC 1996, 2000, 2012 and NGSS 2013 (NRC, 1996, 2000, 2012, 2013) recommended the use of inquiry in school science.

In Australia, primary schools began to utilise the Australian Academy of Sciences PC resources in science teaching, and as a part of professional development (PD) for science teachers (ACARA, 2016). Scientific inquiry is part of the Australian national curriculum (ACARA, 2015, 2023a). The Australian Curriculum (AC) for Science F-10 comprises of three interrelated strands: Science understanding, Science as a human endeavour, and Science inquiry skills. The structure and pedagogy of the curriculum followed the 5E learning model

found in the PC resources (Skamp & Peers, 2012). Feedback from teachers suggests that the 5E model in PC is effective in science teaching (Skamp, 2012; Skamp & Peers, 2012).

In Australia, teachers are required to integrate inquiry into their science teaching (Fitzgerald et al., 2019). This is in addition to the incorporation of scientific inquiry skills in science and other subjects such as History, Geography, Economics and Business, Civics and Citizenship, Critical and Creative Thinking (CCT), and Information and Communication Technology (ICT) (Lupton, 2014). Primary school teachers teach across the entire curriculum, and traditionally they are not science trained teachers, thus resulting in low confidence in teaching science (McKenzie et al., 2008). This is one reason the implementation of IBL in primary science classrooms has been challenging for primary teachers in Australia (Ireland et al., 2014). Inadequate time for science teaching and teacher views on IBL have been identified as other factors influencing the adoption of IBL in Australian primary classrooms (Fitzgerald et al., 2019).

### **2.3 Meaning of Inquiry**

Inquiry has been defined as the process of seeking knowledge or truth (Webster, 2011). In science education, the term inquiry has been defined in diverse ways, hence the development of different understandings, which to a large extent have been accused of causing confusion among science teachers as to exactly what ‘inquiry’ is and what comprises inquiry teaching and learning (Capps et al., 2016; Daphne et al., 2010; Lee & Shea, 2016; Mugabo, 2015; Tosa, 2011). NRC (2000) provided specific characteristics of inquiry in which teachers may implement some or all the features of inquiry. These features range from teacher-led to student-led instruction depending on the level of teacher guidance. Despite the NRC science education documents providing a definition for the term ‘inquiry’, research suggests that uncertainties around the meaning of the term remain (Capps et al., 2016).

### **2.3.1 *Alternative Definitions of Inquiry***

Evidence reveals that some teachers define inquiry as discovery learning (Demir & Abell, 2010; Mugabo, 2015), hands-on activities (Capps et al., 2016; Mugabo, 2015), or solving authentic problems (Capps & Crawford, 2013; Capps et al., 2016), while other teachers liken inquiry with the nature of the activity and teacher and student responsibility while undertaking the task (Cavas, 2012; Morrison, 2013). These activities may be part of inquiry, however, they do not capture the full range of inquiry practices in a science classroom. The NRC standards defined inquiry as learners working under the supervision of the teacher to develop an understanding of science concepts by interacting with scientifically oriented questions and data (NRC, 2012).

Other scholars have presented different meanings for inquiry. Barman (2002) provided a two component definition of inquiry as a teaching strategy and learner science process skills. Lederman (2003) defined inquiry as knowledge about inquiry effectively adding the third component of inquiry. Bybee et al. (2000) have identified a series of definitions of inquiry: promoting curiosity (habits of mind), a teaching approach for enhancing learner motivation, hands on minds on, and learners manipulating materials and equipment. Bybee et al. (2000) posited that for an inquiry to be defined as a complete inquiry, learners must learn something new. Even when the inquiry does not generate the desired responses, at least the inquiry contributed to a better understanding of the process as well as the factors under investigation (Bybee et al., 2000, p. 479). Minner et al. (2010) explained that IBL can be defined as having three aspects: (1) the presence of science content, (2) student engagement with science content, and (3) student responsibility for learning, student active thinking, or student motivation within at least one component of instruction: question, design, data, conclusion, or communication (p. 5). In contrast, the NRC 2000 defined inquiry as “a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of

experimental evidence; using tools to gather, analyse, and interpret data; proposing answers, explanations, and predictions; and communicating the results" (NRC, 1996, p. 23).

Crawford (2014) provided a detailed overview of recommended inquiry practices to be used in a science classroom. He suggested that teachers should pose scientific questions and guide learners to find answers to those questions, while the students interpret the data, the text in the book, and/or images on the book or computer. Crawford further argued that in an inquiry classroom, students generate and evaluate data to create scientific explanations as they take part in science practices and discussions.

Science educators and researchers have, over the years, failed to agree on the meaning and use of the term “inquiry” in science education. The lack of consensus has affected teachers’ understanding, as well as the implementation of inquiry in science classrooms (Osborne et al., 2004). Consequently, there is a need for consensus on the meaning of the term inquiry among science educators to promote its understanding and widespread use in science lessons. In pushing for consensus, the NRC (2000, p. 25) lists five essential features of classroom inquiry.

- Learners are engaged by scientifically oriented questions.
- Learners give priority to evidence.
- Learners formulate explanations from evidence to address scientifically oriented questions.
- Learners evaluate their explanations considering alternative explanations, particularly those reflecting scientific understanding.
- Learners communicate and justify their proposed explanations.

## **2.4 IBL Models**

Several models have been used to describe the nature of IBL in literature. These models include the 5E (Engagement, Exploration, Explanation, Elaboration, and Evaluation) (Bybee et al., 2006), the Pedaste et al’s Phases of Inquiry Model comprising Orientation,

Conceptualisation, Investigation, Conclusion and Discussion (Pedaste et al., 2015), the Uum et al.'s Phases of Inquiry comprising of Introduction, Exploration, Designing the Investigation, Conducting the Investigation, Conclusion, Presentation/Communication, and Deepening/broadening (Van Uum et al., 2016) and the Models of Engaged Learning and Teaching (MELT) comprising six facets of inquiry: embark and clarify; find and generate; evaluate and reflect; organise and manage; analyse and synthesise; and communicate and apply (Willison, 2020). Of all these Models, the most promising for this thesis was the MELT framework.

The MELT pedagogical framework (Willison, 2018, 2020) has been used in various research studies and is effective in describing the nature of learning in different contexts (Torres, 2018; Torres & Yazbeck, 2021; Willison et al., 2017). The MELT framework is adaptive and allows for a rich description of the nature of IBL, the extent of teacher guidance as well as the affective component of the learning process. Due to its adaptability and scope, the MELT framework was adopted to characterise the nature of IBL in this study.

## **2.5 Teacher Knowledge of Inquiry-Based Learning**

Teacher knowledge of inquiry-based learning (IBL) has the potential to influence how science teachers implement IBL (Capps et al., 2016; Ozel & Luft, 2013; Tal et al., 2019). Tal et al. (2019) argue that teachers with insufficient knowledge about inquiry may adopt a narrow approach to inquiry. This may result in the overutilization of procedures and technicalities, thus limiting opportunities for learners to experience intellectual curiosity and creativity that characterize scientific work essentially influencing how learners experience inquiry.

### **2.5.1 Teachers' Understandings and Beliefs of IBL**

There has been ongoing debate concerning the various approaches taken when studying teacher knowledge of inquiry. Morrison (2013) defined "conceptions" as teachers' thoughts and understandings, while "beliefs" were defined as teachers' trust and faith. Demir and Abell

(2010) suggested that teachers may possess diverse ideas about inquiry, and as such, the ideas they have about inquiry may influence how they enact inquiry. Conception can, therefore, be defined as teachers' opinions, views, feelings or beliefs about inquiry (Ssempala, 2017). Whether a researcher investigates teachers' conceptions, beliefs, knowledge or understandings, the aim is to determine what teachers know and think about IBL (Capps et al., 2016; Crawford & Capps, 2016).

### ***2.5.2 Science Teachers' Knowledge of IBL***

Central to this current study is the investigation of science teachers' knowledge of the principles of inquiry: meaning of IBL, teacher role during IBL lessons, learner role during IBL lessons, and role of assessment during IBL lessons. This knowledge may be referred to as 'teachers' pedagogical knowledge of inquiry'. Literature suggests that teachers must have the three categories of knowledge to effectively teach: subject matter knowledge, pedagogical knowledge, and pedagogical content knowledge (Shulman, 1986). Hence, this literature review considers teachers' pedagogical knowledge of IBL as a teaching and learning approach.

Guerriero (2014) explains that pedagogical knowledge entails knowledge that is related to the art of teaching. It includes the principles, strategies, and techniques in all aspects of teaching. Aspects of pedagogical knowledge include lesson planning, classroom management, instructional strategies, assessment strategies, daily routines, and physical classroom layout among others (Guerriero, 2014). NRC (1996) suggests that teachers should select appropriate strategies and techniques to maximise student learning during inquiry learning. The strategies should take into consideration that, in science, learners must be "doing" if lessons are to be effective.

Teacher knowledge of the principles of IBL appears to be one of the most crucial factors predicting the effective adoption of IBL in science classrooms (Blanchard et al., 2009; Crawford, 2007; Long & Bae, 2018; Ozel & Luft, 2013). Crawford (2007) explained that

investigating science teachers' knowledge of IBL is critical, since knowledge guides implementation. Capps et al. (2016) posited that knowing what teachers know about the principles of IBL would necessitate better development of tools to measure the enactment of IBL. Information on teachers' knowledge of IBL can contribute to the understanding of the inconsistencies that exist between what teachers think practising IBL is and the actual classroom practice of IBL (Capps et al., 2016). This understanding may also make it possible to ascertain how teachers' knowledge of IBL fosters learner autonomy (LA) in school science.

A review of the literature revealed that science teachers possess diverse understandings of IBL. Asay and Orgill (2010) and Wang and Zhao (2016) reported that teachers' understanding of IBL could be context specific. This assertion was further strengthened by Mugabo (2015) who revealed that there is no shared understanding of what IBL is, as his study found teachers in Rwanda to have a diverse understanding of IBL. Another study by Ireland et al. (2012) focusing on 20 primary science teachers in Australia revealed that teachers held divergent views on IBL. Three types of conceptions were revealed: (a) the experience-centred conceptions, where teachers provided interesting sensory experiences, (b) the problem-centred conception where teachers engaged learners with challenging problems, and (c) the question-centred conception where teachers supported learners to ask and answer their questions.

Some studies on teachers' knowledge of IBL reveal that science teachers hold either little, incorrect, or incomplete knowledge of IBL when compared with IBL as conceived in science reform documents (Demir & Abell, 2010; Kang et al., 2008; Mugabo, 2015; Seung et al., 2014). For instance, Seung et al. (2014) investigated preservice primary teachers' (PSETs) and their mentors' understanding of the essential features of IBL using evidence-based reflection. Findings showed that both PSETs and their mentors had an incomplete understanding of inquiry. It was further revealed that PSETs and their mentors differed in their levels of understanding of each feature of scientific inquiry, showing greater understanding of

some features than others. Another study by Demir and Abell (2010) inquired into the meaning of inquiry as conceptualised by beginner teachers and their instructors in an Alternative Teacher Certification Program (ATCP), at a Midwestern University in the USA. Findings revealed that teachers had incomplete views of IBL. However, the University faculty had a complete understanding of IBL and revealed that they understood that both beginner and practising teachers have incomplete views about inquiry. Despite this, there is a dearth of studies investigating whether the different knowledge levels have an influence on how teachers facilitate LA during school science lessons.

Other studies categorised science teachers' knowledge of IBL in a range from naïve to sophisticated (Capps & Crawford, 2013; Ireland et al., 2012). For instance, Capps and Crawford (2013) examined a group of 5<sup>th</sup>-9<sup>th</sup> grade teachers' views about inquiry in the USA after participation in an inquiry-based professional development (PD) programme. Results of the pre-online questionnaire revealed that around eighty percent of the teachers who participated in the study possessed views about IBL ranging from naïve to emerging. Only five teachers had informed views about IBL, demonstrating that the majority of teachers in that group did not have informed views of what IBL is. The post online questionnaire revealed that teachers who participated in the training showed more informed views of inquiry when compared with teachers who did not participate in the training. However, studies have not been conducted to determine whether these different levels of teacher views of IBL influence how LA is facilitated in school science. Since teachers' knowledge of IBL guides implementation (Long & Bae, 2018; Tal et al., 2019), it is important to determine how the different levels of teacher knowledge of IBL mediate IBL classroom practice and facilitate LA.

Another finding among the studies on teacher knowledge of IBL is that the majority of science teachers describe IBL in terms of the common essential features of inquiry, as espoused in the USA reform documents such as NRC 2000 and NRC 2012 (Demir & Abell, 2010;

Mugabo, 2015; Niyitegeka, 2020; Ozel & Luft, 2013). Such common essential features of inquiry include questioning and investigating while overlooking the less common but essential features of inquiry such as analysing data, drawing conclusions, and communicating findings. Demir and Abell (2010), in their phenomenological study of four beginner teachers in the USA, revealed that teacher views on inquiry were incomplete because they did not include crucial aspects of inquiry as detailed in NRC 2000. The teachers indicated inquiry as entailing learner-generated questions and data collection while missing developing explanations, justifications, and communication in their definitions.

Niyitegeka (2020) used everyday teaching scenarios to investigate Rwandan primary science teachers' understanding of IBL. Findings revealed that Rwandan science teachers' understanding of IBL was limited to asking and answering questions; teachers clearly missed other IBL scenarios as described in the Rwandan Competency based curriculum (learner poses a question, learner plans investigations and conducts their own experiments, learner proposes explanations, learner constructs and tests explanations against current scientific knowledge and learner communicates ideas to others (MINEDUC., 2015; Niyitegeka, 2020). It was concluded, therefore, that Rwandan upper primary science teachers have an incomplete understanding of IBI.

The reviewed studies illuminate teachers' understanding of IBL at all levels of learning from primary schools to colleges. The most common finding in these studies is that science teachers demonstrate a diverse understanding of inquiry. While the majority of the teachers relate inquiry to a form of learning that is driven by teacher or learner questions, many think that inquiry entails some sort of hands-on activity (Capps et al., 2016). These diverse, and sometimes limited understandings influence the ways in which IBL is facilitated in school science (Capps et al., 2016; Crawford & Capps, 2016).

## **2.6 Nature of Inquiry-Based Learning**

The National Science Education Standards (NSES) argues that classroom inquiries can take different forms ranging from partial to full inquiries (NRC, 2013). NRC (2000) explains that full inquiries involve all the essential features of inquiry while, in partial inquiries, learners may be engaged in some of the essential features of inquiry. Moreover, NSES explains that inquiry-based learning (IBL) can differ in the “amount of structure, guidance, and coaching provided by teachers to learners engaged in inquiry” (NRC, 2000, p. 28), with increased responsibility for learners to pose questions, design investigations, gather data and communicate the results, the inquiry is more open whereas with less learner responsibility, the inquiry is deemed more structured or guided (NRC, 2000). IBL has been distinguished into three levels: structured, guided and open (Çavas et al., 2013; Lelebicioglu et al., 2017).

### **2.6.1 Structured Inquiry**

Structured inquiry is highly prescribed and characterised with teacher-led instruction in which students have minimal freedom for decision making (Çavas et al., 2013; Lelebicioglu et al., 2017). The teacher provides a problem to be investigated with a predetermined procedure for students to execute. Even though students are asked to interpret the findings, they follow a narrow, pre-determined line of thinking (Cavas, 2012; Çavas et al., 2013).

### **2.6.2 Guided Inquiry**

Guided inquiry has less structure compared to structured inquiry, as the teacher provides the scientific question to be explored by the learners, and the teacher guides the learners; however, students hold much of the responsibility for most of the scientific investigation activities (Çavas et al., 2013; Lelebicioglu et al., 2017). Guided inquiry provides students with the freedom to determine the inquiry procedures as well as interpret the findings and draw conclusions (Cavas, 2012; Çavas et al., 2013). Therefore, students share responsibility with the teacher to some extent in guided inquiry.

### **2.6.3 *Open Inquiry***

Full or open inquiry requires learners to take full responsibility for the scientific investigation activities, such as generating the scientific question, designing and conducting the investigation, and analysing and reporting data (Çavas et al., 2013; Leblebicioglu et al., 2017). However, the teacher provides a framework for the inquiry while relinquishing responsibility for the students to dictate the inquiry process. Inquiry can take the form of literature, media, field or laboratory based, and teachers and students must negotiate on the use of equipment, objects, phenomena to be investigated, source of information and the type of inquiry (Tal et al., 2019).

### **2.6.4 *Review of Past Studies on Nature of IBL***

Teachers adopt diverse practices while facilitating the different types of inquiry. Teachers need to scaffold, guide and coach students to some extent. The strategies teachers use to scaffold learning during inquiry-based learning (IBL) essentially determine how learners experience IBL and the extent of learner autonomy (LA) experienced by students (Furtak & Kunter, 2012). A series of research scholars have alluded that teachers' knowledge of IBL guides its implementation (Capps & Crawford, 2013; Capps et al., 2016; Ozel & Luft, 2013). Therefore, it is crucial to investigate teacher practice of IBL to determine whether there is a link with teacher knowledge of IBL. This section reviews the literature based on teacher utilization of IBL in school science.

Several studies have revealed that science teachers' adoption of IBL ranges from frequently adopted, according to studies based on teacher reports (Capps et al., 2016; Marshall et al., 2009), to rarely adopted, based on observational studies (Capps & Crawford, 2013; Crawford, 2014; Kim & Tan, 2011; Tosa, 2011). The self-reported scores have validity issues and can lead to conclusions that are based on poor quality data (Capps et al., 2016). However, self-reports, when combined with classroom observations, may help researchers untangle the nascent challenge of minimal adoption of IBL by enhancing the understanding of what teachers

think IBL is and identifying core characteristics of IBL.

A study by Capps et al. (2016) revealed that teachers' over-reported frequency of IBL was based on a naïve knowledge of IBL. It is assumed that with naïve or incomplete knowledge of IBL, teachers' reported frequency is suspect. If the determined effects of IBL on learning outcomes are based on inaccurate reported frequency of IBL, then conclusions drawn based on such reports could be misleading. Capp's study revealed that reported frequency had no relationship with knowledge of IBL, and called for further studies on teacher knowledge and practice of IBL using diverse measuring instruments to capture actual classroom practice. Information gathered through this process can be used to provide teachers with the correct conceptions about IBL thus supporting them in changing their teaching practices.

A study by Capps and Crawford (2013) investigated teachers' understanding and practice of inquiry among 26 highly qualified 5<sup>th</sup>-9<sup>th</sup> grade teachers in the USA. Lesson descriptions, classroom observations, questionnaires and interviews were used to gather data about teachers' understanding and practice of IBL. The researchers determined that the studied teachers had a limited understanding of IBL. Classroom observation showed that features of inquiry, including abilities, understanding as well as essential features, were observed or described in fewer than half of the classrooms under investigation. It was further reported that when inquiry was undertaken, it was largely teacher-initiated and directed, therefore, a structured inquiry.

Niyitegeka (2020) sought to determine Rwandan upper primary science teachers' implementation of IBL using the Electronic Quality of Inquiry protocol. Findings showed that the majority (17) of the teachers were in the pre-inquiry level (level 1), whereas 3 of the teachers were in the developing inquiry level (level 2). Niyitegeka (2020) reported that teacher-directed pedagogy was predominantly adopted in science classrooms. Teachers in level 1 promoted rote learning and memorization while emphasizing and rewarding correct answers.

In contrast, teachers in level 2 engaged students in various activities and concepts; however, the activities were highly prescriptive and did not require learner critical thinking.

International comparative studies on teachers' knowledge and use of IBL have revealed that teachers in different countries understand and use IBL in diverse ways. For instance, a study by Romero-Ariza et al. (2019) revealed that English and Spanish teachers hold the same positive views about the benefits of IBL. They revealed that IBL enhances learner motivation as well as science teaching. However, the teachers from the two countries had different experiences with the enactment of IBL. Whereas English teachers reported that they frequently used IBL in their science classrooms, Spanish teachers reported that they used IBL less frequently and that they struggled with managing group work.

Oliver et al. (2019) used PISA 2015 data to compare associations among instructional strategies for students across 6 countries. This study inquired into the efficacy of IBL, adaptive and teacher-directed teaching. IBL practice was measured using student reports on the frequency at which teachers used specific IBL related strategies. It was revealed that students who reported a high frequency of IBL in their science classrooms demonstrated low level scientific literacy across the six countries: England, Canada, Australia, Ireland, New Zealand, and the USA. A positive association was found between the frequency of teacher-directed and adaptive teaching strategies and student scientific literacy across the six countries. It was further reported that different elements of IBL are differentially associated with students' scientific literacy. This study utilised student reports on the frequency of IBL, and this may present a substantial problem for the following reasons: firstly, learners may not be able to distinguish which teaching strategy is IBL; secondly, the learners may not remember the frequency of usage of IBL in their science classrooms; and lastly, the learners may underestimate or overestimate the usage of IBL strategies in their science classrooms. As such, the interpretation of these findings should be treated with care, as the frequency of IBL may

not be a true reflection of the actual classroom practice.

Despite the numerous studies on teacher knowledge and practice of IBL, there is insufficient observation data to accurately demonstrate the link between teacher knowledge and practice of IBL, especially as there is a lack of data to show how teacher knowledge of IBL influences the nature of IBL facilitated, and how the nature of the facilitation of IBL influences how learners experience LA. By exploring the teachers' understanding of IBL along with their practice, it may be possible to identify teacher instructional practices that may promote or inhibit LA in school science.

## **2.7 Learner Autonomy**

There are a plethora of meanings and understandings associated with learner autonomy (LA) in the field of education. Holec's seminal definition of LA has been essential in the development and evaluation of LA in educational settings. Holec (1979) described LA as "the ability to take charge of one's own learning" (p. 8). This ability may include taking responsibility for "determining learning goals, defining content and progressions, selecting methods and strategies to be used.....as well as evaluating what has been learnt" (p. 4). However, it has been argued that Holec's definition only focuses on what learners can do (self-management skills) without focusing on how they can do it (cognitive abilities) (Benson, 2011). Despite this criticism, the seminal definition by Holec formed the basis for further research around LA. The concept of LA is regarded as an important educational outcome (Benson, 2000).

LA has continued to gain much attention across the globe, and is closely associated with constructivist and learner-centred theories. Even though there is no single universal theory for autonomy, there is consensus that autonomy is important in educational settings. Murphy (2011) argued that autonomy can take different forms based on the learning context and learner characteristics. LA has conceptual overlaps with IBL and needs to be understood in order to

fully understand IBL.

### ***2.7.1 Definitions of LA***

Jean Piaget conceptualized autonomy and heteronomy in terms of morality when he discussed the goal of education (Kamii, 1984; Kamii et al., 1994). Piaget defined autonomy as an individual's ability to self-regulate and think for themselves (Kamii, 1984; Kamii et al., 1994). After Holec's seminal definition of LA in 1979, Kamii (1984) explains that autonomy entails governing one's actions and is contrary to heteronomy which implies one's actions being controlled or governed by others. Children are supposed to become more independent and autonomous as they grow older; however, this occurs infrequently and unpredictably (Sheffield, 2017). The nature of adult-adult interactions determines how children develop and become autonomous as they grow older (Kamii, 1984). The frequent use of rewards and punishments supports children's natural heteronomy, whereas the provision of opportunities for children to share ideas fosters the development of autonomy (Kamii, 1984; Sheffield, 2017). This typical case applies to caregivers which includes teachers and parents (Sheffield, 2017).

Dam (2003) describes LA as a learner's capacity to accept responsibility for their learning (p. 135). Hence, LA can be taken to mean learners' ability to take responsibility of their learning as well as utilising their knowledge for independent learning. Ramnarain (2010) defined LA as independent learning where learners work on their own with some teacher guidance (p. 3). Hence, LA may involve a teacher, who is in a position of authority, assuming the perspective of a student, acknowledging their feelings as well as offering choices in various stages of learning (Reeve et al., 2004; Roth et al., 2007).

Due to the complex nature of the term LA and the lack of a commonly accepted definition, numerous terms are used synonymously to refer to LA in different contexts (Broad, 2006). Murase (2015) explains that autonomous learning and independent learning are frequently used as synonyms or interchangeably. Morrison (2011) asserts that independent

learning, self-directed learning, independent study, and self-regulated learning are also used as synonyms. The phrase “autonomous learners” may refer to self-regulated learning (Weinstein et al., 2011). In this study, the term LA will be used predominantly. In some situations, “autonomous learners” will be used to refer to those students in the act of learning independently.

A review of the literature on autonomy has shown that there has been a shift from independence towards interdependence or collaborative learning (Benson, 2011; Murase, 2015). Autonomy does not mean that the learner is totally independent of the teacher, peers and others in the learning environment, rather it entails the aspect of mutuality and collaboration in the learning process (Benson, 2011; Murase, 2015). Benson and Cooker (2013) supported this idea by explaining that the concept of LA is understood as a ‘social capacity’ whose development process entails ‘interdependence’. Aspects of interdependence may include individuals working in groups. The changing nature of the understanding of LA means as more studies are conducted, new insights into LA are developed. Based on the diverse definitions around LA, understanding of the concept has been organized around the following themes: LA as ability, LA as autonomy supported, and LA as autonomy demonstrated.

**Learner Autonomy as ‘ability’.** There is a call for a simpler definition for LA because autonomy takes various forms in the way it manifests itself; however, Benson asserts that the problem with LA lies with the way autonomy is described (Benson, 2011; Benson & Cooker, 2013). Benson (2011) defined LA as ‘the capacity to take control of one’s own learning’ (p. 58). Benson asserts that the construct of ‘control’ is more concrete than constructs like ‘charge’ or ‘responsibility’ when compared with prior definitions of LA. Benson further argues that autonomy consists of three components that may be overlapping: freedom, desire, and ability. Freedom refers to the space that learners are given to control their own learning (Benson, 2011).

Desire is the learner's wish to engage in a given/specific learning activity (Benson, 2011), while ability refers to the knowledge and skills involved in learning.

The current study is concerned with the freedom construct, and what teachers do to ensure freedom is extended and utilised. Therefore, in this context, freedom will be taken to refer to 'learner autonomy supported' and as such, the study investigated teacher autonomy supportive practices, henceforth referred to as 'learner autonomy supported' (LAS). Numerous authors have argued that this construct is a pre-requisite and condition for LA (Benson, 2013a).

**LA as autonomy supported.** Learner autonomy supported refers to teacher actions that provide learners with opportunities for choice. These practices are commonly known as teacher autonomy-supportive practices. Reeve (2016) defined autonomy supportive practices as teacher instructional efforts meant to nurture and motivate student autonomy. These are the practices that provide learners with opportunities to manifest LA. The autonomy supportive practices as categorised by Stefanou et al. (2004) were investigated: organizational, procedural and cognitive autonomy support.

**LA as a complex system.** Despite several researchers conceptualising LA as the ability or capacity of learners, there is a group of researchers who do not conceptualise LA in this way (PaivaI & Braga, 2008; Willis, 2011). PaivaI and Braga (2008) view LA as a complex system which comprises different interrelated elements. In their view, LA is defined as "a complex socio-cognitive system, subject to internal and external constraints, which manifests itself in different degrees of independence and control of one's own learning process" (PaivaI & Braga, 2008, p. 447). As a complex system, LA is dynamic, erratic, non-linear, malleable, self-organizing, and sensitive to initial conditions and feedback (PaivaI & Braga, 2008, p. 447). This definition captures the complete image of LA, which makes it overwhelming for teachers and practitioners to conceptualise the integration of the distinct elements in their teaching.

The literature review has shown that LA is understood and conceptualised in diverse ways by different scholars. As such, LA is portrayed as a complex and multi-dimensional construct (Benson, 2011; Lamb, 2017; Little, 1991). When viewed through multiple perspectives, the diverse understandings of LA might reveal the different aspects of LA. However, these multiple understandings might overwhelm both researchers and practitioners. Hence, it might be necessary for researchers to offer an explicit, and clear definition of what LA means in their study.

**LA in this study.** This study sought to determine teacher-autonomy supportive practices, and what learners do with the opportunities that are extended to them. In this study, the perspective of teacher support of LA is referred to as *learner autonomy supported (LAS)*, and what students actually engage in is called *learner autonomy demonstrated (LAD)*. LAS comprises the practices teachers adopt to create opportunities for learners to exercise control over their learning. LAD depends on learners' ability as well as LAS. As such, this study focused on *learner autonomy supported* that affects *learner autonomy demonstrated*.

### **2.7.2 Benefits of LA**

LA has numerous benefits in the learning process. For instance, Sund and Trowbridge (1973) reported that with enhanced LA, there is increased learner engagement, motivation and achievement. LA also contributes to enhanced learner enjoyment of learning, competence, and better learning outcomes (Reeve et al., 2004; Rogat et al., 2014) and increased motivation (Haerens et al., 2015). Smith et al. (2018) explained that LA is important to learners because it trains them to make independent decisions and become critical thinkers, which are crucial skills for adult life. Hence, LA is an important attribute which should be facilitated in science classrooms. It has also been shown that students with greater autonomy demonstrate a greater perceived academic performance (Deci et al., 1981), enhanced academic performance (Boggiano et al., 1993) and self-regulation (Turner et al., 2003), increased learning effort (León

et al., 2015), task engagement and performance (Patall et al., 2010).

### **2.7.3 *Misconceptions of LA***

Despite numerous studies showing the importance of LA in learning, several misconceptions about LA exist. Firstly, there is a misunderstanding between LA and self-instruction, in which these two terms are treated as synonyms. Additionally, learners being autonomous is assumed to imply learners learn without teachers, and, as such, teacher interventions are seen as barriers to the development of LA (Little & Leni, 2017). With this kind of perception, teachers' roles may be threatened (Benson & Voller, 2013). Furthermore, it is also believed that LA means learners making decisions about every aspect of their learning in autonomous classrooms (Dam & Legenhausen, 2011). These misconceptions may interfere with teachers' roles in IBL.

Secondly, LA has been understood as a simple, and easy to describe attribute (Little & Leni, 2017, pp. 3-4). This kind of understanding oversimplifies the fact that LA is a multi-dimensional and complex concept (Benson, 2013b), and that a learner may demonstrate higher levels of autonomy when performing certain tasks and lower levels of autonomy when performing other tasks. Hence, LA can be fluid and non-linear.

Another potential LA misconception is that teacher autonomy leads to LA. Little and Leni (2017) proposed that teacher autonomy is a prerequisite for LA. This proposal may make sense in that teachers who know what it entails to be autonomous may know what to expect from learners. Moreover, teachers without experience in developing and promoting LA may find this unsettling. Yet, Aoki (2002) still posits that being an autonomous teacher does not guarantee ability and willingness to support learner autonomy. The most important factor in supporting learners to develop LA is understanding LA, its importance and how to teach the concept of autonomy (Nakata, 2011). Moreover, Nakata argued that when teachers experience autonomy during collaborative projects that entailed implementation of self-directed learning,

they learn the principles of Self-Regulated Learning (SRL) and gain better skills in implementing SRL during classroom instruction (Lau, 2013). However, Little and Leni (2017) argued that if teachers do not have experience with autonomy, they may feel unable to develop LA and thus exacerbate their resistance to the adoption of IBL approaches that support the development of LA.

#### **2.7.4 *Role of Learner in LA***

The role of the learner in LA has been explored in the definitions of LA already presented earlier in this chapter. Holec's definition suggests that learners have a role to play in setting their own learning goals, selecting content and methods as well as monitoring and evaluating their learning (Holec, 1981).

The LA concept deals with learners' freedom, control, capacity and responsibility for their learning. However, learners in primary schools may not fully understand this. Learners need to understand that autonomy offers them opportunities to experience some freedom in their learning, but not to be totally independent of the teacher (Benson, 2010; Little & Leni, 2017). Autonomy relies on the concept that learners will assume more control and responsibility for their learning (Benson, 2011, 2013b; Little, 1995). Teachers will therefore allow students to share control over the learning process.

Teachers can promote learners' control and responsibility through active engagement in the learning process. Several studies have demonstrated that active engagement in learning enhances learners' ability to assume more control and responsibility in their learning. Kahn et al. (2013), in their study of inquiry and LA, revealed that when teachers offer opportunities for decision making and planning investigations, learners explore more. Involving students in determining learning materials increases LA (Rogat et al., 2014). Huang and Benson (2013) reported that when students' authority in making choices and decisions is supported, they develop the capacity to share control with teachers. Therefore, to develop LA there is a need

to allow learners to share responsibility for their learning.

### **2.7.5 *Role of the Teacher in LA***

Teachers need to shift their roles from transmissive teaching to facilitative teaching in order to support and foster LA (Little, 1995). Teachers have demonstrated an awareness of their role when required to foster LA, as they assumed the role of a facilitator by sharing control of the classroom with their students (Feryok, 2013; Kahn et al., 2013). Teachers' awareness of their new roles appears to influence their choice of teaching practices to those that support the development of LA (Feryok, 2013).

Teachers' awareness of their new roles in teaching, however, might not influence their desire to support the development of LA. Nakata (2011) reported that despite Japanese EFL high school teachers acknowledging the value of developing both teacher and LA, they did not promote LA in practice. The Japanese teachers averred that lack of time due to examinations and workload meant they could not foster LA. Additionally, the teachers posited that they had a nascent duty to determine learning goals, hence it was difficult to abandon that duty to focus on LA.

Teachers' readiness and ability to facilitate learner active participation in learning determines the level of control exercised during teaching. Dörnyei (2001) explained that when teachers are ready to promote LA, they will create a supportive learning environment that promotes learner engagement. LA can be promoted by offering opportunities for learners to make choices about learning objectives, activities and content (Reeve, 2016).

The importance of teacher support and guidance has been revealed as a critical aspect that promotes LA. A study of 16-19 years olds in Selby College in the UK reported that students appreciated the support and guidance offered by teachers as it promoted their ability to engage in independent learning (Broad, 2006). The study revealed that students perceive teacher support and guidance as a critical component of developing LA.

To develop LA, teachers as facilitators may need to consider other factors that influence the development of LA, for example, motivation. Reinders (2010) explained that learners require both the ability (skills and knowledge) and willingness to be able to successfully develop LA. Without these two ingredients, learners may not be ready to accept the shared responsibility of the learning process with the teacher. It has been suggested that the process of autonomy development may contribute to low student autonomy. This was witnessed in a study by Inozu (2011) in which students felt anxious when the teacher shifted the decision making roles while making the learners active participants. Hence, learner motivation may be affected by LA, and learner motivation may affect LA as well.

## **2.8 Teacher Autonomy Supportive Practices**

Within the concept of autonomy, a teacher's teaching style can be examined on a continuum from a highly prescribed to a highly open (Willison, 2018), or a highly controlling to a highly autonomy supportive (Deci et al., 1981; Reeve & Jang, 2006). Autonomy supportive practices entail an individual in a position of power, for instance a teacher or parent, being cognizant of the learner's perspective while acknowledging their thoughts and feelings, and offering opportunities for choice (Reeve et al., 2004; Roth et al., 2007). Teachers who are autonomy supportive tend to activate learners' goals and interests. Studies around autonomy support have revealed that autonomy supportive practices have a positive impact on learner engagement (Barber & Buehl, 2013; Black & Deci, 2000). Assor et al. (2002, p. 273) posit that the essence of student autonomy support is to ensure that the teacher remains useful in ensuring learners have adequate support to realise their learning goals.

Teachers who are on the supportive end of the autonomy spectrum may be more knowledgeable about IBL and LA, as well as being more comfortable offering experiences which involve their students in the learning process. In contrast, teachers who fall on the controlling end of the autonomy spectrum may be less knowledgeable about IBL and LA and

more uncomfortable in offering experiences which support the development of autonomy among learners. It is important to investigate these practices in an IBL environment that strongly emphasises the adoption of IBL in science classrooms. This will assist in determining whether there is a need to support teachers to learn how to better facilitate learner engagement.

Research studies based on Self-Determination Theory (SDT) theory have revealed that autonomy supportive teachers listen to their students, allow students to manipulate instructional materials, endorse classroom tasks, communicate relevance, need and purpose of classroom tasks, listen and ask for student opinions, and respond to learner-initiated dialogue and learner emotional perspectives (Großmann & Wilde, 2020; Reeve, 2016; Reeve & Jang, 2006; Reeve et al., 2004). These practices nurture LA because they emphasize the significance of schoolwork in ensuring learners realise their personal goals and interests. Other behaviours perceived by learners as being autonomy supportive include the amount of positive feedback and student choice (Deci et al., 1991). Assor et al. (2002) investigated teacher autonomy support in the light of the SDT. This study identified three teacher autonomy supportive behaviours: fostering relevance, allowing criticism, and providing choice (Assor et al., 2002).

Stefanou et al. (2004) conducted an observational study that identified different types of autonomy offered by teachers: a) organizational, b) procedural, and c) cognitive. Organizational autonomy entails offering learners the opportunity to assume ownership of the learning environment, as well as involving learners in developing classroom rules, selecting group members, and deciding due dates for assignments. Procedural autonomy may include teacher practices such as learners choosing learning materials, and learners deciding how to present content, whereas cognitive autonomy encourages students to assume ownership of their learning. Teacher practices may include opportunities for learners to solve problems, become independent problem-solvers, and allow free debate (Sheffield, 2017; Stefanou et al., 2004).

A study by Bozack et al. (2008) delved into teacher-student autonomy support behaviours in comprehensive school reform classrooms. The study utilised Grades 3, 4 and 5 observational data. The study revealed that eight autonomy support behaviours suggested by SDT were present. This study further reported that despite teachers supporting learners to gain LA, they did not take learner perspective into consideration. Bozack further revealed that learners were frequently encouraged to talk, and teachers responded to learners' questions.

Reeve and Jang (2006) investigated what teachers say and do that affects LA. Autonomy behaviours were measured on a continuum from highly controlling to highly autonomy supportive. The following behaviours were identified as being autonomy supportive: seeking learner input during lesson planning, offering opportunities for learners to work out their problems, and demonstrating the significance of classroom tasks (p. 210).

Ramnarain and Hobden (2015) reported that different strategies were used to support LA during secondary school physical science investigations in South Africa. Observational data revealed that teachers prefer offering support to learners during science investigations while not supporting student independent discovery. It was further reported that teachers adopted diverse support strategies at different stages of the investigation. The following strategies were identified: using a prompt sheet, instructing learners in the use of practical techniques, asking questions at all stages of the investigation, and offering suggestions to learners when they are stuck. It was further revealed that the level of support decreased gradually from choosing a topic, formulating the question, planning, collecting data, analysing data and drawing conclusions. As this study did not investigate teachers' knowledge of IBL, it is not possible to link teachers' support strategies to their knowledge of IBL. Moreover, this study did not investigate strategies that limited student autonomy, and never determined learner actions towards teacher autonomy supportive and inhibitive practices during science investigations.

## 2.9 Learner Autonomy Demonstrated

The degrees of autonomy are well discussed in literature (Huang & Benson, 2013; Littlewood, 1999; Nunan, 1997). There have been several attempts to develop hierarchical models of LA. Nunan (1997) developed a model with five levels of autonomy based on students' actions around content and process domains: *awareness, involvement, intervention, creation* and *transcendence*. This model was based on language theory hence insufficient to reflect LA, which is a socially mediated multidimensional construct (Dang, 2012).

Valenčič Zuljan (2007) developed a model with four levels also based on learner responsibilities: receiving, participation, constructive participation, and personal growth. This Model takes into consideration student roles in the description of LA. The receiving role was defined as the students following the learning content as presented by the teacher and may ask questions if they encounter difficulties. The participation role describes a student with more freedom in taking some actions while learning. The constructive participation role describes a student having responsibility in deciding the content to be covered and participating in giving learning suggestions thus influencing teacher actions. The personal growth role describes a learner with greater responsibility who suggests ideas, creates knowledge and solves problems. As much as these roles seemed appropriate, they were limited to the extent they described student actions in reaction to teacher actions.

Littlewood (1999), while seeking a definition for LA that was not based on culture, proposed an autonomy framework based on levels of 'self-determination'. This framework proposed two levels of autonomy: proactive and reactive autonomy. Littlewood indicated that proactive autonomy controlled the activity and the direction of the activity (Littlewood, 1999). Students determined the learning agenda, enacted activities to meet the learning agenda, and assessed the learning outcomes. Reactive autonomy refers to students engaging in an activity once the activity has been decided by another person (Littlewood, 1999; Trần, 2019).

This study utilised Littlewood's models for autonomy to create the *learner autonomy demonstrated (LAD)* framework (see Chapter 3 model for analysing LAD). Littlewood's model depicts the relationship between teachers and students, hence necessitating the characterisation of student behaviours. Additionally, Littlewood's framework considers the classroom interpersonal environment which may bolster LA (Trần, 2019). This model was modified by Trần 2019 while adding one level below reactive autonomy '*compliant autonomy*' (Trần, 2019). The current study, as detailed in Chapter 3, added two levels, one level before the level added by Trần, that is *underdrive autonomy*, and another level after *proactive autonomy*, that is, *overdrive autonomy*. These levels were important as they necessitated the characterisation of student behaviour that was not aligning with the three levels already developed.

## **2.10 Relationship between IBL and LA**

Learner-centred teaching approaches such as inquiry-based learning (IBL) are grounded in the principle that learners are the focus of the learning process (NRC, 2012). This implies that learners must be given opportunities to interact with knowledge, and therefore gain some level of control of the learning process. This level of learning autonomy fundamentally changes how learners experience IBL. LA is intimately intertwined with inquiry (Kahn et al., 2013). Therefore, teachers can foster LA by facilitating high quality IBL which supports learners to move towards higher levels of autonomy. In high quality IBL lessons, learners are offered opportunities to generate investigative questions as well as find answers to the questions (Ramnarain, 2010).

Science teachers are expected to facilitate and provide authentic learning experiences which allows learners to direct their own learning (Crawford, 2000). Learners are encouraged to develop, refine and articulate their ideas, thus becoming independent (Benson, 2013b). However, paradigm shifts from teaching approaches that are teacher-centred to learner-centred approaches require teachers and learners to adopt new roles that foster LA and do not occur

smoothly (Jacobs & Shan, 2016). Moreover, teachers' abilities to successfully shift their roles and allow learners to own the learning process can be affected by several factors including teacher confidence, class size, teacher beliefs and knowledge (Kahn et al., 2013; Ramnarain, 2010; Ramnarain & Hobden, 2015).

A rare study into the extent of learning autonomy in secondary school science in South Africa, considered the case of Grade 9 students when carrying out scientific investigations. Ramnarain (2010) used qualitative and quantitative approaches to determine that learner-experienced different levels of autonomy at different stages of scientific investigations. The study reported that students experienced different levels at different stages of the investigation, beginning with highly structured when determining questions for investigation and open when interpreting data. Byrne et al. (2016) in investigating IBL in a UK infant classroom revealed that teachers' confidence in IBL allowed the teacher to relinquish some authority and allow learners more freedom to experiment, thus increasing learner autonomy and self-regulation.

Science teachers adopt diverse practices and strategies to support LA in science classrooms. A study by Kahn et al. (2013) revealed that high school teachers of the deaf in the US used open-ended questions, consented to debate and collaboration, appreciated alternative opinions, and offered learners opportunities to fail as strategies to enhance LA. This study also revealed that some teacher characteristics, such as over-guiding and ignoring students' views, limited LA and stifled inquiry. Rogat et al. (2014), in their inquiry into autonomy relevant practices in inquiry settings, determined that 7<sup>th</sup> grade teachers supported learners at different levels across the five dimensions of autonomy: organizational, procedural, relevance, responsiveness, feedback, and cognitive autonomy. These studies, besides determining the autonomy support practices adopted by teachers, did not determine teachers' knowledge of IBL and whether that knowledge of IBL influenced the autonomy support practices that were adopted. Additionally, these studies did not investigate student reactions to autonomy

supportive practices. Hence, the current study besides investigating teacher autonomy supportive practices, investigated student responses to the autonomy supportive practices.

Ramnarain (2020) investigated students' experiences around autonomy when participating in scientific investigations during a science fair in South Africa. Questionnaires and student interviews revealed that students experienced high level autonomy across four phases of inquiry: identifying questions, planning the inquiry, conducting the inquiry and drawing conclusions. This autonomy allowed learners to engage in authentic inquiry, utilise their creativity as well as demonstrate their critical thinking skills. It was further revealed that teacher support during science fair was limited, and as such, students appeared to thrive in this environment.

## **2.11 Contextual Factors**

Context has been defined as a multilayered concept with the potential to influence learning, especially how teachers interpret and implement the curriculum (Denscombe, 2017; Hackling et al., 2017). Classrooms and schools are entrenched in a complex social and cultural context that may impact the development of teachers and students (Hackling et al., 2017). Several contextual factors can influence how schools and classrooms operate, as well as how science teachers facilitate learning. Lewthwaite (2006) described factors influencing science teachers' practice beginning with their own knowledge and beliefs, support from teacher colleagues, school expectations and priorities, parental and community expectations pertaining to the teaching of science, and curriculum policy, as well as the emphasis on professional learning.

Diverse contextual factors such as school context and school philosophy (Hackling et al., 2017), student demographics (Hackling et al., 2014), and physical learning spaces (Hackling et al., 2017) influence classroom culture and instructional practices, which may in turn influence how teachers facilitate IBL and LA. The literature review for this study's

contextual factors focused on student characteristics and classroom culture, since teacher knowledge of IBL and LA has been reviewed.

There is a growing body of evidence that shows that student characteristics and culture have an effect on student achievement (Thomson et al., 2021). Low participation and achievement of socially disadvantaged students is a global and local challenge (Hackling, 2014). The key indicators of high quality educational systems according to the OECD: quality teachers and equitable and quality education (Stewart, 2012). Quality teachers create a supportive learning environment that fosters learning for all students (Stewart, 2012), whereas quality education systems provide access to quality education for all students (Stewart, 2012).

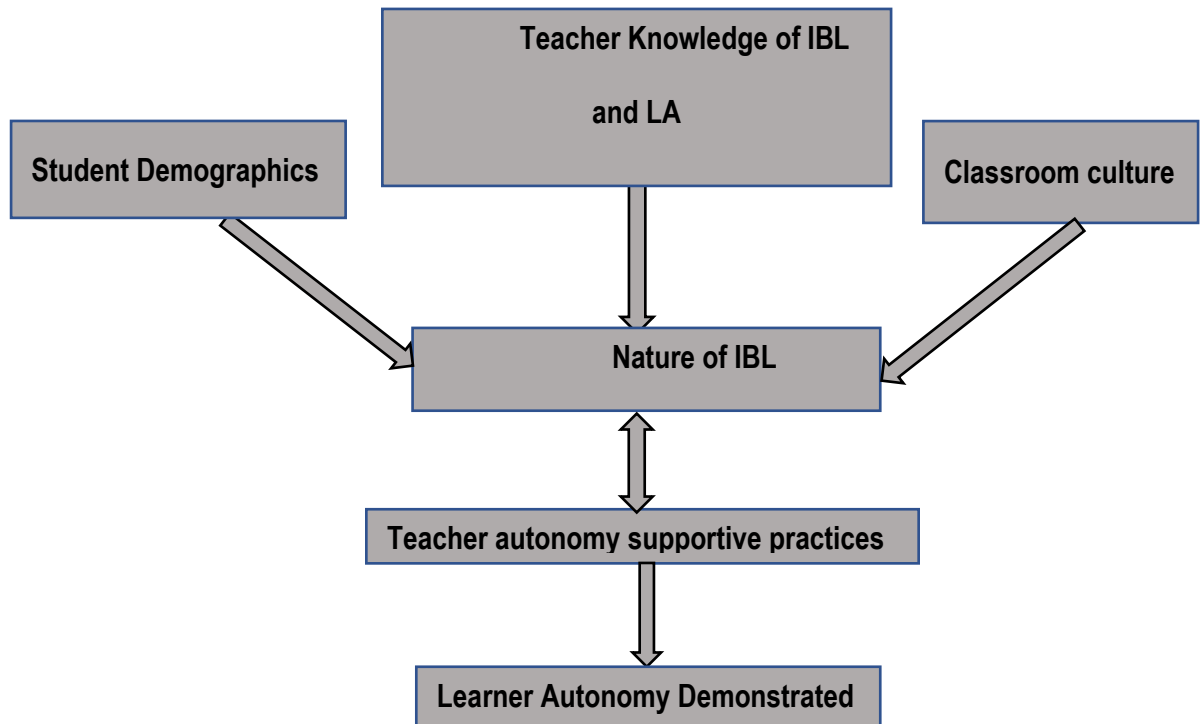
Quality teachers a supportive classroom culture that fosters students' active participation and includes students expressing their opinions with confidence. To achieve this, however, teachers may need to teach classroom participation rules (Darling-Hammond et al., 2020; Hackling et al., 2010). While a supportive classroom culture is important, the nature of science topics is important in influencing the nature of IBL facilitated as some topics may be best taught using explicit instruction (de Jong et al., 2023; NRC, 2000).

## **2.12 Conceptual Framework**

This study is viewed through social constructivism theories in which the key focus is how teachers' knowledge of IBL and LA influences teacher autonomy supportive practices and learner autonomy demonstrated (LAD) in school science. There are many factors that influence teachers' instructional practices, for example, teachers' personal philosophy, teachers' beliefs, knowledge, theories, contextual factors including student abilities and characteristics, and cultural factors and physical learning spaces (Hackling et al., 2017; Thomson et al., 2021).

All these aspects play a fundamental role in influencing teacher practice; however, this study sought to focus on how teacher knowledge of IBL and LA influence the nature of IBL practice and teacher autonomy supportive practices adopted and LAD. Therefore, the nature of

IBL, LAS and LAD are underpinned by the teachers' knowledge of IBL and LA, which also encompasses teacher beliefs and philosophy and contextual factors such as student demographics and classroom culture as exemplified in Figure 2.1.



*Figure 2.1.* Conceptual Framework

The conceptual framework in Figure 2.1 illuminates the conceptualisation of the study as it depicts the associated links among the variables in the study. The framework shows that teacher knowledge of IBL and LA, student characteristics and classroom culture may influence the nature of IBL facilitated. Moreover, the nature of IBL facilitated may influence the nature of teacher autonomy supportive practices employed in science classrooms. Similarly, the nature of teacher autonomy supportive practices employed may influence the nature of IBL facilitated. Lastly, teacher autonomy supportive practices may influence learner autonomy demonstrated.

## Chapter 3 Research Design

This chapter describes the research design that was utilised to investigate primary teachers' knowledge and practice of inquiry-based learning (IBL) and learner autonomy (LA). The first section introduces the qualitative research approach. The second section discusses the data collection methods and procedures including case selection, research site and participants. The third section discusses the data analysis procedures. The fourth section discusses the measures adopted to ensure the quality of the research design is maintained. Lastly, the ethical issues in the study are presented.

### 3.1 Research Approach

Consistent with social constructivist theories, this study adopted qualitative multiple case study and cross-case analysis approaches to investigate how Year 4 teachers defined and facilitated IBL and LA in school science.

#### 3.1.1 *Qualitative Case Study Design*

This study adopted a qualitative study as the framework for investigating IBL and LA in school science. Qualitative research has been defined as a valuable research approach for studying complex phenomena as it entails an in-depth investigation of behaviours and their motives (Denzin & Lincoln, 2018). The following qualities have been ascribed to qualitative research: it is accommodated in a mainstream, classroom setting; the researcher is the key instrument in making meaning; it is interpretive in character; it uses multiple methods; it involves complex reasoning through deductive and inductive logic; it is reflexive; it takes a holistic account of the problem under investigation; it takes an emergent design approach; it pays attention to participant meanings; and, it uses expressive language and voice (Creswell, 2013; Creswell & Poth, 2016; Eisner, 2017). A case study approach was selected from the numerous types of qualitative research as the principal approach for this study because a detailed focus on the teacher as a unit of analysis was the most effective way to address the

research questions and provide deep insights into the phenomena under investigation.

Due to the varying nature of the application of case studies in different disciplines, as well as the diverse theoretical stances underpinning case studies, there has been an ongoing lack of a generally accepted precise definition of a ‘case study’ (Simons, 2009). However, scholars and researchers have consistently agreed that case studies are useful when seeking in-depth explorations of phenomena (Merriam & Tisdell, 2015; Simons, 2009). Researchers contend that case studies normally focus on the particularity, complexity and uniqueness of phenomena (Merriam & Tisdell, 2015; Miles et al., 2014).

A qualitative case study was selected for this study because it presents numerous advantages. Firstly, a case study backs up the description and exploration of a phenomenon within its context as it utilises different sources of data and different perspectives, thus facilitating the uncovering and understanding of various aspects of a phenomenon (Merriam & Tisdell, 2015; Simons, 2009). A case study facilitates an in-depth investigation of complex phenomena (Denscombe, 2010, 2017). Hence, a case study design is appropriate for the study of IBL and LA because both individually are complex, multifaceted, multidimensional phenomena, and, when studied together, are intertwined, rendering less-rich descriptive methods ineffective. Additionally, a case study allows researchers to gather data from the participants’ perspectives.

A qualitative case study offers the potential for researchers to develop a comprehensive, understanding of the phenomenon under investigation (Harrison et al., 2017). This is enabled by close cooperation between researchers and participants. The ensuing trust allows participants to tell their stories through which researchers can uncover underlying motives (Baxter & Jack, 2008; Denzin & Lincoln, 2018). Additionally, a case study approach is flexible (Simons, 2009), as it permits researchers to use multiple data collection methods (Creswell, 2013; Creswell & Poth, 2016). This is especially useful as the complexities of entwined IBL

and LA require data to be gathered through prolonged observation and interviews to develop understanding.

Despite case study approaches presenting numerous benefits, the case study approach has been criticised for a lack of rigour and reliability (Merriam, 2009) and the problem of generalisation (Denscombe, 2010; Merriam, 2009; Zainal, 2007). These criticisms have been addressed by case study research design proponents. The utilisation of strategies such as peer debriefing, member checking, and audit trails help to address the problems of rigour and reliability (Lincoln & Guba, 1985; Yin, 2011).

Generalisation is not the central goal of qualitative research (Lincoln & Guba, 1985; Merriam & Tisdell, 2015). The concept of ‘transferability’ is commonly portrayed in qualitative research instead of ‘generalisation’ (Houghton et al., 2013; Lincoln & Guba, 1985). Provision of adequate details about the research, especially the research context, methods and procedures, will enable researchers and other readers to make informed decisions regarding the extent to which research findings can be transferred to other contexts, thus addressing the problem of transferability (Denscombe, 2010; Houghton et al., 2013; Lincoln & Guba, 1985).

### **3.2 Research Design**

This study is comprised of two interdependent case studies. The two cases were two teachers, teaching science to the same Year 4 students. Classroom observation and interviews of the two Year 4 teachers teaching science over a period of two terms formed the basis of the study. The two teachers taught the same Year 4 class on different days of the week. Mr Smith taught science on Mondays and Tuesdays and Mrs Jasmine taught STEM on Thursdays. A qualitative case study and cross-case analysis design was adopted to investigate the two cases and generate data to answer the research questions (Harrison et al., 2017).

### 3.2.1 Case Study and Cross-Case Analysis Designs

The purpose of the study guides the nature of the case study design adopted (Baxter & Jack, 2008). This study sought to examine how teachers define and facilitate IBL and LA, including how LA is demonstrated. Observation and interview data gathered from the two interdependent cases, which were contextually similar yet different in the operationalisation of the classes, were used to generate data to answer the research questions.

Table 3.1  
*Characteristics of case studies for this study*

Case study	Number of Teachers	Number of Students	Science Topic
Mrs Jasmine	1 sometimes 2	Minimum of 4, maximum of 35	<ul style="list-style-type: none"><li>• Building structures</li><li>• Sound production- using straw musical instruments</li></ul>
Mr Smith	1	18	<ul style="list-style-type: none"><li>• Ecosystem</li></ul>

The cases were first examined as independent cases, then followed with a cross-case analysis. This allowed for exploration of similarities and differences between the cases (Yin & Donald, 2018).

### 3.2.2 Case Selection

Punch (2014) argues that anything can serve as a case, therefore it is inherently impossible to provide a complete definition of a case. However, Simons (2009) posits that it is vital for researchers to define the case in their study. Stake (1995, p. 2) defines a case as an ‘integrated system’ whereas Miles et al. (2014, p. 28) defined a case as ‘a phenomena in bounded context’ which is ‘separated out for research in terms of time, place, or some physical boundaries’ (Creswell, 2012, p. 465). Yin (2018) stated that cases involve tangible (e.g., individuals, groups, organizations) and less tangible (e.g., relationships, communities, decisions) topics. Keeping with the generally accepted definition of a case as a person, a program, a group, an institution, a community or a policy (Merriam & Tisdell, 2015), a case in

this study took the stance of ‘a person’ and ‘a group’. ‘A person’ in this case referred to a teacher and ‘a group’ referred to the Year 4 students. Therefore, a case comprised of a teacher and his/her Year 4 students. This study was comprised of two teachers: Mrs Jasmine and Mr Smith (pseudonyms), hence forming two cases. However, the two teachers were teaching the same Year 4 students. As such, these two cases were interdependent as they were teaching Science to the same group of students on different days of the week. These two cases formed the unit of analysis with an unusually similar context, the Year 4 class with eighteen students.

The selection of a case is vital in case study research (Harrison et al., 2017). Stake (1995) outlines two rules for case selection: the ability to maximise what can be learnt, and hospitability and accessibility of the case for the study. The selected research site, Rising Star Primary School (RSPS) (a pseudonym), is an R-6 Metropolitan Catholic school located in Adelaide, South Australia, and the case study school had approximately 300 students from Reception to Year 6.

The RSPS’s Index of Community Socio-Educational Advantage (ICSEA) rating was 1072 (ACARA, 2023e). This is above the average value of 1000 for schools in Australia (ACARA, 2023e). ICSEA measures the educational and social advantage or disadvantage at the school level. It is based on student family background data, socio-economic status of the area where students live, proportion of indigenous students, location of the school (metropolitan, rural or remote) and other variables having a strong association with student performance (ACARA, 2023e).

The teaching of science is coordinated at each year level. The focus of the study was the Year 4 class of 2021 comprising eighteen students and their two teachers, Mrs Jasmine, teaching Science on Thursdays and Mr Smith, teaching Science on Mondays and Tuesdays. Mrs Jasmine taught other classes the rest of the week while Mr Smith was teaching in another school when not teaching at RSPS. The researcher was not aware of the teachers’ knowledge

of IBL and LA before the study. The researcher therefore expected to gain an in-depth understanding of teachers' knowledge of IBL and LA, and how the teachers' knowledge of IBL related to IBL enacted, learner autonomy supported (LAS) and learner autonomy demonstrated (LAD).

### **3.2.3 Participant Selection**

This study concerned Year 4 teachers' knowledge and practice of IBL and LA. The study comprised of two Year 4 teachers and students at the selected school. The two teacher participants were a convenient sample as both proved to be 'hospitable' and 'accessible' as the study evolved through the COVID-19 pandemic, characteristics that were of the highest importance at that time. The two teachers were also passionate about science teaching and learning.

Mrs Jasmine, sometimes co-taught Science lessons with her Year 5 counterpart as illuminated in the vignettes (*Christmas tree and tree house, and my straw musical instrument performance*), which explains the discrepancy between the number of students for each case (Table 3.1). Mrs Jasmine taught Science where students were building structures using straws and experimenting with sound production using straws. Mr Smith taught science where students investigated various aspects of the ecosystem focusing on the Daintree Rainforest.

The Year 4 teachers assisted the researcher to distribute the participant information sheets and consent forms to students to take to their parents so that the students, together with their parents, could consent to participate in the study if they wanted to. Eleven students comprising of 5 boys and 6 girls consented to participate in the study.

As part of the ethical constraints, the identity of the school, teachers and students has been kept anonymous. Pseudonyms have been used where names were required in analysis and discussion.

### 3.3 Data Collection

This study utilised two methods of data collection: participant observations and semi-structured interviews. These methods were selected to support the realisation of an in-depth understanding of how teachers defined and facilitated IBL and LA as well as an understanding of learner autonomy demonstrated.

#### 3.3.1 *Participant Observations*

Participant observation is one of the comprehensive data collection tools as it offers researchers the potential to understand a phenomenon in a specific context (Simons, 2009). Observation allows researchers to gather direct data, as researchers can record information as it happens therefore offering the potential to capture unusual features of the phenomenon (Merriam & Tisdell, 2015). Additionally, observations enable researchers to develop a comprehensive picture of the research site (Simons, 2009). Moreover, the observation method allows for authentication of participant interview information (Simons, 2009).

**Participant observation.** Participant observation was utilised in this study as it allows researchers to interact with participants to build a relationship. However, the researcher was not intentionally involved in the IBL activities and behaviours of the research participants (Ary et al., 2018). However, as documented in the vignettes, students approached the researcher sometimes and sought help while completing their learning tasks.

To generate data to answer questions about IBL and LA, the researcher carried out 5 classroom observations in Mrs Jasmine's classes and 6 classroom observations in Mr Smith's classes in term 2 of 2021. The lessons observed varied in length based on the day of the week and other planned learning activities. However, lessons ranged from 30 minutes to one and a half hours. The pilot study conducted in term 1 of 2021.

The researcher recorded all the happenings of the lesson which were observed in the form of field notes. These included teacher and student actions, conversations and interactions between teacher and student as well as students and peers. The field notes also depicted student

and teacher emotional engagement, as well as the classroom atmosphere. I transformed the field notes into research vignettes immediately after the lesson observation. The research vignettes were used for data analysis and interpretation. Following the review of the vignettes, three vignettes were selected for each teacher for presentation, analysis, and interpretation. Table 3.2 details all the titles for the vignettes.

A vignette is characterised as ‘personal accounts of fleeting moments of fieldwork work in a dramatic form’(Van Maanen, 2011). The thick description emanating from the personal accounts of fieldwork events allows readers to gain deep knowledge about the represented events and context (Bloom-Christen & Grunow, 2022). The research vignette offers thick descriptions of the teaching and learning moments in the Year 4 classroom. For this reason, they were selected to represent data as the thick description of classroom events contributes to the credibility and transferability of the data (Lincoln & Guba, 1985). The vignettes are also used because they help address the verisimilitude criterion that seeks to determine whether the representations in the text portray real classroom situations (Denzin & Lincoln, 1994). The thick descriptions offer nuanced details that would help the reader to answer questions such as whether the characters in the text are believable.

When writing research vignettes, there are three genres of representation of vignettes: realist; confessional; and dramatic tales. The realist tales are characterised with the absence of the author in the vignette. This strategy seeks to ensure objectivity of the text as only what the research participants do and say is recorded (Van Maanen, 2011). The confessional tales place the fieldworker at the centre by showing how the fieldworker came to know the social work (Van Maanen, 2011). The dramatic tales reconstruct in dramatic forms the notable segments of the field work. Both the subject and the object are always present (Van Maanen, 2011). The current study utilised elements of realist, confessional and dramatic tales when writing the research vignettes. The elements of realist tales are used across the thesis and in the vignettes

when I recorded exactly what the participants said and did without adding my voice. Confessional tales are used when students approached me during the lessons to either show me their work or ask for support. Sometimes I also spoke to some students during lessons to know how they were progressing with their work. The way classroom stories are represented using literary techniques such as questioning depict the use of dramatic tales.

Table 3.2  
*Research Vignettes*

S/No	Topic	Status
<b>Mrs Jasmine</b>		
1.	Australian States and Territories -Geography	Not selected
	Aboriginal art show	Not selected
2.	Sound - My straw musical instrument	Selected - Vignette 1
3.	Sound - My straw musical instrument performance	Selected - Vignette 2
4.	Building structures using straws – Day 1	Not selected
5.	Building structures with straws - Day 2- Christmas tree and tree house	Selected - Vignette 3
<b>Mr. Smith</b>		
1.	What is an ecosystem? Day 1	Selected - Vignette 1
2.	What is an ecosystem? Day 2	Merged with Vignette 1
3.	Who am I?	Selected - Vignette 2
4.	Mutually beneficial	Selected -Vignette 3
5.	PowerPoint presentation (PPT) on Cassowary	Not selected
6.	PPT project	Not selected
7.	PPT project	Not selected
8.	Printing PPT project	Not selected

The researcher developed six vignettes for Mrs Jasmine as detailed in Table 3.2; the three vignettes were selected for analysis, presentation and interpretation based on the following reasons. The first classroom observation in term two was an Art and Geography lesson, and while providing context and introducing key characters, non-science subjects were excluded for the sake of focus. The first day of the building structures lesson was excluded as it largely comprised of the teacher introducing the building of structures using straws with minimal student actions. Therefore, this left the researcher with three vignettes: *my straw musical instrument*, *my straw musical instrument performance*, and *Christmas tree and tree house*.

The researcher developed seven vignettes for Mr Smith as detailed in Table 3.2. Of these, three vignettes were selected for analysis and presentation based on the following reasons. Observations one, two, three and four comprised rich and extensive teacher and student interactions around IBL and LA, therefore offering considerable potential for exploring the concepts under investigation. Observations one and two were merged to create vignette one. Observations five through seven had minimal student and teacher interactions as students were engaged in independent internet-based research to complete PowerPoint presentations. During lesson observation eight, students were printing their PowerPoint projects, therefore, offering minimal student and teacher interactions. Hence, observations five through eight were not selected as they offered minimal opportunities for analysis. The three vignettes developed from observations one, two, three and four were included as data: *what is an ecosystem? who am I?* and *mutualism*.

### **3.3.2 Semi-Structured Interviews**

Interviews, as a method of data collection, have been identified as a crucial data collection method in case studies (Ary et al., 2018). Zhang and Wildemuth (2009) asserted that interviews can be used to investigate participants' perspectives, attitudes, and experiences, as

well as their motivations around a specific phenomenon. Interviews enable researchers to gather in-depth and rich data thus developing a deep understanding of participant perspectives, the research site, the importance of events to participants, and information on unanticipated findings (Ary et al., 2018). Ary et al. (2018, p. 467) further contend that interview data can be controlled due to opportunities for follow up and clarification of the responses.

This study adopted a semi-structured interview approach. Semi-structured interviews are a crucial form of interviews in case study research (Kallio et al., 2016). Semi-structured interviews comprise of specific questions for the research, but also allow the researcher to devolve deeper by asking follow-up questions (Kallio et al., 2016). Semi-structured interviews allowed the researcher to explore participants' perspectives, viewpoints, attitudes, experiences and motivations around complex issues, as well as providing an opportunity to seek for clarification around unclear responses (Creswell, 2013; Creswell & Poth, 2016; Kallio et al., 2016). Semi-structured interviews were conducted with the two case study teachers. Mrs Jasmine's interview lasted for one hour, while Mr Smith's interview was conducted in three sessions, each session lasting approximately 25 minutes. For his convenience, Mr Smith requested to be interviewed over the course of two weeks. All interviews were audio recorded for later transcription and analysis.

Teacher interviews were based on the following themes: (1) teaching experience, (2) knowledge of IBL and LA, (3) practice of IBL, and (4) facilitation of LA (Appendix A). Coupled with teacher interviews, the researcher engaged in ongoing conversations with the teachers during and after lessons on emerging issues. Table 3.3 illustrates the link between the research objectives and the data collection methods.

Table 3.3  
*Research Objectives and Data Collection Methods*

	<b>Research objective</b>	<b>Data collection method</b>
1.	To determine primary teacher’s knowledge of IBL	Teacher interview
2.	To determine the nature of IBL in primary school science	Classroom observation and teacher interview
3.	To determine primary teacher’s knowledge of LA	Teacher interview
4.	To establish teacher autonomy supportive practices in primary school science	Classroom observation
5.	To investigate learner autonomy demonstrated in primary school science	Classroom observation
6.	To determine the relationship between learner autonomy supported and learner autonomy demonstrated	Classroom observation
7.	To determine the relationship between teacher knowledge of IBL and LAD	Teacher interview and classroom observation

### **3.4 Data Analysis**

This study adopted qualitative content analysis (QCA), because QCA fits with the conceptual framework and nature of the data and the nature of the research questions.

#### **3.4.1 Qualitative Content Analysis**

Interview data and research vignettes (observation data) were analysed using qualitative content analysis (QCA). Schreier (2012, p. 1) defined QCA as “a method for systematically describing the meaning of qualitative material. It is done by classifying material as instances of the categories of a coding frame”. QCA enables transformation of a large amount of text into a highly organized and concise summary of vital findings (Erlingsson & Brysiewicz, 2017, p. 94), reducing the data into themes and categories that facilitate the understanding of the data (Schreier, 2012). This process involves iteration, and reflexivity (a back and forth process during the data analysis process) (Erlingsson & Brysiewicz, 2017; Schreier, 2012). Thus, it offers researchers the flexibility to utilise different strategies for data analysis (Erlingsson & Brysiewicz, 2017; Schreier, 2012).

Researchers can adopt inductive approaches that are data driven, or deductive approaches that are concept-driven, or they can adopt a combination of deductive and inductive approaches based on the purpose of their studies (Schreier, 2012). An inductive approach encompasses the generation of themes or categories directly from the data, while deductive analysis is directed by predetermined categories or themes that are grounded in prior theories, and literature (Schreier, 2012; Srivastava & Hopwood, 2018). Inductive researchers often use theoretical frameworks to generate codes, categories, themes and patterns, and to interpret the meaning of the data (Srivastava & Hopwood, 2018). An inductive approach is selected when knowledge about the phenomena being investigated is inadequate, whereas a deductive approach is selected when the study aims to test existing theories or retest existing data in a different setting (Cho & Lee, 2014; Schreier, 2012). However, a combination of deductive and inductive approaches may also be used to generate desirable outcomes (Schreier, 2012). For instance, researchers could create main themes using deductive approaches, and then use inductive approaches to develop subthemes.

QCA is suited to descriptive studies rather than studies focused on theory development (Drisko & Maschi, 2016). The ability to combine openness to data analysis as well as theory-guided investigation enables QCA to be used in analysing multifaceted and complex phenomena such as IBL and LA (Kohlbacher, 2006).

Due to a lack of one size-fits-all guidelines for data analysis (Simons, 2009), researchers have to independently design or adapt their strategies for data analysis based on principles of data analysis and experience (Schreier, 2012; Simons, 2009). Data analysis for this study was based on the QCA principles and guidelines proposed by Elo and Kyngäs, Mayring and Schreier (Elo & Kyngäs, 2008; Mayring, 2014; Schreier, 2012), and the three-step data analysis process proposed by Elo and Kyngäs (2008), which comprises a data preparation, data organising, and reporting phases. The researcher took into consideration the nature of the data and the purpose

of the data in answering the research questions during the data analysis process. Observation and interview data were analysed separately as described in the following sections.

### **3.4.2 Interview Data Analysis Process**

**Preparation.** Following the collection of the interview data, each recording was transcribed into Microsoft Word by the researcher. Pseudonyms were used to ensure anonymity and confidentiality (Creswell, 2013; Creswell & Poth, 2016). Interview data was gathered to investigate teachers' knowledge of IBL and LA, as well as their perspectives on their practice of IBL and the facilitation of LA. Interview data was gathered using semi-structured interviews. Interview questions were based on pre-determined overarching themes.

**Organising.** Organizing entails coding and categorising the data. Renner and Taylor-Powell (2003) contend that researchers attempt to bring meaning to the words before identifying patterns and arranging them into logical categories. The researcher immersed himself in the data by reading and re-reading the transcripts to develop a complete picture of the data, and develop a broad view of what the data was communicating. Data was first organized based on the main pre-determined categories: *teacher knowledge of IBL, teacher practice of IBL, teacher knowledge of LA, teacher facilitation of LA, and factors influencing the adoption of LA*. Sub-categories were then developed by reasoning inductively with the data.

- ***Teacher knowledge of IBL.***

To analyse teachers' knowledge of IBL, the grid in Table 3.4 was used. This grid was developed from a synthesis of literature such as the inquiry grid (Llewellyn, 2013), science practices (Capps et al., 2016; NRC, 1996, 2000, 2012) and other frameworks used to analyse teacher knowledge of IBL (Capps et al., 2016; Ssempala, 2017). Teachers' knowledge of IBL was explored through i) their direct statement about what IBL is, ii) teacher and student role in IBL, and iii) role of assessment in learning. Table 3.4 is a summary of the analytical framework.

Table 3.4

*Analytical framework for science teachers' knowledge of IBL*

<b>Aspect of IBL/Levels of Understanding</b>	<b>Absent</b>	<b>Narrow</b>	<b>Moderate</b>	<b>Broadened</b>
Meaning of IBL	No essential feature of inquiry mentioned	Mentions up to two essential features of inquiry	Mentions three to four essential features of inquiry	Mentions five essential features of inquiry
Teacher role in IBL	Teacher role not mentioned	Describes teacher role as: Transmitting content.	Describes teacher role as: explain, demonstrate.	Describes teacher role as: facilitator, supporter, coach and mentor.
Student role in IBL	Student role not mentioned	Describes student role as: passive learners.	Describes student role as: to follow teacher directions and engage in learning activities to some extent.	Describes student role as: an investigator, and researcher actively engaged in learning.
Role of assessment	Role of assessment not mentioned	Describes role of assessment in IBL as: focusing on knowledge acquisition (assessment of learning).	Describes assessment in IBL as: to guide instruction (assessment for learning).	Describes role of assessment in IBL as: to challenge students' explanations and evidence.

Teacher knowledge of IBL was the most complex theme in the interview data, and, as such, it was analysed based on the framework presented in Table 3.4. The ensuing sub-categories were analysed independently. The findings from the interview data are presented in Chapter 4 for Mrs Jasmine and Chapter 5 for Mr Smith.

### 3.4.3 *Observation Data Analysis Process*

**Preparation stage.** The researcher took notes in the form of field notes of the lesson events focusing on both teacher and student actions. Following each lesson observation, field notes were transformed into research vignettes. Thereafter, the researcher began the analysis of research vignettes using a recursive process. While writing the research vignettes, the researcher took into consideration his feelings, thoughts and understanding about the data. Similarly, the researcher took into consideration his feelings and thoughts during classroom observation, to help the researcher develop familiarity with the data as well as an initial understanding.

**Organising stage.** The researcher sought to know how teachers' knowledge of IBL and LA influenced teacher adoption of IBL and facilitation of LA, including LAD. Since the data did not provide answers to the research questions, the researcher needed to understand the characterisation of the nature of IBL, teacher autonomy supportive practices and learner autonomy demonstrated (LAD). These appeared as three separate constructs in the data: nature of IBL, teacher autonomy supportive practices and LAD.

As a result, the observation data was analysed in three characterisations. The first characterisation of data was learner autonomy supported (LAS), the second characterisation was learner autonomy demonstrated (LAD) and the third characterisation was the nature of IBL in school science.

**Analysis for characterising learner autonomy supported.** Deductive and inductive analysis were used to analyse data at this level. The process of identifying the three main categories of LAS; organizational, procedural and cognitive was guided by Stefanou et al. (2004) teacher autonomy supportive practices framework. However, the sub-categories within the main categories were directed by the researcher's understanding of LAS. Examples of categories, sub-category development are presented in Table 3.5 for LAS and LAD.

Table 3.5

Examples of Data Categorisation for LAS and LAD

Teacher autonomy supportive practices (LAS)			Students' responses (LAD)
Category	Definition	Sub-category	
Organizational autonomy support	Instructions or directions that allow students to own/manage the learning environment.	Freedom to choose partners and group members.	Students working in pairs or groups
		Freedom to choose working spaces.	Students identifying working spots
Procedural autonomy support	Instructions or directions that allow students to own/manage the form of the learning output	Freedom to access resources	Students accessing resources
		Freedom to determine nature of learning output	Students determining animal to investigate for instance in <i>who am I</i> vignette
Cognitive autonomy support	Instructions or directions that allow students to think for themselves, explore ideas and become self-sufficient learners	Allowing and answering student questions	Students asking questions
		Providing rationales	Students justifying decisions
		Informative feedback	Students correcting mistakes
		Encouraging self-evaluation	Students self-evaluating or students presenting their work without self-evaluation

**Analysis for characterising the learner autonomy demonstrated.** Teacher autonomy supportive practices were interpreted as *learner autonomy supported*, whereas student responses to *learner autonomy supported* (LAS) were interpreted as *learner autonomy demonstrated* (LAD). LAS are the teacher autonomy supportive practices adopted. LAD refers to the student’s responses to LAS. The LAD framework was developed based on the review of existing autonomy frameworks and theories on LA (Chapter 2). The framework is presented in Table 3.6.

Table 3.6  
*Learner autonomy demonstrated framework*

<b>Learner Autonomy Demonstrated</b>	<b>Definition</b>
Underdrive	If the students did not undertake any actions based on teacher instructions, they were considered as demonstrating <i>underdrive autonomy</i>
Compliant	If the students adopted actions in keeping with the teachers’ directions, they were considered as demonstrating <i>compliant autonomy</i> (Trần, 2019).
Reactive	If the students initiated some actions in order to follow teacher instructions, they were viewed as demonstrating <i>reactive autonomy</i> (Trần, 2019).
Proactive	If students initiated significant actions in relation to teachers’ instructions, or further initiated new activities in-line with the overall goal of the lesson, they were considered as demonstrating <i>proactive autonomy</i> (Trần, 2019).
Overdrive	If students initiated actions deviating from the teacher’s instructions as well as the goal of the lesson, but were learning oriented, they were considered as demonstrating <i>overdrive autonomy</i> .

The researcher combined level 1 and level 2 analysis to attempt to determine the link between LAS and LAD. Each LAS was matched with subsequent student responses. This allowed the researcher to develop the link between LAS and LAD.

The student's reactions to the LAS were analysed based on the degree of LAD. The students' degree of autonomy demonstrated was based on Littlewood's (1999) autonomy framework, with the original version describing two levels: *reactive* and *proactive autonomy*. One level, *compliant*, was inserted before *reactive autonomy* by Trần (2019). In this study, the researcher has also added another level before *compliant autonomy*, '*underdrive autonomy*', and one level after *proactive autonomy*, '*overdrive autonomy*'. Therefore, there are five levels of autonomy: *underdrive*, *compliant*, *reactive*, *proactive* and *overdrive*. The five levels are described in Table 3.6.

**Analysis for categorising the nature of IBL in school science.** Deductive and inductive analyses were used to analyse data at this level. The process of identifying the six main categories of the nature of IBL: embark and clarify, find and generate, evaluate and reflect, organise and manage, analyse and synthesise, and communicate and apply were guided by Willison's (2020) Models of Engaged Learning and Teaching (MELT). However, the sub-categories within the main categories were directed by the researcher's understanding about the nature of IBL and MELT's description within each facet.

### **3.5 Rigour of Qualitative Research**

The case study design must entertain the critiques of qualitative research generally, including a lack of rigour and reliability, non-generalizability of findings, lack of trustworthiness, bias, and observer paradox (Yin, 2011). Lincoln and Guba (1985) contended that for a study to be valuable, the researcher must demonstrate that the research findings and conclusions are true and trustworthy. Studies that adopt acknowledged practices of good research have acceptable levels of rigour (Denscombe, 2017). Lincoln and Guba (1985)

established the following evaluative criteria that offers rigour in qualitative research: credibility, transferability, dependability, and conformability. Lincoln and Guba's criteria were utilised to control the quality of the study.

### **3.5.1 Credibility**

Credibility refers to the congruence of research findings with reality, which Guba and Lincoln (1994) explained as being alterable and judged based on their complexity, but not on their truthfulness (Merriam, 1988). Lincoln and Guba (1985) averred that credibility can be assured through sustained engagement, persistent observation, and member checking. The researcher used prolonged engagement and persistent observation, peer debriefing, and member checking to ensure credibility of the research findings (Houghton et al., 2013; Lincoln & Guba, 1985). The researcher adopted prolonged engagement by carrying out classroom observations three days a week for one term and a 'detailed scrutiny' of the data to draw credible conclusions (Denscombe, 2017, p. 299). Member checking was also conducted to add to the rigour of the research process. Following the transcription of the teacher interviews, as well as the development of research vignettes, the researcher shared the interview transcripts and the research vignettes with the two teachers and asked them to give any comments that pertained to the transcripts and research vignettes. Both teachers indicated that the interviews and research vignettes reflected the true events.

**Prolonged engagement and persistent observation.** Research evidence has shown that researcher presence can lead to distortion of participant behaviours (Kawulich, 2005). To minimise this risk, there was prolonged engagement at the research site which allowed the participants to adjust to the researcher's presence and satisfy themselves that the researcher did not pose any threat. Lincoln and Guba (1985) aver that prolonged engagement minimises the impact of the researcher on participant behaviours. Persistent observation ensures the researcher develops a comprehensive understanding of the phenomenon under investigation

(Houghton et al., 2013; Lincoln & Guba, 1985).

The researcher was associated with the school site generally with the same class of Year 4 students and specifically during the pilot and data gathering period, which spanned two terms, one term for the pilot study and the other term for data collection. The researcher conducted five classroom observations during the pilot study in the first term and twelve observations during the second term for the main study. Additionally, during the first term, I participated in a Year 4 field excursion which took approximately five hours, and accelerated the process of making the researcher commonplace and unremarkable to the Year 4 students and teachers. This ensured a strong bond between the researcher, the teachers, and the Year 4 students, thus minimising the impact of my presence on the participants' behaviour. The teachers remained hospitable for the duration, and the site access was maintained during the difficult months of COVID-19.

**Peer debriefing.** Peer debriefing allows researchers to check other professionals their changing insights as they gather data (Lincoln & Guba, 1985). Peer debriefing entails discussing and interacting with other professionals, for instance the supervisory panel, colleagues and faculty members, about their thoughts and questions about the research process so that changes and adjustments can be made in a timely manner (Lincoln & Guba, 1985). To ensure the credibility of research findings, the researcher met the supervisory team on a regular basis to discuss emerging issues identified during the data collection process. Initial drafts of research vignettes and accompanying interpretations were shared with supervisors for comment and suggestions. Similarly, emerging themes were shared with supervisors and discussed. The supervisors reviewed the research vignettes, and together with the researcher, identified the vignettes presented for the final theses.

### **3.5.2 Transferability**

Transferability concerns whether the findings can be applied to other contexts while maintaining the meanings and inferences from the current study (Houghton et al., 2013). Transferability can be enhanced through purposeful sampling, gathering rich descriptive data, and developing thick, rich descriptions that can offer readers adequate information to determine whether the findings can be applied to other contexts (Lincoln & Guba, 1985; Yin & Donald, 2018). The researcher gave thick, rich detailed descriptions of data through research vignettes. The six research vignettes provide detailed descriptions of the lessons that were observed. The two teachers, as cases, were very different in terms of their age, training, and teaching experience, therefore the researcher expected divergent views in teacher knowledge and practice of IBL and LA. Moreover, the researcher provided a thick description of the research context and research participants (Chapters 4 and 5). Findings are illustrated with suitable quotes and exemplars.

### **3.5.3 Dependability**

Dependability concerns the stability of the data (Houghton et al., 2013; Lincoln & Guba, 1985). Stable research findings are consistent and can be replicated (Lincoln & Guba, 1985). However, due to the intricate nature and entwining influences in social settings, it is difficult to replicate findings from qualitative studies.

Notwithstanding the difficulty of ensuring replicability, the issue of dependability can be addressed using various techniques. An *audit trail* technique can be used to establish dependability of qualitative studies (Lincoln & Guba, 1985). The audit trail is a process whereby the researcher records the steps in the research process. This includes recording the research process, providing justifications for all decisions and actions as well as demonstrating how conclusions were drawn from the data, from project initiation through to data collection, analysis, and reporting (Lincoln & Guba, 1985). Audit trail allows for the tracking of the research process by an independent external researcher to determine how the research was

conducted including the decisions around data collection, data analysis, and interpretation as well as how the conclusions were drawn (Lincoln & Guba, 1985; Noble & Smith, 2015).

To ensure dependability in this study, the researcher provided detailed documentation showing the explanations of the research process, the methodological decisions (Lincoln & Guba, 1985), and a detailed account of how conclusions were reached, including keeping a record of all notes derived from supervisory meetings. Moreover, the research process, including the data collection procedures, data analysis procedures and processes, are transparently presented.

#### **3.5.4 *Confirmability***

Confirmability relates to the researcher's ability to demonstrate that findings are free of the researcher's influence (Lincoln & Guba, 1985). Denscombe (2017) contends that findings from qualitative studies are rarely free of the researcher's influence. Lincoln and Guba (1985) asserted that while the researcher's influences may not be unsuitable, they may affect trustworthiness if they are undeclared. Researchers can achieve confirmability by adopting strategies such as reflexivity and the use of multiple sources of data (Lincoln & Guba, 1985). Data was gathered using participant observations and interviews. Additionally, a reflexivity statement that demonstrates the influence of the researcher on the study is provided in Chapter One. While every effort was made to gather perspectives that were independent of the researcher, his background, beliefs and understandings fundamentally influenced what was recorded, how it was recorded and the interpretive process (Van Maanen, 2011).

The strategies adopted for confirmability such as reflexivity can also be used to ensure credibility and transferability. Noble and Smith (2015) argued that when credibility and transferability are ensured, confirmability is also attained.

### **3.6 Ethical Considerations**

The study was approved by the University of Adelaide Human Research Ethics Committee (HREC) on 6<sup>th</sup> May 2020, ethics approval number H-2020-067 (Appendix B). Therefore, this study conforms to the ethical requirements and guidelines of the University of Adelaide Human Research Ethics Committee (HREC). Data presented in this study were gathered in one metropolitan Catholic school in Adelaide. Therefore, permission to approach the school was first granted by the Catholic Education of South Australia (CESA) (Appendix C). This was followed with permission from the school Principal to approach the Year 4 teachers (Appendix D). Following the Principal's permission to conduct the study at the school, the Year 4 teachers were approached via email and asked to participate in the study. After consenting to participate in the study (Appendix E Appendix F), the two Year 4 teachers assisted the researcher to distribute participant information sheets and consent forms to the Year 4 students to take to their parents so that the students, together with their parents, could consent to participate in the study if they wanted to (Appendix G, Appendix H, Appendix I). Eleven students returned signed consent forms. All participants were provided with information and consent forms, and Year 4 students' parents' consent was obtained before data was collected.

#### **3.6.1 Level of Risk**

This study was considered high risk by the ethics committee because the research involved young children. The following potential risks were identified:

- The researcher's presence in the class during the observation might make the teacher participants feel uncomfortable.
- Participants spending time participating in interviews.
- Students may behave differently in the presence of an observer in their class.

- Teacher participants might be uncomfortable to talk about issues relating to their school.

### **3.6.2 Measures to Minimise Risks**

The following measures were adopted to minimise the potential risks to the participants:

- Participants were informed that they could withdraw from the project at any time if they wished.
- Detailed information about the project in the form of a participant information sheet was presented to research participants so they could make an informed choice regarding participation in the research project. The participant information sheet informed participants about:
  - i. The nature of the research and its benefits
  - ii. Participants' expectations
  - iii. Potential risks associated with participation in the study
  - iv. How to withdraw from the study.
- Participants were informed that their identities will be confidential as data would be de-identified before being reported.

### **3.6.3 Confidentiality**

Participants' identities were treated with the utmost confidentiality during data gathering, analysis and reporting of research results. The aim was to ensure research participants could not be identified. Participants were informed that their personal information would remain confidential and only the researcher and the supervisory team would have access to the information. Participants were also informed that both interviews and classroom observations would be audio recorded, pseudonyms would be used during data recording, analysis, and presentation. Participants' anonymity was assured during the transcription of interview data. Similarly, during the development of the research vignettes from field notes, pseudonyms were

used for both the teachers and the students. Identifying content in the data was removed or modified to ensure participant anonymity.

#### **3.6.4 Storage of Information**

Research digital materials including audio transcripts and field notes were stored on the researcher's computer which is password protected. Printed research materials were stored in secure lockers in the researcher's office. Only the researcher and the supervisory team had access to the materials. Hard-copy consent forms were kept in a secure locker in the researcher's office during the study. In accordance with the University of Adelaide Human Research Ethics Committee guidelines, the records will be retained for a period of five years after thesis submission.

### **3.7 Limitations of the Study**

Despite the extensive rigour demonstrated, this study has some limitations. For instance, this study focused on two case studies of teachers teaching the same Year 4 class, in a metropolitan Catholic school in Adelaide. Therefore, it has the limitations of investigating a small number of case studies. Denscombe (2017) alludes that case studies have a challenge emanating from the credibility of generalisations of the findings. Yin (2014) has characterised two types of generalisations: statistical and analytical generalisations. Yin avers that statistical generalisations are frequently applied in experimental research and therefore cannot be applied to small sets of case studies. However, analytical generalisations that “depend on using a study's theoretical framework to establish a logic that might be applicable to other situations” (Yin, 2014, p. 18), are suitable in small case studies. Yin further explains that analytical generalisations follow a two-step process:

- i) Conceptual claims entail the authors demonstrating how their research findings have informed the links among specific concepts, theoretical constructs or a given sequence of events.

- ii) Application of the same theoretical principles to other situations outside the current study, where similar concepts and constructs might be relevant.

Despite these assurances, due to the small number of cases, caution should be applied when generalising findings from this study.

Another limitation of this study is that student data was limited to observation data. Students were not interviewed to gather data about their perspectives on teacher and student actions. Student interview data, especially on the influence of teacher actions on student actions, would have revealed how teacher actions influence learner autonomy demonstrated (LAD). Future studies should consider interviewing students to decipher links between learner autonomy supported (LAS) and LAD.

This study focused on teacher knowledge of IBL and LA as it influenced teacher practice. This focus on teacher knowledge may appear to suggest that teacher beliefs are not an important influence on teacher practice. However, in this study, teacher knowledge entailed teacher beliefs as demonstrated in the interview questions that elicited teachers' knowledge of IBL with elements of teacher beliefs. Therefore, the limitation of focusing only on teacher knowledge is addressed through the type of questions that the teachers were asked. This study considers that both teacher knowledge and beliefs about IBL and LA are important (Levitt, 2002; Shulman, 1986), and therefore teacher knowledge implied teacher knowledge and beliefs about IBL and LA.

### **3.8 Delimitations of the study**

The two teacher participants were a convenient sample hence posing a limitation in terms of representation and generalisation. Additionally, the two teachers were not science specialist teachers but were passionate about science, science teaching and learning. Moreover, they were interested in participating in the study. As both teachers stated in the interviews, IBL and LA are important aspects of science and science learning. Therefore, the study does not

seek to generalise the findings due to its limited sample size. However, the sample size of two teachers teaching the same Year 4 students and their students was deemed sufficient to offer rich insights into primary science teaching and learning and provide answers to the research questions.

The research site provided a unique window as both teachers were teaching the same set of students. This window allowed a deep inquiry into how teacher knowledge of IBL and LA influences teacher facilitation of IBL and LA as well as student reaction to teacher facilitation of IBL and LA. These would have been difficult in other settings as two teachers would normally not teach the same subject to the same students on different days of the week. Hence, the study did not seek to generalise these findings to other settings because of the uniqueness of the setting and the small number of cases investigated. However, the study sought to develop a deep and rich understanding of how teachers understand and facilitate IBL and LA. The findings may however be transferred to similar contexts.

### **3.9 Conclusion**

This chapter has outlined the research design for the study which includes the research approach, data collection and analysis procedures as well as strategies adopted to ensure the quality of the research and the ethical considerations for the study. This research was informed by social constructivist theories and used a qualitative case study methodology and cross-case analysis to investigate teachers' knowledge and practice of IBL and LA in one metropolitan Catholic primary school in Adelaide.

Participant observations were used to gather classroom observation data in the Year 4 class during science lessons conducted by Mrs Jasmine and Mr Smith in one term. One-on-one semi-structured interviews were conducted with the two teachers. Both interviews and observation data were analysed using a qualitative content analysis. However, observation data was first transformed from field notes to research vignettes before data analysis. As detailed in

the data analysis section, several checks were instituted to ensure the study had a high degree of research rigour.

To ensure credibility, transferability, dependability, and confirmability of the research findings, measures such as prolonged engagement with the research site, persistent observation, peer debriefing, thick descriptions, and detailed documentation of the research process were adopted. Ethical considerations as outlined in the ethics approval from the University of Adelaide Human Research Ethics Committee were adhered to during the study.

## Chapter 4 Mrs Jasmine's Inquiry-Based Learning Practices

This chapter presents research data and analysis of Mrs Jasmine's teaching of inquiry-based learning (IBL) in a Year 4 Science class in a metropolitan Catholic school in Adelaide, South Australia. The research data comprises interview data and observation data. The chapter is organised into five sections: the first three are based on interview and selected observation data: context; Mrs Jasmine's knowledge of IBL; and Mrs Jasmine's knowledge of learner autonomy (LA). The next section focuses on observation data in the form of three research vignettes about Mrs Jasmine's facilitation of learning. This is followed by a detailed analysis using the three frameworks: learner autonomy supported framework, learner autonomy demonstrated framework, and MELT framework to analyse *learner autonomy supported*, *learner autonomy demonstrated* and nature of IBL facilitated respectively.

### 4.1 Context

The context section explores Mrs Jasmine's educational and teaching background, the classroom culture and the science topics taught. The physical organization of the Year 4 classroom and the Year 4 students' characteristics have been described in the research methods section.

#### 4.1.1 Mrs. Jasmynes' Educational and Teaching Background

The context section explores Mrs Jasmine's educational and teaching background, the classroom culture and the science topics taught. The physical organization of the Year 4 classroom and the Year 4 students' characteristics have been described in the research methods section. Mrs Jasmine holds a Bachelor of Teaching, and a Bachelor of Special Education. During the study, Mrs Jasmine was in her 25<sup>th</sup> year of teaching in the Primary School system. During the study, she taught in a metropolitan Catholic School in Adelaide and was responsible for a Year 4 class on Wednesdays and Thursdays.

### **4.1.2 Classroom Culture**

Prior to the research study, Mrs Jasmine had created a safe and supportive classroom culture for the Year 4 students. She indicated that learning occurs in a safe and supportive environment, especially when it comes to providing opportunities for students to provide answers to teacher questions.

I do it in a safe way, where they feel safe and comfortable. So, whether it's in a small group or one-on-one, like, I've had kids that have presented to me one-on-one with no one else in the room, because that's what made them feel comfortable to start with. You know, but a lot of it was also children not believing they knew what they were doing. Whereas with the IBL, because you're checking in all the time, there's no right or wrong answers, you know, and you can guide them to get to where they need to be and then they feel like they're more, more confident, and more correct (JI).

Mrs Jasmine stated that providing individualised opportunities for students to answer questions, such as small groups or one-on-one, built students' confidence and comfort with the learning environment (Darling-Hammond et al., 2020). Additionally, as IBL allows teachers to provide ongoing monitoring and support, her belief that with IBL there are no right or wrong answers gave students the belief that their ideas and thoughts are valued. When students have that sense that their ideas are valued, their sense of belonging and engagement is enhanced (Rogat et al., 2014).

### **4.1.3 Science Topics**

Both case study teachers indicated that as much as they chose the topics to teach individually, they based the selection on an overall school theme and discussed amongst themselves to ensure there was no overlap. Mrs Jasmine reported “we do plan together. So, either plan with the person that I share the job with, or we plan with the teacher next door”, showing that Mrs Jasmine planned with Mr Smith whom she was sharing the job with and with the Year 5 teacher who she co-taught with some of her science lessons. During the study, Mrs Jasmine was teaching sound and building structures using straws. Sound production can be linked to the Science Understanding strand and physical sciences sub-strand of the AC:

Science.

Mrs Jasmine focused on hands-on activities which were cognitively and creatively demanding for the Year 4 students. Students were engaged in hands-on sound production using straw musical instruments and building structures using straws. In *my straw musical instrument* and *my straw musical instrument performance* vignettes, Mrs Jasmine taught students how to create straw musical instruments and how to determine the influence of the length of the straw on sound; however, she focused more on students playing a tune in the *my straw musical instrument performance* vignette. Students were engaged in building structures in *Christmas tree* and *tree house* vignette.

## **4.2 Knowledge of Inquiry-Based Learning**

Mrs Jasmine's knowledge of IBL was elicited in interviews and explored through the analytical framework presented in Table 3.4. The analytical framework explored teacher knowledge of IBL through teacher interview statements on i) what IBL is, ii) teacher and student roles in IBL, and iii) the role of assessment in learning.

### **4.2.1 Meaning of Inquiry-Based Learning**

Mrs Jasmine defined IBL as students using different approaches to derive answers to questions.

So, inquiry-based learning to me would be posing questions, and kids being resourceful themselves to work out how to answer that question in a variety of ways, using different methods. Whether it be, you know, computers, or books or discussions, or even just simply trial and error when making something (JI).

Mrs Jasmine's definition mentions two essential features of inquiry: posing questions and students finding answers to the questions using different methods. Based on the analytical framework, Mrs Jasmine's knowledge of IBL is *narrow* because she has described only two of the five essential features of IBL in her definition. Mrs Jasmine demonstrated that one can use different methods during investigation, such as books, computers, discussions and trial and

error, hence aligning with scientific inquiry principles that state that data can be gathered using different methods (Lederman et al., 2014). Methods such as trial and error suggest student ad-hoc experimentation, the use of computers references internet-based inquiry and student discussion involves argumentation processes. These methods enable student participation in inquiry. However, Mrs Jasmine did not mention other essential features of inquiry that have been found to be essential for effective IBL, such as students engaging in data analysis, connecting evidence to scientific concepts and communicating results (Capps et al., 2016; NRC, 2000, 2012; Ozel & Luft, 2013). This finding is consistent with other findings that reported that teachers mentioned the common features of IBL while missing less common, yet important, features of inquiry (Capps et al., 2016; Ozel & Luft, 2013).

Mrs Jasmine indicated that she was not formally trained on IBL during her University teacher training.

Not really, it's more like some people have done training in it, and the rest we just sort of learn and help each other. So, for example, like there's, you know, teachers that are straight out of university that probably have done a bit, a bit of it through practice and things like that, but it's not something that they really do a lot (JI).

I have been teaching for a long time. It's [IBL] not something that we did originally. We have done a big focus on it here at school. And we have staff that have sort of worked on it together and shared ideas. And I think that's probably where my experiences come from (JI).

Capps and Crawford (2013) reported that teachers had limited understanding of IBL because training programmes focus on promoting students' basic skills such as reading and writing, while giving limited attention to teachers' understanding of IBL. However, Mrs Jasmine stated that much of her knowledge of IBL stemmed from her interactions with some of her colleagues, especially the Year 5 teacher with whom she collaborated in teaching many of her lessons including some of the science lessons reported in this study. Mrs Jasmine further reported that her school has been focusing on IBL for the last few years, therefore contributing

to her knowledge and use of IBL. Mrs Jasmine's acquisition of knowledge about IBL from interactions with her colleagues is consistent with findings by Zhao and Fan (2022) who reported that a teacher's experience, reflection and exchanges with teacher colleagues are some of the crucial sources of a teachers' knowledge for development.

#### **4.2.2 *Teacher Role in IBL Lesson***

Teacher as a guide, and supporter of the learning process. Mrs Jasmine believes that the teacher's role in an IBL lesson is to guide students during the learning process.

So, my role as a teacher is really just to support children. And also question them in a way where I'm not giving them answers. But I'm helping them come up with different ideas on how they could reach those answers. That makes sense? And getting them to think themselves without actually telling them the answers (JI).

As a guide, Mrs Jasmine avers that she does not provide students with answers but guides students to develop ideas on how to derive answers to questions. Teachers not providing answers, but supporting students to search for answers, is a fundamental aspect of IBL. Mrs Jasmine's description of her role in IBL is consistent with the extant literature description of the role of a teacher in a constructive learning environment, as a guide or facilitator who coaches, models and guides learning while accepting student autonomy (Yukhymenko et al., 2014). When teachers scaffold students to come up with solutions they foster students' problem solving and critical thinking skills (Crawford, 2007).

Mrs. Jasmine believes that students should be prepared for inquiry learning for it to be successful.

And when we first started doing inquiry-based learning, we had lots of conferencing with children. So, we looked at, you know, where they are at, to start with. And then we had step-by-step where they had to get a ride around to achieve that success criteria. And I think the kids having a plan of where they need to go really helped them. Whereas once you [researcher] sort of had come in, we had done a lot of the groundwork. So, they knew how to do that. So, it was already instilled in them [students]. And I think inquiry-based learning doesn't work unless you've done that groundwork, you know, there has to be some knowledge base on how to inquire and how to find answers in different ways (JI).

Mrs Jasmine claimed that IBL will not be successful if teachers do not prepare students for inquiry. Students must be trained how to inquire, which begins by first assessing what learners already know, then training students in inquiry skills and self-monitoring skills, including how students can measure success and develop strategies to arrive at that success. Developing students' skills to undertake inquiry is one of the objectives in many science education policy documents and curricula (Fitzgerald et al., 2019; NRC, 2000), as students need adequate inquiry skills to engage in inquiry (Van Uum et al., 2016).

Based on the analytical framework, Mrs. Jasmine's knowledge of the teachers' role in IBL is *broadened* as she reported that her role in IBL is to guide and support learners in the learning process.

#### **4.2.3 Student Role in IBL Lessons**

Mrs. Jasmine believes that students should be active participants during inquiry learning.

So, their [students] role is to investigate a question or an idea, and see where it takes them, really, but also is their role to be active in their own learning and their choices. And to stay focused until they reach that aim or goal (JI).

Mrs Jasmine indicated that students should be active in making and managing their learning choices, as well as remaining focused until they achieve the learning goal. Therefore, Mrs Jasmine treated students as co-constructors of the learning process who assume some responsibility of the learning process (Mieg, 2019; NRC, 2012; Rannikmäe et al., 2020).

Mrs. Jasmine reported that in her science lessons, students are provided with opportunities to investigate both teacher- and student-generated questions. Examples of investigable questions include: how does the length of the straw influence the pitch produced? And does the thickness of the straw influence the pitch produced? Mrs Jasmine indicated that often students do not investigate similar questions. Mrs Jasmine claimed that due to the nature of IBL, students can begin solving the same problem or question, but can progress on their

own, different paths. Mrs Jasmine was referring to the nature of scientific inquiry in which different researchers can solve a similar problem using different scientific methods, which may result in different or similar results (Lederman et al., 2014).

Yeah, both [teacher and student generated questions]. We do a bit of both. But if we give a question, we will give different questions. So that they [students] are not all doing the same one. Yeah. But often, they will make up their own [questions]. And the thing with inquiry-based learning is you can start somewhere, and that ends up taking you on different tangents. And that's what I love about it. So, kids can really progress in their own way, I suppose from where they are at, like everyone has a next step. And everyone seems to, you know, grow through that (JI).

Mrs Jasmine also stated that inquiry allows learners to learn at their own pace as each student has their own next step. Additionally, Mrs Jasmine indicated that each student can take their own path with inquiry and realise their own unique results. Therefore, IBL provides opportunities for all learners to achieve their own learning goals as they construct understanding of the phenomena being investigated (Furtak & Kunter, 2012).

Based on the analytical framework, Mrs. Jasmine's knowledge about the student role during an IBL lesson is *broadened* because she believes that the student is an active investigator who addresses either student- or teacher-generated questions.

#### **4.2.4 Role of Assessment in IBL Lessons**

Mrs Jasmine engages in assessment *for* learning during IBL lessons. Mrs. Jasmine stated that she utilises a variety of methods to assess learning during IBL lessons such as taking notes on students' questions and their discussions.

So, we take a lot of notes on their [students'] questions, their discussions, like I said before, like there was a step-by-step process, where they started with the learning intention. And then they worked through the success criteria to get to that end product or/and idea or answer. And I suppose our role really was just to give them the skills to be able to do that, but also to make sure that they are engaged (JI).

Mrs Jasmine also reported that teachers can work with the students to ensure they understand the learning intention and success criteria for the activity so students may engage

in self-monitoring based on the success criteria. She reiterated that her role in the learning process is to empower learners with self-monitoring skills and ensure they stay focused on learning tasks (Yukhymenko et al., 2014).

This description implies that Mrs Jasmine is engaged in *assessment for learning*. In that, as students assess their learning against the success criteria, they can adjust their learning progress to remain in sync with the success criteria and learning intentions. Additionally, Mrs Jasmine stated that she takes notes on students' questions and their discussions. Taking down 'lots' of student-generated questions provided data for Mrs Jasmine to see 'where they started' conceptually, as question posing provides a powerful understanding of both where students are at and where they want to go (Chin & Osborne, 2008). Mrs Jasmine could use this understanding to provide appropriate support to extend student learning to an end product, idea or answer.

Based on the analytical framework, Mrs Jasmine's knowledge of the role of assessment during IBL lessons is *moderate* as her assessment is based on guiding learning and supporting students to remain engaged, but is not *broadened* because assessment in IBL is used to challenge students' evidence and claims in IBL (Ssempala, 2017).

### **4.3 Teacher Knowledge of Learner Autonomy**

This section presents findings on teacher knowledge about learner autonomy (LA). Teacher knowledge of LA was explored through i) meaning of LA, ii) teacher's role in promoting LA, and iii) student's role in LA.

#### **4.3.1 Meaning of LA**

When asked what LA meant to her, Mrs Jasmine defined LA as students assuming responsibility and control of their learning.

So that's where children take control of their learning. And I suppose responsibility for their learning, to some extent, which you do a lot through your inquiry-based learning (JI).

Mrs Jasmine's definition of LA implies that LA does not mean teachers abandoning students or students taking full control of the learning process. The statement 'to some extent' in her definition shows that Mrs Jasmine leaves room for teacher guidance as students take control of their learning (Al-Busaidi & Al-Maamari, 2014; Borg & Al-Busaidi, 2012), indicating that learning is a shared responsibility (Mieg, 2019). Mrs Jasmine's conceptualisation of LA as students assuming responsibility and control of their learning indicated that she understood LA as *proactive autonomy* where students initiate actions to take control of their learning.

#### **4.3.2 Teacher Role in Promoting LA**

Mrs Jasmine takes the learner's perspective when planning for learning. Mrs Jasmine believes that her role in supporting LA is to provide opportunities for learners to learn about their interests and desires. This is achieved by listening to learners, and then creating learning opportunities that align with learners' interests.

Yeah, like I said, before, giving the kids a voice, and actually listening, listening to what works and listening to what they enjoy, and what they want to learn, and then helping them get there (JI).

Taking learners' perspectives entails giving them a voice to communicate their needs. When students communicate their needs, responsive teachers decipher learners' interests, and then plan teaching while taking into consideration students' interests (Großmann & Wilde, 2020; Rogat et al., 2014). Teachers then provide adequate support for students to achieve their interest, thus fostering student motivation and engagement (Großmann & Wilde, 2020; Rogat et al., 2014).

Involving students in planning for learning fosters student LA. Students' ideas sourced from diverse sources are integrated in planning for learning, thus ensuring students' interests are taken into consideration.

So often, we'll talk to the children about things that they're interested in before we plan. And also, we're using any assessment we do or anything we notice we use that to inform our teaching. So, if there's something that they're interested in, or something that they need to, you know, get better at, then we'll use that as part of our planning. And we'll work out okay, well, what can we do to help them achieve that? You know, or if it's something they're interested in? Okay, well, what do we want to know? And I think the kids definitely enjoyed that. And I think when they've had a say that they're more likely to be more engaged in it (JI).

When students' opinions are utilised in planning teaching, learners feel involved, and their opinion is valued, thus promoting their active participation in the learning (Großmann & Wilde, 2020; Rogat et al., 2014). Furthermore, as teachers use students' ideas to plan learning, they also support students to ensure their needs are met. Mrs Jasmine's amplification of the role of the student as an active participant in the learning process who excels when their interests are taken into consideration shows that Mrs Jasmine conceptualises LA as *proactive autonomy* in which students initiate additional learning actions to achieve learning goals.

Mrs Jasmine adopted a series of strategies to support and promote LA. Students' interests were fundamental in the way Mrs Jasmine supported and promoted LA.

Yes. So yeah, like I said, we find things that they're interested in. We get them to come up with the questions that they want to investigate. We do lots of group work, where they can choose who they work with. And the good thing is they don't always choose their friends. Like they do mix it up a lot, or they help each other in a positive way. What else do we do? Lots of conversations. So, we do lots of lots of conversations where we're looking at, okay, where are you at? Where to next? How can we get there? Yeah, how do you feel, you know, that sort of thing? (JI).

To support LA, Mrs Jasmine took note of students' interests, as well as getting students to come up with questions they wanted to investigate. Giving students the responsibility to generate their own questions for investigation promotes students' cognitive autonomy thus fostering deep sustained engagement in learning as they enact strategies to investigate their questions (Furtak & Kunter, 2012; Rogat et al., 2014; Van Uum et al., 2016). Additionally, students have the responsibility to determine group members, which fosters organizational autonomy (Rogat et al., 2014; Stefanou et al., 2004). Moreover, Mrs Jasmine averred that she

engages students in conversations to determine students' current knowledge and the knowledge they need to realise their goals. These conversations are a form of assessment *for* learning which Mrs Jasmine uses to plan for learning (Willis, 2011).

#### **4.3.3 Student Role in LA**

Mrs Jasmine indicated that a learner who is demonstrating LA is one who is actively engaged in learning. Additionally, the learner develops strategies to answer their own questions, share and present their findings, as well as ask questions.

I would say, coming up with their own questions, coming up with different ways to answer the question. And also, being confident to share their ideas with others, and present their findings. That to me would show and also maybe even, you know, asking us questions, as well (JI).

Mrs Jasmine's description of a learner who is demonstrating LA shows that she takes LA to be a form of open inquiry, independent learning or discovery learning where students are responsible for their own learning beginning with generating the questions for investigation, developing strategies to conduct the investigation and presenting their findings (Alston et al., 2020; Atkin & Karplus, 1962; Ozdem-Yilmaz & Bilican, 2020). This description of a learner who is demonstrating autonomy as a learner, who investigates their own questions, shows that Mrs Jasmine perceives that LA could involve more *overdrive autonomy* where students go beyond teacher-set parameters to achieve their own learning goals.

#### **4.3.4 Importance of LA in Science Learning**

Mrs Jasmine stated that LA is important in science learning since it enhances student motivation and engagement, which are key foundational aspects for students' success in learning.

100%. Yeah, it's [LA] important because, I just think if kids have a say, I've said this, so many times haven't I? If they have a say, they're more likely to have success. And that's what we're here for. You know, and I think to establish a really mutually respectful relationship between teachers and students where you're not seen as the dictator, you're almost seen as an equal, you know, you're there to support them. But without actually, you know, telling them what to do. Yeah. But also, it's you know, teaching them to be

resourceful and teaching them to question and problem solve and things like that, which they need to be able to do (JI).

Mrs Jasmine indicates that when students have a say in their learning, for instance in determining learning goals, they will succeed in learning. To ensure students have a say in their learning, Mrs Jasmine avers that teachers and students should share equal responsibility for the learning process, thus providing opportunities for students to determine learning goals creates a sense of ownership of the learning process, and thus students may demonstrate procedural autonomy (Rogat et al., 2014). When teachers establish mutually respectful relationships, and offer relevant support for students to undertake learning activities, student motivation, interest and engagement in learning tasks is enhanced (Großmann & Wilde, 2020). As such, students develop self-regulation skills as they become co-constructors of the learning process (Rannikmäe et al., 2020; Rogat et al., 2014).

#### **4.3.5 Factors Influencing Promotion of LA**

Mrs Jasmine's perspectives on factors influencing the promotion of LA were organized into two major themes: factors promoting and factors hindering the promotion of LA in school science.

**Factors promoting facilitation of LA.** Mrs Jasmine identified numerous factors that contributed to the promotion of LA in primary school science. Firstly, Mrs Jasmine reported that teachers being passionate about LA would drive them to promote LA. Teacher passion has been identified as a significant factor influencing the adoption of teaching practices (Serin, 2017), hence it may influence facilitation of LA.

I suppose, being passionate about it ourselves. The other thing is having knowledge of being able to give feedback like valuable feedback. And also, I suppose, teaching them how to question and inquire and even infer, like that's a really tricky one for kids being able to infer what's being asked or expected and clear expectations, I think too. Yeah, but also, I just strongly believe too like I know I've said this a lot. But if you've got a learning intention, and you give the kids the success criteria, and you give them a voice to give ideas on what we're doing, then they're more likely to achieve that success, and then the IBL works a lot better (JI).

Secondly, Mrs Jasmine reported that teacher knowledge of giving valuable feedback would foster promotion of LA. Valuable feedback would provide students with ideas for the next steps, thus empowering students to take responsibility for their learning. Additionally, Mrs Jasmine stated that teaching important skills such as questioning and inference would promote LA. Students with questioning and inferring capabilities would generate their own questions, and investigate and analyse the data, thus experiencing greater levels of autonomy (Kahn et al., 2013; Van Uum et al., 2016). Moreover, Mrs Jasmine reported that giving students a learning intention and the corresponding success criteria promotes LA. Providing learning intentions and success criteria is akin to providing structure in terms of clear communication of learning expectations. When teachers communicate learning expectations, students are able to plan their learning as well as self-monitor in line with the success criteria, thus assuming greater levels of responsibility for their learning (Eckes et al., 2018; Inayat & Ali, 2020).

**Factors hindering the promotion of LA.** Mrs Jasmine identified three factors that hinder the promotion of LA. Firstly, Mrs Jasmine reported that teachers wanting to have total control of children's learning would be a major hindrance to the promotion of LA. If teachers have total control of the learning process, students will have no opportunities for decision making (Furtak & Kunter, 2012; Rogat et al., 2014; Stefanou et al., 2004).

Well, I think probably what would hinder it [LA] for some would be the fact that they like to have total control of the children's learning that would absolutely hinder it [LA]. And I suppose behaviours could hinder like behaviours of kids. And I suppose, you know, the lack of resources, or, you know, I think too, like if kids lack resilience, and lack social skills, that could definitely hinder it to start with, but you know, it's always a work in progress. You can always build on that (JI).

Secondly, Mrs Jasmine reported that students' behaviour and inadequate resources could hinder the promotion of LA. If students' behaviour is undesirable, teachers would wish to have control of the class, thus restricting LA. Research evidence has shown that when teachers have classroom management issues, they assume total control of the learning process

to effectively manage student behaviour, restricting LA in the process (Reeve, 2009). Moreover, Mrs Jasmine stated that students' lack of resilience and social skills would affect the promotion of LA. Mrs Jasmine implied that resilience and good social skills are prerequisites for LA. As such, teachers would experience difficulties when attempting to promote LA when students lack resilience and good social skills. Resilience is particularly fundamental when students are carrying out tasks independently (Ma, 2021). Reeve (2009) reported that there are three types of factors that hinder promotion of LA: pressure from above, which may include lack of resources, pressure from below, which may include teacher reaction to student behaviour, and pressure from within, which may include teacher control dispositions.

#### **4.4 Mrs Jasmine's Research Vignettes**

This section comprises three vignettes that provide the observation data that illuminates Mrs Jasmine's teaching of the Year 4 Science class. The students were engaged in hands-on inquiry learning using straws to create musical instruments and build structures. The three vignettes are *My straw musical instrument*, *My straw musical instrument performance* and *Christmas tree and tree house*. The vignettes are presented chronologically followed by data analysis.

##### **Vignette 1: My Straw Musical Instrument**

"Today, we are going to make musical instruments using straws" Mrs. Jasmine announces to the students seated on the carpet facing the electronic screen. She asks "now, have you ever heard in music *do-re-mi*?" The students respond in a chorus "yeah" as they complete the rest of the tune in unison "*fa-so-la-ti-do*". Mrs. Jasmine explains that each note has a different sound, so there are different notes which sound slightly different. "So, what we're looking at today is you are going to be making your own musical instruments using straws". A chorus of voices respond "wow". Mrs. Jasmine continues "so what you have to do is explore the length of the straw because the length of the straw changes the sound of the note."

So, if you're using the same size straws, the same width and they go to different lengths, okay, but don't share”.

She goes on “I wanna show you a video once I get this working. But in the meantime, I want you to just think about making a musical instrument. You've got to somehow make those straws into an instrument. So, you can have something a bit like a harp, which has all the different strings in a row joined together. You can make it look like a guitar with the straws like the string.

Maeve asks, “do we have to work in groups or do it by ourselves?”, “that’s fine, you can work in groups, that’s your choice” Mrs. Jasmine responds. “....until the first bit is done, where you are planning your own instrument using straws while you are thinking about it and working out who is in your group. Remember, you are planning instruments, different lengths for the straws make different sounds for the notes. But then once your instrument is made, you are going to actually play it” Mrs Jasmine clarifies. She goes on “....now if you want to, I will try and get this working, if I can’t, just get your phone, IPad or laptops, and actually put this website it will lead to an example of what you can do with the straw” Mrs Jasmine explains as she displays the website on the electronic screen.

“So, you got to think about what your instrument is going to be, who you are going to work with. How many straws you need, how many different lengths, if you have a look on here at the top, and it won't make too much difference, but they're sort of up into the top of the straw. You can experiment with if you do, that will make a different sound” Mrs. Jasmine expounds.

Mrs. Jasmine suggests “I would recommend that you work with at least one other person, because I think it's more fun working with others but also you may have same ideas that you can share, but that is your choice, okay?” Students disperse as they select partners. Numerous groups and pairs have been formed.

Maeve working with Joy and Lara takes a mini-white board from the cupboard and draws eight lines arranged from the longest to the shortest. Lara and Joy gather a pair of scissors, straws, and a ruler. As soon as they have the resources on their table, they begin cutting some straws. Mrs. Jasmine interjects “guys, stop cutting yet, actually plan it” Chorus response from the group “we actually are”, as they chat.

A few minutes later “Guys come to the floor, then I will go through with you the video” Mrs. Jasmine announces. As students gather on the carpet, Mrs Jasmine begins “So think about ‘how do you think musical instruments actually produce the beautiful sound that they do?’” waits a few seconds then asks, “Have you ever thought about it?” Billy responds “Yes, I have”. Mrs Jasmine then explains “.....depending on the instrument, the sound wave that is made can be affected by changing the length of part of the instrument such as the strings on the guitar or piano or if you are looking at a trombone, the air you blow into that air column will be different lengths. Okay, and that's what we are going to do”. Then the students watch the YouTube video which Mrs. Jasmine summarises as follows “Okay, so just revising that. So, if you do read at the top, you don't have to. But experiment with it [straw] you do a thicker one or a thinner one that you cut in, cut a little bit off the top, see if it makes a difference to the sound. And the other thing they did was added another straw and then he marked out even with across the second straw. And each time that mark got up to the first straw made a different note sound or like a recorder which you put hands and hold on the top and play as you move your fingers covering the different holes. Putting holes in it also changes the sound. Okay, so experiment, which is why I said just plan what it's going to look like not actually how it sounds yet. Alright? Now I'm going to show you one more video. Okay. This is essentially really just about vibrations”. She goes on “All right, this is just some examples and a procedure telling you step by step how to do it if you'd like, you don't have to. Mrs Jasmine tries to play the video then laments “the video isn't working, right? Does anyone want these instructions?” students remain silent “No,

you think you can work it out yourself?” Some students respond “yes”. Mrs Jasmine goes on “And remember, he said it's about four centimetres. That's the length so you might even need to use your ruler and measure it out. Right, go give it a go. Remember there's different size straws, different widths”.

The three girls move back to their table, as Maeve is absorbed in her diagram, Lara and Joy arrange the straws on the table. “Maeve, what are you doing?” Lara queries, Maeve responds, “I am writing my plan”, as she continues drawing lines on the mini-whiteboard. “I chose the colours, red, orange” as Lara comments Mrs. Jasmine interjects “...is colour important?” Maeve responds “No”. “But it makes it look nice” Mrs. Jasmine comments as Maeve says “exactly”. Maeve continues looking at her drawing as the other girls stare at their straws on the table.

Billy has one thin straw in his hands, he makes wedges, then blows air from the un-wedged tip. As there is no sound, he flattens the wedged tip using his front teeth, he repeats this procedure thrice then blows air through the un-wedged tip of the straw. There is a buzzing sound “puu puu”. He smiles and blows again. Mrs. Jasmine excitedly comments “ahh, ha ha listen guys, listen to Billy”. Billy blows through his straw again making a buzzing sound, he repeats again and again to the amusement of Mrs. Jasmine, myself and other students as well. He is the first student to successfully create a straw that produces sound.

Mrs. Jasmine asks, “tell me, how did you make it?” Billy without talking demonstrates the process. “Billy, can you try with a different straw size then compare whether the sounds are similar. Billy picks one straw from the table, cuts off about 2cms, then flattens one end and makes wedges and blows through the un-wedged tip. Air flows freely without producing any sound. He tries twice without success. He drops the straw on the table, picks another straw, makes a slit at the tip, then picks the shorter straw, snugly fits it into the tip with a slit. He then blows through the un-wedged tip; it produces some sound. He looks at the straw while

turning it upside down, he shakes it in a whipping motion, then blows into the straw, and it produces a neat bustling sound. He smiles and makes alternate sounds. He begins to play alternately his two different straws: the single straw he made earlier and the multi-straw instrument with a shorter and longer straw joined together. “Billy, can you try and move the one at the bottom, like move it up and down and see if it can produce different notes” Mrs. Jasmine suggests.

“Mrs Jasmine, we are done” Lara announces as her group displays their instrument. Mrs. Jasmine asks “oh, nice, so how are you going to play the straws to make a tune?” Maeve responds, “we just start from one end to another”. Mrs. Jasmine quips “yeah, guys think how you are going to play the straws to produce a tune. Remember the aim is to produce sound to make a tune”. “Oh, yeah, we didn’t see” Lara comments. Their instrument comprises of eight straws of different sizes arranged in a horizontal flair strapped on an A4 sheet of paper using masking tape, in no obvious order.

Lara, with a short thin straw in her hands, walks over to Billy who is busy modifying his instruments and stares at him. She asks, “what did you do?” As Billy completes demonstrating the process, Lara walks quietly to her table, flattens the tip of the straw, makes wedges, and then blows through the un-wedged tip, a buzzing sound is produced. She smiles and blows her straw again and again while moving around the class. Mrs. Jasmine asks her “how did you make it?” She excitedly explains the process as Mrs Jasmine asks “Have you tried with a different size of the straw? You need to experiment with other sizes so that you can produce different sounds. This will help you to make a musical tune”. Lara responds “I haven’t tried” as she picks a thicker and longer straw than the one in her hand. She quickly flattens one side, makes wedges, flattens again and then blows through the wedged tip. Lara smiles as her straw produces sound, Mrs Jasmine who’s been watching asks “which one has a higher pitch, the longer or shorter one?” Lara responds “I don’t know” as she blows into the longer straw,

and appears to be listening to the sound, smiles, then blows into the shorter straw, smiles again and repeats the cycle three more times, then reports “Mrs. Jasmine, the shorter one has higher pitch than the longer one”. Mrs Jasmine responds “yeah” as she attends to a group of students arriving from dance.

Mrs Jasmine demonstrates the process of creating straw instruments to the group arriving from dance and sets them to their working spots. Mia, one of the new arrivals, picks several straws, she then drops them on her table. She picks one straw, makes wedges and blows. It doesn't produce any sound; she repeats this procedure with four different straws unsuccessfully. She bends one of her straws into an L shape then begins to blow through the wedged tip as she moves around the class. Mrs. Jasmine queries “Mia, how can you make it better?” Without a response, Mia moves closer to Billy and spends a few minutes watching him. She goes back to her desk, takes one straw, makes wedges, flattens the tip and chops off the tip. She then blows through the un-wedged tip, it produces a buzzing sound, she smiles and repeats again producing a rhythmical buzzing sound. She moves around the class playing her straw in a dramatic way that brings excitement as other students join in laughter.

A few moments later I ask Ryan how he was doing as he appeared to struggle with his straw instrument. Having spent several straws unsuccessfully, he responds, “I am so jealous, mine can't seem to work”. He picks another straw, makes wedges and blows. It still doesn't work. As he looks at me in despair, Mrs Jasmine asks “What can you do differently?” Ryan just stares at Mrs. Jasmine, who then explains the procedure for making musical instruments using straws before walking away. Ryan picks a straw and repeats Mrs. Jasmine's procedure, then blows into the un-wedged tip, it produces a bustling sound. He smiles, then repeats this act as he moves around the class producing different unsystematic tunes. By this time, the class is in a frenzy as there are tunes from all corners.

“Nemwel, I am done” Remi announces while looking at me. “Can you play?” I ask. She plays her straw as she walks back to her desk. She picks a thinner shorter straw, makes wedges, and flattens the tip, blows producing a buzzing sound. She walks back to where I am standing then blows into her straw. “As she is blowing Mrs. Jasmine asks, “Have you discovered which straw makes a higher pitch?” Remi blows into the longer and thicker straw, then blows into the shorter and thinner straw, then reports “this one has a high pitch” while pointing at the short thin straw. Mrs Jasmine responds “good” as she attends other students.

As students continue with their straws and tunes, I engage in a conversation about this science lesson with Mrs Jasmine who comments that she tries to question her students and guide them wherever they are not succeeding. She reiterates that learning in her class is fun and the kids enjoy what they are doing.

Moments later Mrs Jasmine announces “Guys, you need to pack up, you can finish your instruments tomorrow”. The guys tidy up and keep their straws in zip bags.

### **Vignette 2: My straw musical instrument performance**

“Now, Remi, could you get all the straws out of the cupboards, all the different types of straws” Mrs Jasmine requests (Mrs Jasmine has just released majority of the Year 4 students to other Thursday afternoon activities and requested the Year 5 teacher with her students to join her and the three Year 4 students remaining for Science (Remi, Luna and Ryan) in the Year 4 class to continue with the straw instrument making project). “Straws, I love straws” Ryan shouts as he joins Remi to pick straws from the cupboard. Some students who left for the other Thursday afternoon activities come back into the classroom. Remi and Ryan place the straws inside the box on the bench as they join the rest of the students on the carpet.

Meanwhile Mrs. Jasmine displays the aim of the lesson on the electronic screen ‘*to make musical instruments using straws*’. “Okay, so, if you were in here last week when we started, the Year 4’s were here. This is actually good fun, but it does take a lot of persistence,

which means you have to keep trying, keep trying, keep trying, modifying until you work it out”. Mrs Jasmine then offers a similar explanation to the explanation in *my straw musical instrument* vignette on how instruments produce sound. Mrs Jasmine then exemplifies the effect of length on sound produced by different instruments such as guitar, piano and trombone.

“Okay, now I'm just going to show you something, which shows you how to do it, but your task is, to make your own musical instrument. And we have got different widths of drinking straws, you can cut them to whatever length you want. You are going to explore by changing the length of the straws to see that changes the notes that they produce and the sounds that they produce. You can work in small groups, but at the end, once you've got the sound working, you're going to make up a tune with other people in your group. So, you've got to have different sounds coming out of different straws. So, let's see” Mrs. Jasmine explains as she works on her computer. Seconds later, a video plays on the electronic screen. “This is just a guide on how to make musical instruments using straws (<https://www.youtube.com/watch?v=8zrsx8V8XwQ>)” Mrs Jasmine announces.

As the students watch the video, Mrs. Jasmine emphasizes the key points. At the end of the video, she remarks “Now, it did take some people a long time last week, like half an hour to actually get the reed part of the straw flat enough for you to be able to make a sound. Okay, so experiment with different sizes and things like that. Different straw size and work out what you got to sound and who you're going to work with. Like something really simple would be easier. When you are done, you will identify a spot where you will work from to plan your instruments and tunes”.

Swiftly while chatting students pick straws and scissors from the box on the bench as they head to their workstations. Remi picks five straws, three thick and two thin straws as she walks to her table. She takes one thick straw and makes wedges, then flattens the wedged tip using her teeth, she repeats the process thrice before blowing air through the un-wedged tip of

the straw, the straw produces a bustling sound. Remi smiles and walks towards Mrs Jasmine as she plays her straw. “Sounds like a duck” Mrs. Jasmine jibes as she asks “what song do you want to make? Twinkle twinkle?” Remi shrugs her shoulders while looking at Mrs. Jasmine with anticipation. Mrs Jasmine smiles as she moves over to check what other students are doing while Remi walks back to her table.

A few moments later, Remi creates a multi-straw musical instrument with two straws joined together using a masking tape. She walks over to Mrs. Jasmine while playing her straw instrument “Good” Mrs. Jasmine remarks and asks, “can you make it to move so that you can keep changing the length?” Remi nods while walking away. Remi adds another straw to her multi-straw instrument, therefore creating an instrument with three straws. She happily plays her instrument as Mrs Jasmine comments “well done”, Remi moves around the class playing her instrument while smiling.

Ryan has spent several straws unsuccessfully. He makes wedges on a thin red straw, then blows into the straw through the un-wedged tip. Unfortunately, the straw does not produce any sound. When I ask him how he is doing, he shows me his straws without talking and moves from one table to another watching what other students are doing. Moments later, at his desk, Ryan picks one of his several straws, flattens the wedged tip, he repeats this action several times before blowing air through the un-wedged tip. A buzzing sound comes off. He blows into his straw a few more times before he drops the straw on the table and creates two more straws that produced sound. He gathers his three straws in one hand and blows into them, which does produce some sound. He moves around the class playing his straws.

Mia who has just joined the Science lesson picks some straws and walks over to her table. She makes wedges on one thin straw, blows into the straw, but the straw does not produce any sound. She makes wedges and blows into several straws, none of them produces any sound. She walks over to a group of Year 5 students and watches as they enjoy their tunes. A few

minutes later, she walks back to her desk, picks one straw flattens the wedged tip and blows through the un-wedged tip. As the straw produces a buzzing sound, she smiles and walks to the front of the class, picks several straws and heads back to her desk. She repeats the same process and creates six straws that produce sound. She arranges the straws on a sheet of A4 paper, then straps them to the paper using masking tape, and moves around the class showing off her instrument.

Remi has made holes at various spots along her three-straw instrument, to make it look like a flute. She plays her instrument while covering some holes with her fingers alternately, producing some tune while Mia is also playing her tune while moving around the class to whoever cares to listen. The classroom is now in a frenzy with different buzzing sounds.

“Guys, work with your partner or in your groups to make a tune which you will play for the class. And you are going to come up with your own tune, now for this activity, you need to be in different areas, otherwise it’s going to be confusing the music you are creating” Mrs Jasmine announces. She goes on “...so you are going to split up into small groups of two’s or three’s finding your group, you are going to find a spot within these two rooms or that little room there. You are trying to make a tune, and you are going to present to everybody in about 15 minutes”.

Mia, Ella and Remi have agreed to work together in the year 5 class to create their tune. Remi appears to be singing as Mia listens keenly. The Year 5 Teacher comes along and asks the girls the tune they are going to play. Remi plays a tune while saying “it’s not working”. The Year 5 teacher guesses “twinkle twinkle?” Remi just stares at the teacher. The Year 5 teacher walks off to other groups.

The Year 5 teacher calls all the students to sit on the Year 4 carpet to make their presentations. She announces that each group will play their tunes, and the other students are going to guess the song they are playing. As students settle on the carpet, she begins calling

out the groups. The first two groups are Year 5 students, the third group comprises of Remi, Mia and Ella. The fourth group comprises of Ryan and a Year 5 boy. Group three comprising of Remi, Mia and Ella present twinkle twinkle little star tune. As they present, Remi keeps saying it's not working. Group four comprising of Ryan and a Year 5 boy presents the star wars tune. As students finalised guessing the last tune, Mrs Jasmine concluded "Length does make a difference on the pitch". She then announces "pack-up and clear the mess".

### **Vignette 3: Christmas tree and tree house**

"Guys, what you can do though, you can do STEM with the straws" Mrs Jasmine suggests to the four students remaining for science. Mrs Jasmine has just released the rest of the Year 4 students to various Thursday afternoon activities: drama, and Science. She spends the next few minutes sorting out student participation in science as well as the other Thursday afternoon activities.

Last week students began a STEM challenge, building structures using straws. The STEM challenge was a collaboration between the Year 5 teacher and Mrs Jasmine. The students working with their partners were required to build a tall structure with a big base using straws, pipe cleaners and masking tape. The structure had to be unique and creative.

#### ***"The Christmas tree"***

"Girls, what are you making" I ask Milly and Ella who are working on the carpet. Milly responds "we are making a Christmas tree and it's very special" as she points at the Christmas tree structure on the carpet. There are two star-shaped cones, the smaller top cone and the larger bottom cone placed next to each other in a jig-saw flair.

As Milly explains, Mrs Jasmine announces "Guys, remember you are building something that other people have to guess what it is without you telling them". Seconds later, the Year Five teacher comes along, and Mrs Jasmine asks, "Does it have to be free standing?" The Year 5 teacher says it doesn't have to. Mrs Jasmine quips that she can already work out

what Milly and Ella are building while remarking that it is really good. She asks, “is that good girls?” Ella comments “we could change it” Milly murmurs “wait wait wait” as she stares at the cones. Mrs. Jasmine comments “I think its fine”.

Mrs. Jasmine prods “What else could you add to it?” Ella responds, “a star” Milly retorts “we’ve got a star!” Mrs Jasmine nudges “you’ve got a star, you could add some, but what do Christmas trees normally have?” Milly displays a piece of tinsel as she remarks “I made a piece of tinsel”. “Cool, you can fix it somewhere” Mrs. Jasmine suggests as Milly fixes the tinsel on the bottom cone to Mrs. Jasmine’s admiration, who in turn remarks “ahaa, so what else could you put there?” Milly while gazing at their structure for about 5 seconds remarks “I can’t remember”. Mrs Jasmine laughs lightly, then Milly reminisces “oh yeah, I remember now”, but says nothing as she walks to the cabinet and comes back in seconds with a small bowl containing assorted items. Mrs Jasmine prods further “What goes on trees normally, on that sort of tree?” there is some silence as Milly stares at the Christmas tree. Mrs. Jasmine asks, “what do you put on your trees at home?” Milly quickly responds “baubles” Mrs. Jasmine reacts “there you go” as Milly retrieves two baubles from the bowl and places them inside the bottom cone as she remarks “oh I know”. Mrs Jasmine wonders “and how are you going to attach them when you have big gaps in the middle?” Ella responds “I know” as she walks off to the cabinet.

Milly joins Ella on the cabinet, Milly picks additional straws whereas Ella picks two nets then ties the open end of one net and shows it to Mrs Jasmine who smiles while walking away. Ella drops the net on the floor and walks away again and comes with two baubles in her hands. Milly asks, “what’s that?” Ella responds “baubles” Milly comments “that’s so good, I know this is going to make our Christmas tree way better”. They place the baubles inside the lower cone as they chat.

Moments later Ella walks back to the cabinet and returns with a thick straw and flower glitters in a bowl. She fills the flower glitters into the thick straw, shakes and accidentally spills some flower glitters on the floor. Milly, who has just completed making a brown bauble remarks “I am making a brown bauble, Ella, I am a genius inventor in making baubles” as she fixes the bauble on the bottom cone. “What are you doing?” Milly asks while looking at Ella. Ella responds, “putting the flower sprinkles into the straw”. Milly jibes “oh, this is really messy”.

Ella seals one tip of the straw with a masking tape and fills the straw with flower sprinkles using the unsealed tip to scoop additional flower glitters. Once she fills the straw with flower glitters [approximately three quarters full], she covers the unsealed tip with her hand and shakes. She smiles and increases her shaking tempo; as she shakes, she spills all the flower glitters, some into the bowl and others on the carpet, she places the straw on the carpet and joins a conversation with Maeve and Joy who are a few strides away.

Few seconds later “Ella, come” Milly calls out. Ella joins Milly at the floor. Milly, who is seated on the carpet fixing a second tinsel onto the bottom cone, turns to Ella, “Ella, from now on, when you make a tinsel, do not use green, and I made a green one. No more green pieces of tinsel, okay?” Ella nods as she walks away.

Mrs Jasmine who has been watching silently announces that students should only use straws in completing their projects. Ella quickly gathers all the flower glitters into the bowl as Milly, who has just finished making a square, places it next to the bottom cone, then uses masking tape to strap them.

Mrs Jasmine declares “guys, remember whichever mess you create, you will clear it up. The mesh nets need to go away”. Milly puts the two mesh nets inside the cabinet as she says, “this is so much fun”. She walks back and joins Ella on the carpet who is cutting some straws.

Mrs Jasmine while pointing at the straws Ella has been cutting asks, “Ella, what are you doing with those?” Ella responds, “I am going to put them on the Christmas tree up here”, “ahaa, excellent” responds Mrs. Jasmine. Then Ella quickly packs the straws into the box on the bench.

Students attending cooking class start streaming back. Mrs Jasmine announces “Girls, if you would like to join slime, Theo and Lenny are up here, you can go down”. Maeve and Joy with big smiles quickly place their straws on the bench and walk out of the Year 4 classroom. Milly and Ella walk quickly, carrying their Christmas tree and drop it on the bench as they dash outside.

Lara, who has just come back, was working with Milly last week, she picks the Christmas tree from the bench, places it on the carpet with a sigh. The Christmas tree on the carpet is disfigured. She bends over, touching one straw after another in what appears to be an attempt at fixing this disfigured structure. Mrs Jasmine comes to her aid “Lara, what do you think happened to that?” Lara responds, “I don’t know”. “That’s not how it looked before” Mrs. Jasmine comments. Lara moves the disjointed straws from one position to another. “The square was at the bottom” Mrs. Jasmine hints as she looks on. Lara picks up the square and gazes at the structure on the carpet. “So, what are you going to do?” Mrs Jasmine asks after a few seconds. Lara stares at the structure as she says, “I don’t know”. Mrs Jasmine suggests “why don’t you go down the staffroom and get the girls to help you”. Lara replies “okay” as she dashes off.

### ***“Tree house”***

“How are you going to get into the tree house” Mrs Jasmine asks Theo who has been staring at the tree house since he came back from slime. They started making the tree house last week with Billy and Jayden. Mrs. Jasmine goes on “how do you get into a normal tree house?” He responds “ladder”, Mrs Jasmine continues “yes, you can do a ladder”. Theo picks

one straw and places it over the top horizontal bar and the bottom horizontal bar, then binds with masking tape.

“Lenny, Lenny, come in and help Theo, they are doing something on the tree house” Mrs Jasmine calls out. Lenny walks over and helps Theo to fix another straw parallel to the first one, just about a centimetre apart. At this point I am wondering where the ladder will be leading to. To the roof or? Lenny keeps on staring at the structure, a few seconds later he picks a thinner straw from the bench and says “I think we better use thinner straws” he shows the thinner straw to Theo, and Mrs Jasmine then explains that it will work better for a ladder. Mrs Jasmine nods as she walks away.

Lenny takes a pair of scissors then cuts the straw into two almost equal parts. He then places the straw across the two vertical parallel straws just about two centimetres from the ground. He then explains to me “I think of it being diagonal instead of being straight off on the side of the tree”. He demonstrates to Theo how a diagonal ladder would look like.

Moments later, Lenny picks masking tape and remarks while looking at me “I know what I am doing but I easily get distracted”. He then straps the straw making the first step of the ladder while Theo is looking on. Lenny then straps the second straw to the two parallel vertical straws approximately 1 centimetre from the first straw thus, making the second step of the ladder.

Mrs Jasmine who has been silently watching announces “guys, you should be packing, clear all the mess”. Theo places the tree house on the shelf next to the teachers’ desk. While Lara, who came back to class without the girls is assisted by Lenny to place the Christmas tree on the bench.

#### 4.4.1 *Teacher Autonomy Supportive Practices*

**Organizational autonomy support.** Mrs Jasmine's teaching style provided many opportunities for her group of students in terms of organizational autonomy across the three vignettes. The opportunities for organizational autonomy revolved around the students' choice and decision-making responsibilities regarding selection and working with partners, determining when to hand in assignments for assessment and limiting choice by selecting groups for students.

- *Opportunities to select and work with partners*

Mrs Jasmine provided opportunities for students to determine their partners and group members across the three vignettes. The choice to select and work with partners was manifested when Mrs Jasmine announced that students would complete their learning tasks either in pairs or individually. Sometimes, students queried whether they would undertake learning tasks with their partners. For instance, in *my straw musical instrument* vignette Mrs Jasmine responded to Maeve's question that it was up to students to determine whether to work individually or with partners. However, as she was releasing the students to undertake planning for their musical instruments, she recommended that students should work in pairs, as she justified that pairs can share ideas and it is fun working together. Therefore, within the broader choice of determining whether to work alone or with partners, Mrs Jasmine justified the rationale for group work (Assor et al., 2002; Rogat et al., 2014), hence giving students the opportunity to make informed decisions around group work. Similarly, in *my straw musical instrument performance* vignette, Mrs Jasmine recommended that students should work in small groups of twos or threes to make instruments and create a tune, essentially directing students to work in groups, but giving them the choice to be either in a group of twos or threes.

Students reacted to Mrs Jasmine's provision of choice to select and work with partners by demonstrating *compliant* and *reactive autonomy*. For instance, in the *my straw musical instrument* vignette, Billy and Jayden chose to work together at the beginning of the lesson

thereby demonstrating *compliant autonomy* as they followed Mrs Jasmine's instructions. However, as the lesson progressed, Billy and Jayden worked independent of each other, thereby demonstrating *reactive autonomy*, as they took actions that deviated from Mrs Jasmine's recommendations of working in groups or pairs, but in keeping with the broader choice given initially of whether to work with others or individually. Students demonstrated *compliant autonomy* when they selected group members in *my straw musical instrument performance* vignette. For instance, Remi worked with Mia and Ella to present their tune as per Mrs Jasmine's instructions.

With similar instructions recommending that students should work with at least one other person in *my straw musical instrument* vignette, some students chose to work in a group of three. For instance, Maeve's group started their activity as a group, thereby demonstrating *compliant autonomy*. However, as the lesson progressed, Lara created a straw instrument individually, thereby demonstrating *reactive autonomy*, by deciding to leave her group and working alone, contrary to Mrs Jasmine's recommendation that students should work with at least one other person. The data shows that some students' (Billy and Lara) learner autonomy demonstrated (LAD) in *my straw musical instrument* vignette shifted from *compliant autonomy* to *reactive autonomy* as the lesson progressed.

The data shows that organizational LAD is fluid and concurs with findings by Willison et al. (2017) that revealed that the level of LA demonstrated in their study was tidal and dependent on context, student characteristics and teacher purpose. Little (1991) argues that LA is fluid and may result from the nature of teacher instructions and student progress in learning tasks. Organizational LAD in this analysis might have resulted from the nature of learning tasks, the nature of teacher instructions and the students' progress.

- ***Opportunities to determine when to hand in assignments***

Mr Jasmine's teaching style provided opportunities for her students to determine when to hand in learning tasks for assessment. She regularly walked around the class checking students' progress. However, some students chose to present their work for assessment when they felt they needed feedback, or they were ready for assessment, thereby demonstrating *proactive autonomy*. For instance, Maeve's group as well as Mia and Remi, when they completed making their straw instruments in *my straw musical instrument* vignette presented their instruments or played their instrument for Mrs Jasmine to assess.

Mrs Jasmine's warm and approachable nature coupled with her style of appreciating student progress may have instigated the students' presentation of their instruments for assessment. However, some students waited for Mrs Jasmine to pass around and assess their progress. The level of confidence with the correctness of their answers may influence student feedback-seeking behaviour (Hattie & Timperley, 2007, p. 95). Baartman et al. (2022) reported that students are not used to seeking feedback, but still mentioned that high performing students are intrinsically motivated to seek feedback as they have positive perceptions of feedback, implying that if students think their performance is good, they will seek feedback. This may mean that Mia and Milly, who regularly sought feedback, perceived their performance to be good.

- ***Limiting choice: Choosing groups for students***

Mrs Jasmine occasionally constricted students' choice for organizational autonomy. For example, when she directed Lenny to work with Theo she restricted Lenny's organizational autonomy around choice to select group members or determine which group to work with in *Christmas tree* and *tree house* vignettes. Lenny complied with Mrs Jasmine's directive by assisting Theo to complete the tree house, thereby demonstrating *compliant autonomy*. Teacher directives limit a student's choice, as students are only left with the option of complying (Furtak

& Kunter, 2012; Rogat et al., 2014), working off task or doing nothing. Directing Lenny to work with Theo was in contrast to Mrs Jasmine's interview assertion that in her classes students choose who they want to work with. This showed that sometimes, teachers do not always do what they say because their beliefs are complex and sometimes contradictory (Mansour, 2009).

Teachers may elect to determine partners for students based on the learning intention, and student characteristics (Burke, 2011). It appears Mrs Jasmine paired Theo who was struggling to complete the tree house with Lenny, a gifted student, to foster peer learning (Krange et al., 2020; Obidoa et al., 2012). Some studies have shown that educator selected groups are better than self-selected groups in terms of performance, attitude and behaviours (Felder & Brent, 2001; Post et al., 2020), while other studies have shown similar performance between teacher-selected and self-selected groups (Pociask et al., 2017). Due to the contested nature of the literature on group formation, teachers may need to strike a desirable balance between teacher-selected and student-selected groups, and take into consideration students' feelings in terms of organizational autonomy support.

**Procedural autonomy support.** Mrs Jasmine provided opportunities for procedural autonomy across the three vignettes. Opportunities for procedural autonomy allow students to develop a sense of ownership of the form of the learning output (Furtak & Kunter, 2012; Rogat et al., 2014). These opportunities include freedom to access resources and freedom to determine design of their learning outputs among others.

- ***Opportunities to access learning resources***

Mrs Jasmine provided opportunities for students to access pre-determined resources for their learning tasks in the three vignettes. The resources were placed on the bench next to the teacher's desk for ease of access (straws, masking tape, and scissors) for *my straw musical instrument* and *my straw musical instrument performance* vignettes and (straws, masking tape, scissors and pipe cleaners) for *Christmas tree and tree house* vignette. Therefore, students had

the choice to access the resources when they wanted, essentially offering procedural autonomy (Rogat et al., 2014; Stefanou et al., 2004). Students reacted to this opportunity by accessing the resources when making their straw instruments and structures, thereby demonstrating *compliant autonomy*.

- ***Opportunities to access and use resources of choice***

Mrs Jasmine provided students with opportunities to use additional resources of choice during science lessons. However, Mrs Jasmine did not explicitly announce that students could only use straws, masking tape and scissors, and, as a result, some students explored other resources that they thought would be useful for their straw instruments and structures. Opportunities to access additional resources of choice provided autonomy for students to make decisions on how they wanted to complete their learning outputs, essentially supporting procedural autonomy (Stefanou et al., 2004). For instance, Maeve went beyond the resources presented for use and utilised a mini whiteboard during her planning for the straw instrument project, thereby demonstrating *reactive autonomy* in *my straw musical instrument vignette*. Similarly, Mia used A4 paper to complete her straw instrument in *my straw musical instrument performance vignette*, and Ella and Milly accessed and utilised baubles, flower glitters and tinsels to complete their Christmas tree in *Christmas tree and tree house vignette* thereby demonstrating *reactive autonomy*.

The data shows that Mrs Jasmine adopted a safe and supportive learning environment in which students experienced ownership of the learning environment, and hence had the confidence and willingness to access additional resources without fear (Rogat et al., 2014; Stefanou et al., 2004).

- ***Restricting access to resources***

Despite Mrs Jasmine's support for the use of resources of choice, sometimes she constricted students' opportunities to use resources of choice. For instance, in the *Christmas tree* and *tree house* vignette, Mrs Jasmine directed Milly and Ella to return the mesh nets to the cabinet. Informing students to put the mesh nets away, without seeking to understand why they had the mesh nets, may have denied students the opportunity to justify the need for the mesh nets. Mrs Jasmine did not take into account the students' perspective, denying students the choice for procedural autonomy (Rogat et al., 2014; Stefanou et al., 2004). Milly and Ella reacted to this restriction by complying with Mrs Jasmine's direction by returning the mesh nets to the cupboard thereby demonstrating *compliant autonomy*.

- ***Opportunities to determine the nature and design of their Science projects***

Mrs Jasmine offered students opportunities to determine the nature and design of their science projects, in this case straw musical instruments for *my straw musical instrument* and *my straw instrument performance* vignettes and structures in *Christmas tree* and *tree house* vignette. Students had the choice to determine the number of straws to use, number of holes to cut along the straw instrument and how to play their instrument in the *my straw musical instrument* and *my straw musical instrument performance*. Billy chose to create an instrument with two straws thereby demonstrating *compliant autonomy*. Maeve's group chose to make an eight-straw musical instrument in which they arranged the straws on a sheet of paper thereby demonstrating *reactive autonomy*.

Similarly, students had different reactions in the *Christmas tree* and *tree house* vignette in which they had choices to determine how tall and wide their structures should be. For example, Billy's group reacted by building a tree house in keeping with the teacher's instructions thereby demonstrating *compliant autonomy*. Milly's reacted by building a horizontal Christmas tree decorated with additional features such as baubles, tinsels and flower

glitters, thereby demonstrating *reactive autonomy* as their structure deviated from teacher instructions. Ella at some point in the lesson drifted and created a straw stuffed with flower glitters, thereby creating a structure that differed in form and purpose from the lesson goal but still learning-oriented thereby demonstrating *overdrive autonomy*. It is not clear, however, whether Ella was trying to determine the movement of particles in straws while shaking them or if she was just playing with glitters. Even though this study did not explore the concept with the student, it appeared Ella explored movement of particles in straws.

The data re-affirms the fluid nature of LAD because Ella's autonomy shifted from *reactive autonomy* to *overdrive autonomy* within the same context as the lesson progressed. As demonstrated earlier, the autonomy construct is fluid, moving towards higher levels, then back towards lower levels (Little, 1991; Willison et al., 2017). Moreover, as Ella and Milly demonstrated *reactive autonomy*, Billy demonstrated *compliant autonomy*. This shows that autonomy is variable, even with similar conditions, students can demonstrate different levels of autonomy (Little, 1991).

- ***Time management***

Mrs Jasmine rarely used time signals during her science lessons. However, during the *my straw musical instrument performance* vignette, Mrs Jasmine utilised time signals to alert students that they would be presenting their tune to the class "...you are trying to make a tune, and you are going to present to everybody in about 15 minutes". On other occasions, especially at the end of the lesson, Mrs Jasmine announced that students should pack away their learning outputs without giving any time signals. Students reacted to Mrs Jasmine's time signal by completing their learning tasks in readiness for the presentation, thereby demonstrating *compliant autonomy*. The implication of time signals on student behaviour is discussed in Chapter 5 for Mr Smith.

- ***Using worksheets to scaffold learning***

Mrs Jasmine's teaching style and learning scope did not provide opportunities for students to use worksheets in their learning. The use of worksheets is explored in Chapter 5 for Mr Smith.

**Cognitive autonomy support.** Mrs Jasmine provided opportunities for cognitive autonomy in diverse ways in her Science lessons. Cognitive autonomy support practices encourage student ownership of learning in terms of content, ideas, skills, and thinking (Rogat et al., 2014; Stefanou et al., 2004). These practices include offering informative feedback, offering opportunities for thinking and planning, offering hints to extend students' exploration among others.

- ***Offering informative feedback***

Teacher informative feedback provides opportunities for students to enact new actions towards meeting the success criteria. The informative feedback can be in the form of a question, a suggestion or a comment around student performance, without being judgemental (Großmann & Wilde, 2020; Reeve & Cheon, 2021). It may also show students' progress in terms of skill use, product development and conceptual development of phenomena under investigation. Mrs Jasmine offered informational feedback in diverse ways. For instance, in the *my straw musical instrument* vignette when Maeve and group presented their instrument, Mrs Jasmine asked "oh, nice, so how are you going to play the straws to make a tune?" when Maeve responded, Mrs Jasmine commented "yeah, guys think how you are going to play the straws to produce a tune. Remember the aim is to produce sound to make a tune".

With this informative feedback, which began by appreciating students' performance and then offering information on task requirements, Lara sought help from Billy to create a straw that produces sound. Eventually Lara created a straw that produced sound, thereby demonstrating *reactive autonomy* by enacting some actions that enabled her to create a straw

that produced sound. Students may experience informative feedback as autonomy supportive as it gives them information that elicits further actions towards the realisation of lesson objectives (Gan et al., 2021; Rogat et al., 2014).

- ***Opportunities for thinking and planning***

Mrs Jasmine afforded students an opportunity to think and plan their musical instruments in line with teacher-stated learning intentions in *my straw musical instrument* vignette. Offering students opportunities to think and plan their learning outputs fosters cognitive autonomy around ownership of ideas. Students have the responsibility to think and plan the type of instrument to create and to determine the resource requirements.

Students reacted to the thinking and planning opportunity by designing their instruments, thereby demonstrating *compliant autonomy*. For instance, Maeve used a mini whiteboard to design her eight-straw instrument, while Lara gathered the required resources.

Additionally, when Maeve's group presented their instrument to Mrs Jasmine for assessment, Mrs Jasmine asked the students to think about how they were going to play the instrument. Lara reacted to this opportunity by seeking support from Billy to create a straw that produces sound thereby demonstrating *reactive autonomy*. Lara's autonomy shifted from *compliant autonomy* to *reactive autonomy*. Lara experienced ownership of ideas as she determined how to solve the problem of having an instrument that may be unplayable to creating an instrument that produces sound (Furtak & Kunter, 2012; Rogat et al., 2014). The shift in Lara's LAD re-affirms the fluid nature of LA (Willison et al., 2017), and may have resulted from Mrs Jasmine's evaluation and suggestion for students to think about how they were going to play the instrument, implying that learning progress coupled with teacher suggestions and student characteristics may influence LAD.

- ***Offering hints to extend students' exploration***

Mrs Jasmine utilised hints to extend students' thinking and subsequent actions towards realisation of lesson goals. Mrs Jasmine observed students generating ideas for their musical instruments and structures across the three vignettes, then offered hints to support students' exploration and completion of their learning tasks. Hints and advice support further learning fostering cognitive autonomy (Großmann & Wilde, 2020). For instance, Mrs Jasmine suggested to Billy and Remi in *my straw musical instrument* and *my straw musical instrument performance* vignettes respectively that they try different sizes of straws when they created straws that produced sound. Moreover, when Billy and Remi created multi-straw instruments, Mrs Jasmine suggested they try to move the straws up and down so that they could keep changing the length and see if the straws could produce different notes. The changing length would enable students to decipher the influence of length on pitch, thus facilitating learning. While in the *Christmas tree and tree house* vignette, Mrs Jasmine hinted to Lara, who was struggling to fix the Christmas, that the square was at the bottom, despite Lara picking the square, she was unable to fix the Christmas tree. Earlier on while creating the Christmas tree, Mrs Jasmine suggested to Milly to fix the piece of tinsel she had identified somewhere on the Christmas tree.

In response to Mrs Jasmine's suggestions and hints, students demonstrated diverse reactions. When Mrs Jasmine suggested to Remi and Billy to try different straw sizes, Billy and Remi created a two-straw and a three-straw instrument respectively thereby demonstrating *reactive autonomy*; Billy and Remi went beyond just trying another straw size by devising a way to join the straws into one longer straw. Increasing the length of the straw may have provided opportunities for Remi and Billy to move the straws up and down so they could determine the influence of length on sound produced. Billy and Remi demonstrated *compliant autonomy* by moving the straws up and down while playing their instrument in response to Mrs

Jasmine's suggestion 'can you try to move the straw up and down to compare the sounds'. However, Billy and Remi did not report their findings. Lara in the *Christmas tree and tree house* vignettes picked the square thereby demonstrating *compliant autonomy*. However, by just staring at Mrs Jasmine without taking any action, Lara demonstrated *underdrive autonomy*. Contrary to Lara's reaction, when Mrs Jasmine suggested to Milly to fix the piece of tinsel somewhere on the Christmas tree, Milly quickly placed the tinsel inside the bottom cone thereby demonstrating *reactive autonomy*.

Billy and Remi's LAD shifted from *reactive autonomy* to *compliant autonomy*. While Lara's LAD shifted from *compliant* to *underdrive autonomy*. This finding further illuminates the fluid nature of LAD and provides further evidence that LAD is 'a back and forth' attribute (Little, 1991; Willison et al., 2017). The learning context and teacher action requested contributed to the varying nature of LAD. Additionally, the data shows that familiarity with the task may influence LAD. Milly was more familiar with the Christmas tree structure compared to Lara, hence Milly's quick, positive reaction to teacher suggestions and Lara's underdrive reaction to Mrs Jasmine's suggestion, because she was not there when the girls began constructing the Christmas tree.

- ***Encouraging students to try different ideas***

Mrs Jasmine provided opportunities for students to try different ideas. Opportunities to attempt different ideas fosters cognitive autonomy as students generate the ideas they want to experiment with, leading to a sense of ownership of the ideas, learning and thinking (Rogat et al., 2014; Stefanou et al., 2004). Mrs Jasmine encouraged students to experiment with a different number of straws with different lengths and widths to determine the different sounds they produce. These freedoms challenged students to think beyond one straw instrument, thus supporting them to explore how straw length affects sound produced. In response to this opportunity, students created straw instruments using different sizes of straws thereby

demonstrating *compliant autonomy*. Billy created a two-straw instrument in *my straw musical instrument* vignette, whereas Lara and Remi created straw instruments using different sizes of straws, while Remi created a multi-straw instrument in the *my straw musical instrument performance* vignette.

Mrs Jasmine allowed students to initiate and try their own ideas. For example, in the *Christmas tree and tree house* vignette, Lenny suggested to Mrs Jasmine that he wanted to use the thinner straws to make a ladder for the tree house. Mrs Jasmine nodded thereby allowing Lenny to try his idea. Lenny reacted to this freedom by explaining to Theo that a diagonal ladder was better than a straight ladder for the tree house. Despite having the freedom to try his idea of a diagonal ladder, Lenny chose to adhere to what Theo had started creating. Lenny's initiative to try a diagonal ladder showed that he was operating at *reactive autonomy* as he sought to help Theo create a ladder in response to Mrs Jasmine's directive. However, his decision to support Theo to complete a ladder on the side of the house showed Lenny operating at *compliant autonomy*.

Allowing students to try their ideas makes students as co-constructors of learning opportunities. As a result, students assume greater responsibility for their learning, and, as such, apply their prior knowledge and assimilate new information to develop new understandings (Rannikmäe et al., 2020). Lenny's initiative of using thinner straws for the diagonal ladder was a classic example of Mrs Jasmine taking students' perspectives as co-constructors of learning opportunities; however, Lenny missed the opportunity to create new knowledge when he assisted Theo in completing the ladder on the side of the house, contrary to his vision of having the ladder off the tree.

The data shows Lenny's autonomy operating between *reactive* to *compliant autonomy* within the same conditions. It appears Lenny's LAD was influenced by the nature of the learning task and the progress made in the learning task, coupled with the nature of grouping

and the partner Lenny was working with (Little, 1991).

- ***Questioning to scaffold students' thinking***

Mrs. Jasmine used diverse questions to scaffold students' thinking when they engaged in hands-on learning. Questions, especially open-ended questions, foster autonomy support as they elicit student ideas and give students opportunities to think in response to the questions. For instance, in the *Christmas tree and tree house* vignette Mrs Jasmine utilised a series of questions to extend Milly's and Ella's thinking as they constructed the Christmas tree. The following excerpt illuminates Mrs Jasmine's questioning:

Mrs. Jasmine: What else could you add to it?

Ella: A star

Milly: We've got a star!

Mrs Jasmine: You've got a star, you could add some, but what do Christmas trees normally have?"

Milly: I made a piece of tinsel (as she displays the piece of tinsel).

Mrs Jasmine: Cool, you can fix it somewhere (Milly fixes the tinsel in the bottom cone)

Mrs. Jasmine: ahaa, so what else could you put there?

Milly: I can't remember".

Mrs Jasmine: What goes on trees normally, on that sort of tree? (Some silence)

Mrs. Jasmine: What do you put on your trees at home?

Milly: Baubles

Mrs. Jasmine reacts there you go.

The narrowing nature of Mrs Jasmine's questioning from general open-ended questions to narrow open-ended questions guided Milly and Ella to decipher the connection between the Christmas tree they were building at school and the Christmas trees at home, thus introducing interesting features such as baubles, tinsels and flower glitters. Mrs Jasmine's open-ended questioning coupled with the use of relevant examples and feedback fostered cognitive autonomy as the questions linked students' schoolwork with real life experiences, allowing students to travel back in time and space to re-imagine their Christmas trees at home, then generate ideas to complete their Christmas tree at school. These levels of relevancy offer students opportunities for cognitive autonomy as students think and reflect on what they already know and have at home, which they can apply in their present context (Rogat et al.,

2014), to successfully complete their learning tasks.

Students reacted to Mrs Jasmine's questioning by responding to her questions thereby demonstrating *compliant autonomy*. For instance, when Mrs Jasmine asked Milly about things that go on trees, Milly answered 'bauble' as she placed the bauble inside the lower cone, thereby demonstrating *compliant autonomy* when she responded bauble and *reactive autonomy* when she placed the bauble inside the lower cone. The data shows that teacher questioning offers guidance which can stimulate student ideas towards enhanced learning.

- ***Restricting students' discussions***

Mrs Jasmine sometimes restricted students' discussions which may have limited students' opportunities to make their thinking and ideas visible. Restricting students' discussions might negatively impact students' ways of thinking, thus influencing the nature of their learning outputs. For instance, when Maeve's group was planning their instrument in the *my straw musical instrument* vignette, they had a conversation around student roles when Mrs Jasmine interjected 'is colour important?' in response to a student indicating that they determined the colour of the straws. When Mrs Jasmine interjected, the students remained quiet as they disengaged from the discussion thereby demonstrating *underdrive autonomy*. It appears Mrs Jasmine sought to refocus students' discussion to important variables under investigation. However, her interjection shut down student discussion thus generating an unanticipated student reaction. The data shows that teacher questioning elicits compliance from students as they seek to answer teacher questions; however, when teachers provide negative feedback, students disengage from further participation (Chipchase et al., 2017).

- ***Allowing and responding to student questions***

Mrs Jasmine did not explicitly provide opportunities for students' questions; however, she responded to student questions especially around working with partners. Mrs Jasmine responded to Maeve's question regarding working with partners in the *my straw musical*

*instrument* vignette (see opportunities to select and work with partners in organizational autonomy).

- ***Task clarification***

Mrs Jasmine regularly clarified task requirements before releasing students to undertake learning tasks. For instance, during the *my straw musical instrument* vignette, when Maeve asked whether they were going to work with partners, Mrs Jasmine clarified “...until the first bit is done, where you're planning your own instrument using straws while you're thinking about it and working out who's in your group. Remember, you're planning instruments, different lengths for the straws make different sounds for the notes. But then once your instrument is made, you're going to actually play it”. This clarification guided students’ ensuing actions as they followed teacher instructions to plan their instruments thereby demonstrating *compliant autonomy*. The clarification of concepts is vital in fostering student learning by ensuring the learning intentions and next actions are clear (Rannikmäe et al., 2020). When learning intentions and expectations are clear, students are able to regulate their actions better, hence leading to desired learning outcomes (Inayat & Ali, 2020). However, Mrs Jasmine’s instructions were prescribed, therefore requiring compliance from students and demonstrating low cognitive autonomy (Furtak & Kunter, 2012).

- ***Encouraging self-evaluation and self-correction***

Mrs Jasmine did not explicitly provide opportunities for self-evaluation and self-correction in her teaching. However, her comments and questions sometimes fostered students’ self-correction. For instance, in the *my straw musical instrument* vignette she suggested to Maeve and her group to think how they are going to create an instrument to create a tune when they presented their instrument for assessment (see opportunities to determine when to present assignment for assessment), essentially implicitly asking the students to self-evaluate and self-correct. Lara reacted by approaching Billy for support in the creation of a functional straw

instrument thereby demonstrating *compliant autonomy*.

- ***Providing rationale***

Mrs Jasmine provided rationale by linking prior lessons with current lessons. By articulating to students the links between lessons in relation to content and skills being developed by teachers, Mrs Jasmine illuminated that the purpose of the lesson was grounded in prior lessons. This practice exemplifies the rationale by showing the connectedness among lessons and creating a lesson goal that relates to recently developed knowledge. For instance, when Mrs Jasmine was facilitating students' understanding of the straw making process in the *my straw musical instrument performance* vignette, she mentioned how students struggled with creating a straw that produced sound in the previous lesson. Mrs Jasmine clarified that the process needed commitment and focus. Students reacted by creating straws that produce sound following the previous lesson procedures and the procedures demonstrated in the current lesson thus demonstrating *compliant autonomy*. For instance, Remi and Ryan created recorders.

Similarly, in the *my straw musical instrument* vignette, Mrs Jasmine provided the rationale as to why students should work with partners when carrying out learning tasks. Mrs Jasmine asserted that working with pairs is fun and allows students to share ideas. Students reacted to this opportunity by working with partners thereby demonstrating *compliant autonomy* (see opportunities to select and work with partners). When teachers provide a rationale, students might perceive the task to be meaningful, therefore they engage in carrying out the task (Reeve, 2009; Rogat et al., 2014; Steingut et al., 2017).

- ***Responsiveness***

Several practices in Mrs Jasmine's teaching illuminated her responsive nature that included active listening and using students' ideas to guide learning (Kiefer et al., 2014; Rogat et al., 2014). Mrs Jasmine exhibited active listening in the *Christmas tree and tree house* vignette when she asked Milly and Ella what their Christmas trees at home normally have and

Milly responded “I made a piece of tinsel” as Ella displayed the piece of tinsel. Mrs Jasmine commented “Cool, you can fix it somewhere”, showing that she was actively listening. Ella responded by fixing the piece of tinsel on the lower cone thereby demonstrating *reactive autonomy*. Additionally, Mrs Jasmine demonstrated responsiveness when she asked Lara, who had just created a straw that produced sound in the *my straw musical instrument* vignette, how she made the straw, and, as Lara explained, Mrs Jasmine asked additional questions such as “have you tried with a different size of straw?” This showed that Mrs Jasmine was attentively listening to Lara’s responses. Lara reacted to Mrs Jasmine’s responsiveness by trying different straws and eventually reporting that the shorter one had a higher pitch than the longer one.

#### **4.4.2 Nature of Inquiry-Based Learning**

This section describes the nature of inquiry-based learning (IBL) facilitated by Mrs Jasmine across the three vignettes using the Models of Engaged Learning and Teaching (MELT) framework as detailed in section 3.4.3 level 3 analysis. The six facets of MELT are: embark and clarify, find and generate, evaluate and reflect, organise and manage, analyse and synthesise, and communicate and apply.

**Embark and Clarify.** The embark and clarify facet was structured as Mrs Jasmine stated the lesson purpose across the three vignettes and clarified the scientific concepts the students would explore during the lesson in the *my straw musical instrument* and *my straw musical instrument performance* vignettes: ‘To explore the length of the straw because the length of the straw changes the sound of the note’. Hence, she provided the problem to be investigated as the students were responsible for the planning and exploration of variables. Mrs Jasmine’s provision of questions/problems to be investigated partially contradicts her interview findings that revealed that students were engaged in addressing both teacher- and student-generated questions. Observation data has shown that students were engaged in addressing teacher questions across the three vignettes. Therefore, showing a contrast between teacher

self-reports and observed practice (Capps et al., 2016).

To ensure students were well prepared to embark on the journey of creating musical instruments and building structures using straws, and exploring the effect of length on pitch, Mrs Jasmine had students recount their prior knowledge through questioning, then utilised explicit instruction, relevant examples and YouTube videos to foster students' conceptual understanding of the phenomena under investigation in the *my straw musical instrument* and *my straw musical performance* vignettes (Darling-Hammond et al., 2020; Van Uum et al., 2016). Furthermore, Mrs Jasmine provided students with thinking and planning time to plan their musical instruments and select their partners in the *my straw musical instrument* vignette. Provision of students' thinking and planning time sought to foster students' ability to plan prior to the actual instrument making, thus facilitating a smooth embarkation and fostering students' interest and engagement (Murdoch, 2006). Maeve while working with her group used a mini-whiteboard to draw a sketch of their planned instrument, whereas Lara gathered resources for use such as straws, scissors and masking tape for their group. The group was socially engaged as they shared roles amongst themselves establishing the conditions of inquiry (Hopkins et al., 2015).

Evidence of the structured nature of inquiry is further illuminated when Mrs Jasmine encouraged students to use straws with similar width but to vary the length to determine the influence of the length on the sound produced, in effect prescribing the actions students needed to undertake in the *my straw musical instrument* and *my straw musical performance* vignettes. The implication is that Year 4 students may experience difficulties in generating their own questions or problems to investigate and may even experience more difficulty in determining the variables to explore (Ruggeri et al., 2021; Swaboda et al., 2022). Therefore, Mrs Jasmine offered guidance by stating the problem and variables to be explored. However, some researchers assert that IBL facilitators like Mrs Jasmine should have allowed students to

explore the concept of length and sound before offering explicit instruction (Alston et al., 2020; Marshall, 2013). Others disagree, stating that discovery learning from phenomena is more than merely inefficient, it may lead to resilient non-scientific understandings, and, worse, frustration with learning that leads to disengagement (Kirschner et al., 2006; Klahr & Nigam, 2004). Findings from the *Christmas tree and tree house* vignette support this argument; due to minimally guided embarkation, Milly and Ella embarked on constructing a horizontal Christmas tree deviating from initial teacher instructions of constructing a tall structure with a big base.

Mrs Jasmine created a supportive learning environment that fostered students' emotional engagement. Embarking is a complex process which can elicit diverse emotions depending on how the teacher facilitates and clarifies the phenomena under investigation. Mrs Jasmine often began her lessons by using lesson triggers that drew on students attention before she declared the lesson purpose and problem to be investigated (Rannikmäe et al., 2020). "So, what we're looking at today is you are going to be making your own musical instruments using straws". Followed with a chorus response "wow" from the students in the *my straw musical instrument* vignette, showing feelings of excitement and happiness illuminating how Mrs Jasmine's opening statement drew on students' feelings to emotionally engage them in the learning task (Kourti, 2019). To draw on students' curiosity, Mrs Jasmine began the lesson with a question "now, have you ever heard in music *do-re-mi*?" Students responded in the affirmative as they completed the tonic solfa notation "*-fa-so-la-ti-do*". Essentially revealing their knowledge on the tonic solfa notation and manifesting their interest with the lesson content (Keller et al., 2020; Kourti, 2019). Students showed excitement and interest in the *my straw musical instrument performance* vignette as well when Ryan shouted "straws, I love straws" as she joined Remi to gather straws from the cupboards. Such opening questions as used by Mrs Jasmine captured student's attention leading to engagement in learning (Keller et

al., 2020). Mrs Jasmine taught the *my straw musical instrument performance* vignette in a similar version to the *my straw musical instrument* vignette. Student emotional engagement is equally similar despite the small number of Year 4 students that remained for Science in the *Christmas tree and tree house* vignette.

**Find and generate.** The find and generate facet was not explicitly stated in Mrs Jasmine's facilitation of learning across the three vignettes. However, Mrs Jasmine utilised teacher questioning and suggestions to promote students' manipulation of materials, thus facilitating student data generation. For instance, in the *my straw musical instrument* vignette, when Lara created a straw that produced sound, Mrs Jasmine asked her whether she had tried different straw sizes, in effect, Lara created a different straw size that produced sound. Mrs Jasmine followed with "have you tried whether they are making different sounds? Which one has a higher pitch, the longer or shorter one?" To which Lara responded "I don't know" as she played her straws to generate data to respond to Mrs Jasmine's question. She concluded 'the shorter one has a higher pitch than the longer one'. Similarly, Mrs Jasmine asked Remi 'have you discovered which straw makes a higher pitch?' Remi played her two straws alternately while listening to the sounds. She then reported 'this one has a high pitch' while displaying the short thin straw. Even though Mrs Jasmine used questioning to instigate student generation of data, both Lara and Remi determined their own strategies to generate data to respond to Mrs Jasmine's questions. Both Lara and Remi played their instruments and reported their findings. Therefore, the nature of inquiry in this case was guided. Mrs Jasmine asked Remi similar questions in the *my straw musical instrument performance* vignette; however, in this case Remi did not report her findings, as Mrs Jasmine moved on to observe other students.

The observation data showed that students were investigating similar problems contrary to Mrs Jasmine's interview assertion that when she provided students with questions to investigate, she provided them with different questions. However, the observation finding does

concur with her interview assertion that even when students investigate similar problems, they progress at their own pace as demonstrated across the three vignettes. Therefore, there are mixed results on the link between teacher self-reports and observed actual classroom practice (Mansour, 2009).

Students need guidance and structure to gather requisite data. Observation data showed that without Mrs Jasmine's questioning which offered guidance, students may have continued playing different tunes without testing the influence of length on pitch. It appeared some of the students needed teacher guidance to generate data that was pertinent to the inquiry questions. Untimely fading of teacher support meant students did not report their findings (van de Pol et al., 2019). Moreover, without structure, in this case, teacher questioning, students may fail to generate requisite data and lose the focus of the learning activity (Eckes et al., 2018). For instance, Mrs Jasmine questioned Billy in the *my straw musical instrument* and Remi in the *my straw musical instrument performance* vignettes about whether they had tried different straw instruments, as the students made straw instruments of different sizes. However, Mrs Jasmine did not follow up with the students to determine whether they had tested the different straw instruments. Hence, students kept playing with the straws without reporting their findings or testing the influence of length on pitch.

Data generation processes can be frustrating and exciting, depending on the progress the students are making. The data generation exercise was frustrating for Ryan and Mia in the *my straw musical instrument* and *my straw musical instrument performance* vignettes, and for Lara in the *Christmas tree and tree house* vignette. As Ryan struggled to create a straw instrument that produced sound in *my straw musical instrument* vignette, he lamented "I'm so jealous, mine can't seem to work" when I asked him how he was doing. It appeared jealousy controlled his drive as he kept trying straw after straw without consulting others, till Mrs Jasmine offered additional guidance, then he was able to create a straw that produced sound. It

was not clear why Ryan did not seek help until Mrs Jasmine offered to support him. However, once he created a straw that produced sound, he was confident and smiled while playing his straw for all to see, showing the shift in emotion from frustration to excitement based on teacher support. Ryan experienced a similar shift in emotion in the *my straw musical instrument performance* vignette, but this time he sought help from peers to create a straw that produced sound. The data show that peer and teacher support can help bolster emotional engagement as they help struggling students to overcome data generation challenges (Kourti, 2019).

**Evaluate and reflect.** The evaluate and reflect facet required students to evaluate the data gathered and reflect on their learning. However, evaluation and reflection were not explicitly stated across the three vignettes.

Mrs Jasmine utilised teacher questioning to instigate student evaluation of data. For instance, in the *my straw musical instrument* vignette, Mrs Jasmine's questioning instigated Lara and Remi's data collection as exemplified in the *find and generate facet*. Data collection naturally leads to evaluation of the quality of data. When Lara was asked to state which straw produced a higher pitch, she played her straws alternately four times while listening to the sound produced before she concluded 'the shorter one has a higher pitch than the longer one'. Lara demonstrated repeatability of the measurements in science, laying trust in repeatable measures where she listened to the sounds repeatedly before concluding (Mohajan, 2017; Van Uum et al., 2016; Willison, 2020).

Whereas Lara made four measurements before concluding, Remi attempted one measurement and reported her findings when she was asked the same question as Lara. Remi might have trusted her data generation skills contrary to principles of reliability of the data (Mohajan, 2017; Van Uum et al., 2016). It may appear, therefore, that whereas Lara demonstrated exemplary data evaluation skills like those of a scientist (Mohajan, 2017; Van Uum et al., 2016), Remi demonstrated inadequate data evaluation skills. Lara operated at open

inquiry in relation to data evaluation as she initiated the data evaluation process. When Mrs Jasmine asked Billy and Remi the same questions in the *my straw musical instrument performance* vignette on data generation, Billy and Remi did not report their findings, hence it was not possible to ascertain whether the data would have been evaluated.

Mrs Jasmine did not provide opportunities for students to reflect on the learning process across the three vignettes. Reflection opportunities may facilitate better conceptual understanding of the phenomena under investigation (Van Uum et al., 2016). Inability to reflect in the *my straw musical instrument* vignette was also demonstrated in the *my straw musical instrument performance* vignette as Ryan and Mia encountered similar difficulties and needed peer and teacher support to create a straw that produced sound. Students would have benefited from reflection activities including coming up with a report on their findings, documenting the straw creation process, drawing sketches of instruments and structures and stating what they could have done better (Van Uum et al., 2016). This finding that students did not have reflection opportunities contradicts other findings that have shown that teachers engage students in reflection at the end of a learning exercise (Van Uum et al., 2016).

Emotional engagement was manifested in different ways in the evaluate and reflect facet. Lara was discerning as she demonstrated good judgement by evaluating her data four times before reporting her findings (Van Uum et al., 2016). Remi manifested frustration when asked by the Year 5 teacher what song she was playing as she kept lamenting ‘it’s not working’ without actually evaluating why her instrument was not working (Kourti, 2019). This finding that students manifested diverse emotions during analyse and synthesis is consistent with findings in literature that students experience different emotions during inquiry learning (Attard et al., 2021).

**Organise and manage.** The organise and manage facet is linked to ‘data collection and analysis’ as students organise data to reveal patterns. Teacher questioning and suggestions often instigated student data generation, further influencing how students organized the data to reveal patterns. For instance, in the *my straw musical instrument* vignette when Mrs Jasmine asked Lara, “which one has a higher pitch, the longer one or shorter one?” this question led Lara to organise her data into two data sets so that she could analyse the data to reveal patterns: pitch and length of straw in keeping with the format of Mrs Jasmine’s question. As a result, Lara reported, ‘the shorter one has a higher pitch than the longer one’. Because Lara did not record her data, nor did she analyse the data on paper or computer, her organization of themes to reveal patterns was not visible. However, her conclusion reveals that in her head she organized the data into length of straw and pitch of sound produced. Similarly, Remi’s response to Mrs Jasmine’s question reflected the influence of Mrs Jasmine’s question format on how Remi presented her response. Therefore, Mrs Jasmine’s questioning style influenced how Lara and Remi organized data to reveal patterns.

Teacher questioning and suggestions can facilitate student organization and management of resources. For instance, when Remi created a two-straw instrument, Mrs Jasmine suggested ‘can you move it up and down?’ Mrs Jasmine’s suggestion prompted Remi to add another straw thus organizing her instrument into a three-straw instrument. This organization of the straw instrument presented unique opportunities for Remi to test whether length has an influence on pitch, in keeping with the goal of the lesson and the problem being investigated.

Teacher evaluation of students’ projects often instigated further actions leading to the re-organization of learning resources. Notably, when Mrs Jasmine evaluated Maeve’s group instrument and recommended that the group should think how they were going to play their instrument, the group was re-organized as Lara chose to work alone, eventually creating a

functional straw musical instrument. The breakaway episode illuminates the complexities around group work. Despite research demonstrating that the majority of IBL lessons are comprised of group work activities, group work poses numerous challenges to both teachers and students (Kutnick & Blatchford, 2014). Even though this group appeared to have a well-defined working arrangement, Mrs Jasmine's evaluation of their work disrupted this arrangement as Lara sought success by working individually (Kutnick & Blatchford, 2014). As group thinking may be difficult to manage, teachers may need to facilitate group collaboration to ensure harmonious interaction among group members (Van Uum et al., 2016).

Moreover, Mrs Jasmine used diverse grouping strategies to organize and manage resources. For instance, she began her lessons with a whole class introduction, followed by group/pair or individual work tasks. Students were regularly organized into pairs as they worked with partners and in small groups of three. Small group size appeared effective as students worked harmoniously to complete their tasks (Kutnick & Blatchford, 2014). However, group work was not without its tensions as already discussed in Lara's case where she sought to work alone due to her group's failure to create a straw instrument meeting the teacher's set criteria.

While organizing information, students experienced different emotions that influenced the learning outcomes. Lara worked harmoniously to combine the different data sets to report her findings in the *my straw musical instrument* vignette (Willison, 2020). However, she experienced frustration when trying to fix the disfigured Christmas tree in the *Christmas tree and tree house* vignette, because she could not figure how to fix the tree. Feelings of frustration can lead to disengagement and poor learning outcomes (Kourti, 2019).

**Analyse and synthesise.** Mrs Jasmine's questions, evaluation and subsequent suggestions of students' straw instruments often instigated students' analysis and synthesis. For instance, when Mrs Jasmine asked Lara to identify the straw with a higher pitch in the *my*

*straw musical instrument* vignette, Lara played her two straw instruments alternately four times each before she responded, “the shorter one has higher pitch than the longer one”. The play, listen, play, listen appeared to be an analytical process that assisted Lara to separate the sounds produced by the two straw instruments. Lara worked out that there was a difference in the pitch produced by the two straw instruments, and she inferred that the difference was due to the length of the straw. She stated to Mrs Jasmine “the shorter one has higher pitch than the longer one”. To arrive at this analysis, Lara shifted from the pitch produced by the short thin straw to a generalisation “the shorter one has higher pitch than the longer one”. Remi had a similar experience even though she only used one measure to arrive at her conclusion when questioned by Mrs Jasmine on which straw had a higher pitch. Lara and Remi appeared to possess data analysis skills; however, due to limited variability of the data gathered, and the adoption of literacy-free science lessons (science lessons where the teacher did not emphasise literacy learning), students did not record their data analysis process and did not synthesise their understanding into written, presented or multimedia forms. Additionally, Lara and Remi did not link their findings to scientific concepts. This finding is inconsistent with other findings that report that students were consistently engaged in gathering and recording data (Van Uum et al., 2016). However, this finding is consistent with Seung et al. (2014) who revealed that teachers did not encourage students to connect explanations to evidence.

While Mrs Jasmine facilitated students’ creation of straw instruments in the *my straw instrument performance* vignette, she did not question students in ways that fostered students’ presentation of data as she did in the *my straw musical instrument* vignette. Hence, students like Remi and Billy who created straws that produced sound did not report their findings around the effect of length on pitch. Therefore, the researcher was unable to discern Remi’s conclusion, and subsequent analysis and synthesis. The data shows that if teachers do not offer structure and guidance, students may lose track of their learning, and they may not generate requisite

data, hence they are not able to make visible their analysis and synthesis capabilities (Eckes et al., 2018; van de Pol et al., 2019; Van Uum et al., 2016). Students may benefit from structured guidance to collect data either in the form of questions or worksheets, rather than merely engaging in exploration of the hands on activities (Fernandez et al., 2023). It appears Mrs Jasmine was focused on students creating instruments and tunes for presentation, rather than exploring the effect of length on pitch, as this was explored in the previous vignette (lesson). This is similar to having fun with manipulation of materials without linking activities to scientific concepts (Fernandez et al., 2023) .

Analysis and synthesis are complex processes and, as such, students may experience diverse emotions as they analyse the data and their learning. Mrs Jasmine’s facilitation of hands-on learning activities around straws was highly engaging and interesting to students. As evidenced, students engaged in data analysis with minimal anxiety. For instance, when Mrs Jasmine asked Lara whether she had determined which straw produced a higher pitch, Lara replied ‘I don’t know’. Manifesting uncertainty (Kourti, 2019), but at the same time willing and determined to provide the answer. When Lara played her instruments, she was discerning the different sounds and determining which straw actually produced a higher pitch. To effectively separate the sounds, Lara needed great attention and thoroughness (Kourti, 2019). When she found the answer, she communicated with joy, showing that students’ success in learning can generate happiness (Kourti, 2019). Remi manifested what Willison (2020) referred to as *slapdash* as she quickly responded to Mrs Jasmine’s question basing her response on one measure.

**Communicate and apply.** Communication and application were influenced by a series of factors. The factors included teacher questioning, provision of a safe and supportive learning environment and provision of opportunities for presentation.

Teacher questioning instigated student communication and application of knowledge. For instance, when Mrs Jasmine asked Lara which straw produced a higher pitch in *my straw musical instrument* vignette, Lara responded ‘the shorter one has higher pitch than the longer one’. The teacher’s question influenced how Lara framed her response. As much as it appears she adapted teacher language to construct her conclusion, the way she presented the conclusion revealed that she was not well adapted to using scientific language to present scientific findings (Willison, 2020). Similarly, Remi adapted the teacher’s language in the question to frame her response. Student communication, whether teacher or student instigated, exposed students to feedback or criticism (Van Uum et al., 2016). As such, it may have contributed to further improvement depending on the nature of feedback or criticism (Van Uum et al., 2016). Lara and Remi’s communication of their findings was teacher-instigated, hence guided inquiry. However, during the lesson, students experienced *open inquiry* as they instigated applications of prior knowledge and skills, as well as communicating with teacher and peers. The data shows that students can experience different levels of inquiry within the same lesson depending on the nature and level of task being undertaken (Ramnarain, 2010; Ramnarain & Hobden, 2015; Willison et al., 2017).

Provision of formal opportunities for presentation provided a platform for students to play their straw musical instrument. Mrs Jasmine provided formal opportunities for students to play a tune using their straw instruments in the *my straw musical performance* vignette, hence making visible their learning outputs. For instance, Remi, Mia and Ella presented ‘twinkle twinkle’. Ryan and his Year 5 partner presented “star wars”. Additionally, these opportunities enhanced students’ presentation and communication skills. However, besides students playing their tunes, they did not communicate whether the variables under exploration, that is length and pitch, were related. It appears Mrs Jasmine was focused on the hands-on and performance part of the lesson, and not the inquiry part. Hence, despite students communicating during the

lesson on various aspects, they did not scientifically communicate their research findings. The students missed potential learning opportunities to acquire inquiry skills across the three vignettes. An inquiry framework such as the 5E or MELT would provide a guiding framework for teachers to follow to ensure such potential opportunities for learning are not missed (Bybee et al., 2006; Van Uum et al., 2016; Willison, 2020).

Lara was a joyous and constructive student who communicated her findings effectively when questioned by Mrs Jasmine in the *my straw musical instrument* vignette. She communicated her needs throughout the lesson, for instance, when she needed support to create a straw that produced sound, she approached Billy and asked “how did you make it?” She demonstrated good judgement by seeking support from an experienced peer (Kutnick & Blatchford, 2014). Remi experienced worry and uncertainty when preparing to present her tune in the *my straw musical instrument performance* vignette. For instance, while she was presenting her tune, she kept lamenting “mine can’t seem to work”, even though her instrument was working. Remi’s self-efficacy was low as she was not sure about her tune hence she experienced anxiety (Kourti, 2019).

#### **4.5 Chapter Summary**

This chapter explored Mrs Jasmine’s inquiry-based learning (IBL) practices whilst teaching sound production using straw musical instruments and building structures using straws to Year 4 students.

The findings revealed that Mrs Jasmine had a *narrow* knowledge of IBL and interpreted LA in a *proactive sense*. Mrs Jasmine utilised diverse autonomy supportive practices to foster LA: cognitive autonomy, procedural autonomy, and organizational autonomy. Mrs Jasmine adopted both high and low autonomy supportive practices in her teaching. The majority of Mrs Jasmine’s autonomy supportive practices were high autonomy as they provided students with diverse opportunities for choice. Students reacted by demonstrating diverse levels of LA

ranging from *compliant autonomy* to *reactive autonomy* to *proactive autonomy* and *overdrive autonomy*. The low autonomy support restricted students' opportunities for choice, leading to low levels of autonomy being demonstrated as students' LAD ranged between *underdrive autonomy* to *compliant autonomy*.

Mrs Jasmine facilitated guided hands-on inquiry learning. Students experienced four essential features of inquiry (questioning, data collection, data analysis and communication) in the *my straw musical instrument* vignette and two essential features of inquiry in (questioning and data collection) the *my straw musical performance* vignette; however, students did not explore any essential feature of inquiry in the *Christmas tree and tree house* vignette. Therefore, students did not experience the full range of IBL practices in Mrs Jasmine's lessons. Mrs Jasmine combined IBL and explicit instruction where she predominantly used IBL hands on learning.

It appears Mrs Jasmine's knowledge, and beliefs influenced how she facilitated science learning, as she adopted a more open inquiry approach with high autonomy support thus facilitating students to manifest diverse levels of LAD. However, there was a complex relationship between her knowledge of IBL and the nature of IBL facilitated.

## **Chapter 5 Mr Smith's Inquiry-Based Learning Practices**

This chapter presents research data and analysis of Mr Smith's teaching of inquiry-based learning (IBL) in a Year 4 Science class in a metropolitan Catholic school in Adelaide, South Australia, the same class Mrs Jasmine teaches on Wednesdays and Thursdays. The chapter mirrors Chapter 4's organisation of five sections: the first three are based on interview data and selected observation data: context; Mr. Smith's knowledge of IBL; and Mr Smith's knowledge of learner autonomy (LA). The next section focuses on observation data in the form of three research vignettes about Mr Smith's facilitation of learning. This is followed by a detailed analysis using the three frameworks: learner autonomy supported framework, learner autonomy demonstrated framework, and MELT framework to analyse *learner autonomy supported*, *learner autonomy demonstrated* and nature of IBL facilitated respectively.

### **5.1 Context**

The context section details Mr Smith's educational and teaching background, and the classroom culture. The physical organization of the Year 4 classroom and the Year 4 students' characteristics have been described in the research methods section.

#### **5.1.1 Mr. Smith's Educational and Teaching Background**

Mr Smith holds a Bachelor of Education in History and Physical Education. During the study, Mr Smith was in his first year of teaching and was responsible for a Year 4 class on Mondays and Tuesdays. He started teaching in the case study school in term 2 of 2021; however, he has been an Education Support Officer (ESO) in the school since 2018.

#### **5.1.2 Classroom Culture**

Mr Smith created a classroom culture in which he fostered student questioning. For instance, following lesson introduction, he regularly asked students whether they had any questions before releasing the students to undertake their learning tasks. This practice of allowing student questions created a safe environment in which students frequently asked

clarification questions, seeking clarification around organizational autonomy, especially with working with partners (Rogat et al., 2014).

### **5.1.3 Science Topics**

Both case study teachers indicated that as much as they chose the topics to teach individually, they based the selection on an overall school theme and discussed the topics amongst themselves to ensure there was no overlap. Both Mrs Jasmine and Mr Smith indicated that every term, the school identified a theme that all subjects were based on. For instance, during the study period, the school was focusing on Australia and Australia States. Therefore, teachers designed their lessons based on Australia and Australia states. Mr Smith indicated that he engaged in a discussion with Mrs Jasmine to ensure they covered different science topics. Mr Smith taught the greater Ecosystem unit in which he focused on the Daintree Rainforest. The ecosystem unit can be linked to the Science Understanding strand, Biological Sciences sub-strand -living things in the AC: Science. Students engaged in internet inquiry on various concepts of the ecosystem including what is an ecosystem, mutualism and animals in the Daintree Rainforest. These topics were sometimes abstract and cognitively demanding as students had to synthesise information from the internet to make meaning. Some concepts within these topics were less visible to learners due to their complex nature. However, Mr Smith scaffolded students' information search to promote students' conceptual understanding.

## **5.2 Knowledge about Inquiry-Based Learning**

Mr Smith's knowledge of IBL was elicited in interviews and then explored through the analytical framework presented in Table 3.4. The analytical framework explored teacher knowledge of IBL through teacher interview statements on i) what IBL is, ii) teacher and student roles in IBL, and iii) the role of assessment in learning.

### 5.2.1 *Meaning of Inquiry-Based Learning*

Mr Smith defined IBL as teachers giving students a focus, and then students searching for different types of information in keeping with the teacher's focus. Therefore, Mr Smith understood IBL as students searching for information.

Giving the students, I guess, a focus, but then the students inquiring or finding out different information. So, I guess, me kind of ... almost like a pyramid ... me telling them what the focus is, but then the students kind of realizing that there's so many things that filter down from that (SI).

Mr Smith metaphorised IBL as a pyramid where students can begin at one point at the top of the pyramid with a teacher provided focus, but end at different points because students can find different things that filter down from the apex of the pyramid. These things may include students realising there are different methods they can use to find information, and they may generate different types of information as they take different paths down to the base of the pyramid. Therefore, IBL allows students to operate as co-constructors of knowledge as envisioned in social constructivism theories (Cooper, 1993; Rannikmäe et al., 2020).

Mr Smith's definition of inquiry takes into consideration two aspects of the nature of scientific inquiry. Inquiry begins with a question, in this case, a teacher-provided focus. Secondly, students may adopt different approaches to search for information and may find different types of information, hence construct their own understanding of the phenomena under investigation (Rannikmäe et al., 2020). Mr Smith's statements imply that, to him, researchers can adopt different scientific methods which may lead them to gather different types of data even though they may be investigating similar questions (Lederman et al., 2014).

Mr Smith's definition mentions two essential features of inquiry: giving a focus and students finding information; essentially giving a focus is akin to giving questions and finding information is similar to data collection. Based on the analytical framework, Mr Smith's knowledge of IBL is *narrow* because he has described two essential features of IBL in his definition. However, Mr Smith did not mention other essential features of IBL that have been

found to be fundamental, such as students engaging in data analysis, connecting evidence to scientific concepts and communicating results (Capps et al., 2016; NRC, 2000, 2012). This finding is consistent with Mrs Jasmine's and with other's findings that reported that teachers mentioned the common essential features of IBL while missing the less common but essential features (Capps et al., 2016; Ozel & Luft, 2013).

### **5.2.2 *Teacher Role in IBL Lesson***

Teacher as a facilitator of the learning process during IBL lessons. Mr Smith believes that the teacher's role in an IBL lesson is to facilitate learning.

And then for me to be like almost a facilitator of learning. And you know, just to sit back and observe but also be that support network if they [students] do have questions that they are stuck, or not sure where to go from here ... just being ... not giving them the information, but just maybe giving them some thoughts or ideas about where to go to next. Inquiry I feel like there's never, you could go on forever with inquiry. I guess it's where they decide to stop. And then that shows, you know, how much information they have learned (SI).

As a facilitator of learning, Mr Smith provided the perspective that he operates as an observer who monitors the learning process and provides the necessary support that students may need to complete their inquiry. Additionally, Mr Smith indicated that as a facilitator he serves as the support network to offer guidance to students in the form of ideas and thoughts around solving specific problems without giving students the exact answers, hence supporting students to construct their own knowledge. This facilitation process of fostering students' problem-solving skills through their own knowledge construction process in IBL is well explored in the literature (Crawford, 2007; Daphne et al., 2010; Rannikmäe et al., 2020).

Mr Smith demonstrated the cyclic nature of inquiry as he explained that where a student decides to end the inquiry determines how much the student has learnt. Mr Smith portrays the teacher's role in student inquiry as a supporter of student persistence to keep them inquiring until they address the focus under investigation (Van Uum et al., 2016). The cyclic nature of inquiry implies that as student-researchers draw conclusions from the data, new questions are

generated which the researcher may elect to investigate (Pedaste et al., 2015). Therefore, this cyclic process may never end, until the researcher determines when they have gathered enough information to answer their research questions. Mr Smith's description of his role implies that it is students who determine when to stop the research, contrary to findings in Van Uum et al. (2016) that show that teachers commonly determine when students should stop and present their findings.

Based on the analytical framework, Mr. Smith's knowledge regarding the teacher's role in IBL is *broadened* as he believes that the teacher's role in IBL is to facilitate learning.

### **5.2.3 Student Role in IBL Lesson**

Students as researchers during IBL lessons. Mr Smith believes that the student's role in IBL is to research using diverse resources.

Oh, I guess just what we've been doing in class. So, using a variety of different resources, whether it's the stuff that I've given them, or whether it's, you know, researching on laptops, or whether it's working independently. Even if it's you know an activity that we've posted on seats or something like that depends on I guess, our focus, even if it's a worksheet, as bad as that sounds, like doing lots of different things that all link in with each other, but different ways of doing it, because that supports because the whole classroom, because they all learn differently (SI).

Mr Smith's description of the student's role in IBL captures different aspects of scientific inquiry. Mr Smith reported that students use different resources to search for information, and, when he mentioned 'but different ways of doing it', Mr Smith was referring to researchers using different inquiry procedures to investigate a problem (Lederman et al., 2014). Additionally, Mr Smith stated that whatever students do depends on the focus. In this case, the focus might be the research question, and as such, the research question influences inquiry procedures adopted (Lederman et al., 2014). Adoption of different procedures for research may be influenced by the level of support students receive and the different student learning styles. Essentially, as each student adopts different approaches to solve the problem, they are actively participating in the knowledge construction process (Rannikmäe et al., 2020).

Based on the analytical framework, Mr Smith's knowledge of the role of students during an IBL lesson is *broadened* because he believes that the student is an active learner and investigator.

#### **5.2.4 Role of Assessment in IBL Lesson**

Mr Smith reported that carrying out assessment during IBL is a problematic exercise. However, he reported that he uses observation to assess learning.

Yeah, inquiry-based learning is a bit of a tricky one. So, I guess, just through observation, that's a key one. So, I guess there's three types of assessment. There's obviously diagnostics which is the pre-assessment. And then there's the other two assessments (SI).

And I try to do a pre-assessment for everything. So then ... the level of knowledge that I know that they're working at before. And then ... so say, if you were a lower student that didn't know a lot but now you know, they're working at stuff and there's a good progression there that I know that is now up to standard, even though you might still be able to see I know that you've worked towards ... or if you come in with a lot of knowledge and how do I expand or grow or make you, you know, not bored or that that base level - how do I keep extending you? So, through observation that way, that's always through a pre-assessment (SI).

Mr Smith's description of the role of assessment in IBL indicates that he is engaged in assessment *of* learning and assessment *for* learning. Mr Smith reported that assessment was used to determine what students have learnt. This was achieved by conducting a pre-assessment before beginning a new topic, as well as utilising a rubric to assess students' knowledge at the end of the unit. This implied that Mr Smith engaged in assessment *of* learning as he assessed students' knowledge acquisition. Moreover, Mr Smith mentioned that assessment helps to discern students' current knowledge level, hence facilitate the development of strategies to expand or help the students to grow. Thus, Mr Smith depicted assessment *for* learning as he sought to use the results of the assessment to extend learning (Harlen, 2013; Willis, 2011). Mr Smith's assertion that assessment in IBL is problematic is consistent with extant literature that reports that assessment *for* learning is not easy (Harlen, 2013).

Based on the analytical framework, Mr Smith's knowledge of the role of assessment in IBL is *moderate*, because he uses assessment *for* learning instead of using assessment to challenge students' claims and evidence in IBL (Ssempala, 2017).

### **5.3 Teacher Knowledge of Learner Autonomy**

This section presents findings on teacher knowledge of learner autonomy (LA) which was examined through teacher statements on i) meaning of LA, ii) teacher role in promoting LA and iii) student role in LA.

#### **5.3.1 Meaning of LA**

Mr Smith reported that LA was a new term to him:

Learner autonomy? Ooh, that's... I actually have never really heard that word before. That's a good, ah ... yeah, that's an interesting word. I'm not sure (SI).

Mr Smith indicated that he had never heard about the term learner autonomy, implying that this was a new term to him. However, when the researcher hinted that LA revolves around independent learning, Mr Smith indicated that independent learning is among the five focus areas of the school in which three of the areas he was teaching during the study fit: independent learners; creative learners; and curious learners.

Oh so, my five ... Yeah, yeah, my five focus areas. Okay. Yeah, so obviously, independent learning is, I guess that's, that's the whole focus of, or one of our five focus areas at the school. What we're doing at the moment would probably be within this unit would be independent learners, creative learners, and curious learners (SI).

Mr Smith's linking of his current teaching to his support for independent learning may imply that he had knowledge about the concept rather than the terminology of LA. The definition of LA is problematic because different researchers and scholars have used different words including LA, self-regulated learning, independent learning, and self-directed learning to mean the same thing (Morrison, 2011; Murase, 2015).

### 5.3.2 *Teacher Role in Promoting LA*

Mr Smith believed the teacher should play the role of a facilitator in LA. As a facilitator he provided opportunities for students to extend their learning.

Checking up on students, making sure they have an understanding of what the goal is, what our aim is, what our focus is, where they are going to go next, extending the information that they have found, rather than, you know, narrowing it down. Independent learners as well, especially with our research that we're doing, making sure that they're not just copying everything that they see off the Internet, and actually putting it into their own words, questioning me, independent learning of even, you know, words that they don't understand. They're not just putting in their ... their books, they are actually then going that extra step and researching what that word means (SI).

To support LA, Mr Smith created an environment that facilitated students' independent learning. This environment entailed clear communication of the learning goals and student expectations, offered students opportunities to ask questions, extended their learning, and supported students to monitor their learning. Therefore, Mr Smith assumed the role of a facilitator of the learning process who provides adequate structure and guidance to foster student learning, therefore nurturing LA (Alonazi, 2017; Hong-mei, 2018).

Mr Smith's description of the role of the teacher in promoting LA implied that he provided opportunities for procedural and cognitive autonomy as he supported students to actively participate in the knowledge construction process by bolstering student questioning and researching (Rannikmäe et al., 2020; Rogat et al., 2014). Mr Smith supported procedural autonomy when he indicated that he ensured that students did not copy information off the internet. Therefore, he gave students procedures on how to use information from the internet to develop their answers. Moreover, he supported cognitive autonomy by ensuring students understood the lesson aim, extended the information generated by students and supported students to search for word meanings, thereby fostering student's conceptual understanding.

Mr Smith likened his role in promoting LA to planting seeds in students' minds:

I guess for all ... all areas, actually, not just STEM. But for the project that we've been doing, you know, students then can usually come up to me with laptops and ask those

questions, and I'll not tell them what to do, but I'll plant seeds in their minds for, "maybe you could do this?" Or "maybe you could do that", or how, like, you know, question - "what does it?" ... "what do you think this means?" and kind of go off and, hopefully take that ... those key questions and yeah and work with them (SI).

The metaphor of planting seeds in students' minds syncs with the ideals of constructivism theories (Rannikmäe et al., 2020). By using this metaphor Mr Smith meant he empowers students through hints and suggestions. Students then assume responsibility of their learning by using the hints and suggestions to generate their own ideas, which they can investigate and use to generate useful information and advance their learning. The role of a teacher as a facilitator of learning is to create a supportive learning environment that actively engages students in constructing knowledge (Rannikmäe et al., 2020). Mr Smith's assertion of planting seeds through giving students hints, suggestions or questioning seeks to empower students to take responsibility for their learning similar to seeds germinating when students utilise teacher hints to come up with new ideas leading to their own learning (Rannikmäe et al., 2020). Additionally, Mr Smith adopts autonomy supportive language when offering hints and suggestions such as 'maybe you could use this'. This is non-pressuring language and is autonomy supportive (Reeve, 2009).

Mr Smith claimed that ICT use promotes independent learning by providing students with opportunities to take responsibility of their own learning.

Definitely. Yeah. 100% ICT definitely promotes independent learning ... like, even simply logging onto a computer, and saving your work. Like, you know, creating your own PowerPoint presentation that's different to anyone else's, like it opens up those ... those, you know, students, I guess, curiosity or their creative side as well. So ... that's purely because I'm obviously doing it as a PowerPoint presentation (SI).

Mr Smith reported that ICTs, such as computers, provide students with opportunities to exercise control of their learning. For instance, when students have the responsibility to log into their computers, save their own work and create PowerPoints to present their work, they are essentially experiencing procedural autonomy (Rogat et al., 2014; Stefanou et al., 2004).

Additionally, ICTs offers students a platform to exercise their curiosity and creativity, thus experiencing independence in decision making which fosters students' cognitive autonomy (Rogat et al., 2014).

### **5.3.3 Student Role in LA**

Mr Smith claimed that independent learners have the ability to ask questions and seek for help to progress their learning.

So, when they're in that learning zone, or they've jumped into the learning pit where they're ... they're unsure but they're still curious learners, and they're giving everything a go. And you know, even if they're getting stuff wrong, or they're not understanding the concept of it, they're still being independent learners. As I say to, you know, all the children in my class, if you ... if you get things wrong, you know, three or four times at least you're giving it a go. And you know, and you'll learn from your mistakes, and I still learn from my mistakes, and that's part of, you know, part of living, and you'll be better for it. So ... yeah. I get excited sometimes when, you know, students have given stuff a go, and they're understanding the basic concepts of something but they're not quite there (SI).

Mr Smith's description of the student role in LA using the metaphor of the learning zone or the learning pit is similar to that described in the learning challenge by James Nottingham (Nottingham, 2017). When students have a problem to solve and jump into the learning pit, where they are experiencing cognitive conflict associated with struggle, frustration and uncertainty, they are still focused and curious as to how they are going to solve the problem themselves. They may need support to go through the learning pit. Students need opportunities to construct understanding themselves and therefore experience LA while in the learning pit. Despite failure, they continue to learn from their mistakes, and remain focused and persistent as they continue to explore different ways through which they can construct understanding of the phenomena under investigation (Nottingham, 2017). Once they construct that understanding and experience that eureka moment, it can be assumed they are out of the learning pit. Mr Smith indicated that he is often excited when he sees students gaining an understanding of some basic concepts as students work their way out of the learning pit. He

argued that this is a step-by-step process which begins with struggle and cognitive conflict, leading to developing a basic understanding and finally students gain a deeper understanding of the concept under investigation, therefore experiencing LA as they resolve the cognitive conflict. Nottingham (2017) argued that learning is a challenge that learners need to go through to mature. Hence, teachers can give students strategies to be better independent learners.

Mr Smith further described independent learners as learners who are curious, resilient and persistent. Additionally, Mr Smith declared that autonomous learners are great at managing their time, asking questions, clarifying concepts and ideas, cross-checking their work and always seeking information on the next steps. This description is consistent with definitions of LA where teachers facilitate learning but provide students with greater responsibility for their learning (Benson, 2011; Huang & Benson, 2013). Thus students experience organizational, procedural and cognitive autonomy as they control and mediate their learning (Rannikmäe et al., 2020; Rogat et al., 2014). Mr Smith's description of autonomous learners takes LA to be more about *reactive* and *proactive autonomy*.

#### **5.3.4 Importance of LA in Science Learning**

Mr Smith stated that LA is important in science learning as it provides a great starting point for students in the science classroom.

Definitely yeah, because that's obviously you know, in life they're going to be independent learners. So, you know, within the classroom it's a great starting point for the students and you know, simple things like going on the laptop and... and researching information that's not only for science that's for, you know, that's... that branches out to whole... whole world, whole life. So ... yeah, that ... that's obviously the focus and of what I guess every teacher would be ... would be about and not only in... in the area of science, in ... in all subject areas (SI).

Mr Smith explained that LA is important not only in science but also in other subjects and an individual's whole life, as it fosters acquisition of lifelong learning skills. Mr Smith expounded that skills such as researching are important life skills that students can use in all spheres of life. This assertion is consistent with extant literature that LA fosters the

development of lifelong skills, especially digital skills due to researching online as students find information for themselves (Beauchamp & Parkinson, 2008; Howlett & Waemusa, 2019; Oates, 2019).

### **5.3.5 Factors Influencing Promotion of LA**

Mr Smith's perspectives on factors influencing the promotion of LA were organized into two major themes: factors promoting and factors hindering the promotion of LA.

**Factors promoting facilitation of LA.** Access to adequate learning resources fosters the promotion of LA. Mr Smith indicated that his school is well resourced hence it is easier to support LA. Coupled with the availability of resources, Mr Smith declared that students in his class come from well-travelled families, so students have a good understanding of Australia, making the teaching of the 'ecosystem' unit much easier as students had a rich background knowledge of Australia and the Daintree Rainforest.

A lot of the students in this class, again, based on the socio-economic area we ... that we have lived in, they have a good understanding of Australia, because a lot of them have travelled before. So, a lot of them can obviously put their ... obviously their mind or reflection on, you know, areas that they have been in, especially with, you know, the Daintree Rainforest, or Queensland in general (SI).

When students have an adequate background knowledge on a topic being explored, they can apply their prior knowledge, engage with the topic more creatively as they generate their own questions to investigate and construct their own understanding of the phenomenon under investigation (Rannikmäe et al., 2020).

Mr Smith reported that lessons across the curriculum are linked making it easier for students to transfer knowledge across subjects.

But this, what we've been learning as well, has been an excellent link with our HASS unit. So, our Science and HASS has linked really well, because there's been a focus on Australia. So, we've looked at Australia, states, capitals, territories, you know, and hot spots or locations, tourist spots. And then we've also looked within Australia's inhabitants, and, you know, First Nation people. And now we're kind of, you know, blending in the STEM, the Cassowary side of things, and you know, the ... everything's

kind of linked well together. So, we've ... it's not like we've just started with this, with ... there's been different areas, and it's good to see, students, again, you know, having that lightbulb moment, so to speak and saying, oh, like, you know, I remember that we're learning about this, and this kind of links with this. And there's a ... they can kind of see a bit of a chain effect of what they have been learning (SI).

Knowledge, skills and attitudes transcend school subject categories (Nottingham, 2017). Mr Smith explained that different subjects in the school focused on various aspects of Australia. HASS and science linked with each other around the concepts covered during the study. That meant students were learning similar concepts across the two subjects. Mr Smith argued that because students learnt similar concepts, they transferred knowledge across subjects especially because they started with HASS, so by the time they were coming to science, they had adequate background knowledge.

“Yeah, they come with a better level of readiness and a better understanding compared to, you know, I would assume that's ... you know, hasn't ... I guess, had that experience. But yeah, we're lucky because we started our HASS unit earlier than this. So that was a ... that was another factor. If we hadn't started our HASS, and they didn't ... hadn't been learning about Australia ... (SI)”.

Ability to transfer knowledge from HASS to science meant students had a rich background knowledge around the ecosystem necessary to allow them to take greater responsibility for their learning (Rannikmäe et al., 2020). When students have sufficient background knowledge, they can experience a chain effect when learning about similar concepts as they connect prior knowledge to assimilate new knowledge (Rannikmäe et al., 2020). The chain effect occurs when students realise that what they are learning in science is what they learnt in HASS, even though there might be differences in how it is presented. Thus, this expands how students develop understanding of the concept.

**Factors hindering the promotion of LA.** Mr Smith referred to an incident in which the class laptops/iPads were not charged, leading to modification of learning tasks. The modified learning tasks reduced the responsibility offered to students, thus hindering the

promotion of LA.

I feel like I've been blessed with the students that I have been given. That's it. Yeah, it's a really good question. Because I obviously can't really compare what I've been doing with this specific unit to ... to another class that I have had. So, the fact that, yeah, there hasn't really been anything that has hindered other than obviously, what happened yesterday, but that's not a hindrance on the students' learning (SI).

In this lesson, students were supposed to complete their independent research including the development of PowerPoint presentations. However, because students forgot to charge their laptops/iPads, they were not able to use the ICTs to complete their research. As a result, students were engaged in a different learning activity that did not offer the opportunities for LA such as those offered during the independent research activity. When ICTs are not properly managed, their usability may be impacted influencing their application and subsequent learning outcomes (Beauchamp & Parkinson, 2008). However, Mr Smith stated that despite technology failure, students' learning was not affected as they still engaged in learning using a different instructional strategy.

#### **5.4 Mr Smith's Research Vignettes**

This section comprises three vignettes that provide the observation data that illuminates Mr Smith's teaching of the Year 4 science class. In contrast to their hands-on inquiry when with Mrs Jasmine, the students were engaged in internet inquiry with Mr Smith. The three vignettes are *What is an ecosystem*, *Who am I* and *Mutualism*. The first vignette represents two consecutive science lessons and focuses on the meaning of the ecosystem. In the *who am I* vignette, students participated in a guessing game involving animals in the Daintree Rainforest. Students completed a worksheet with a series of questions around mutualism in the Daintree Rainforest in the final vignette *Mutualism*. The vignettes are presented chronologically followed by data analysis.

### **Vignette 1: What is an Ecosystem?--**

“Who will explain to Nemwel what we covered last week?” Mr Smith asks the students seated on the carpet. Billy responds, “We learnt about what an ecosystem is and the things that live in there”. Mr Smith prods “good, what about the water, where does the rainwater lead to?” Remi re-joins “ocean”. Mr Smith responds “good and was it a small area?” Billy answers “Big”. “Big area and why did it look very clean? What did we say about national parks?” Mr Smith nudges on. There are several hands up. “Maeve” Mr Smith calls out. Maeve responds, “Because they don't have much litter like they don't have any littering because you can't take animals in there”. This questioning continues for sometime...“What did we do on YouTube, I put a video on, what did the video show?” Mr Smith poses. “What an ecosystem is” Remi replies. Mr Smith repeats “what an ecosystem is”, before he could complete Maeve interjects “and a difference to a habitat”. “Good, that's what we are going to do today” Mr Smith announces. Mr Smith then opens a Microsoft Word document on the electronic screen with five questions.

He goes on while pointing at the electronic screen “remember, we wrote these in our books. So, what we're going to do at the moment is, we are going to do some paired research. And we are going to google and write our answers in our books, and I am going to walk around. With this, I would like to see not only these questions answered, but I'd also like to see an explanation of a drawing. So, you could draw what an ecosystem you think looks like and label it. Explain the difference through a drawing but also with writing as well. And what living things would be found in the Daintree Rainforest. You can draw and write those as well. Are there questions about what is required? A few hands are up. Mr Smith calls out “Yes Joy”. A student asks, “how do we work with our partners and computers?” “You can sit on your desk, one of you can use the computer or iPad, and one of you can have your book and be writing. One of you can be the scribe”. Mr Smith responds and informs the students they have 30

minutes to complete their task.

As students walk to their desks Mr Smith announces, “Make sure you have one researcher and one scribe”. Students access iPads and laptops as they select partners and occupy their working spots. The students chat with their partner and between pairs seated close to each other as they write their responses. Mr Smith spends the next few minutes handling class management issues.

“Everyone is writing in their own books” Mr Smith announces as he explains to me the focus of his science lessons for Term 2. As Mr Smith explains, Remi approaches and Mr Smith asks, “What’s up Remi?” “Mr Smith, can we use our own words?” Remi asks. Mr Smith explains “I prefer you do, yes. It is copyright, you know that we are not meant to copy something the way it is, so read something exactly like what we did this morning, and you know when we were doing guided reading (Remi nods). So, we read something then change it, then put it in our own words rather than writing exactly the way it is. So, use the questions to help you answer”. Remi queries further “do partners write the same thing or?” Mr Smith responds, “Yes, they can. I want your drawings to be different though. Remi nods and walks over to her desk.

As Mr Smith walks around the class checking students work Theo invites “Sir, see what I found on my computer”. “Hey, what did you find?” Mr Smith asks. “What’s an ecosystem?” Mr Smith reads Theo’s written response, then he says “an ecosystem is...” “Use this to start off” Mr Smith guides. Mr Smith then prods “what did we say last week? Is a rock a living thing?” Theo responds “no”, Mr Smith nudges on “why is a rock not a living thing? Does it grow? Does it move? Does it reproduce? Does it need oxygen?” Theo shakes his head as Mr Smith asks. Mr Smith goes on “what you’ve got there is right, good, that is correct, but it’s not enough for me”. Mr Smith goes on with the questioning then clarifies “incorporate the question I have put there to start you off then lead you.... ‘An ecosystem is’ we obviously know an

ecosystem is filled with living things; I want you to explain what those living things are. So, if you can explain what a living thing is, you can also explain the non-living things, for instance, a rock is a non-living thing and why is a rock a non-living thing?” Theo responds, “doesn’t need oxygen”. Mr Smith responds “good, it doesn’t need oxygen, it doesn’t reproduce, it can’t get up and walk over there, can it?” Theo shakes his head. “However, non-living things are within an ecosystem too because there are still rocks in there. If you go down to the beach, which is an ecosystem, there are rocks, there are pebbles, and there are shells...” Mr Smith then moves on to other tables as Theo walks back to his table.

Moments later Mr Smith calls out “boys and girls, I need your attention for a minute, may I have your attention for 30 seconds? Okay, going through these questions, what have I always said? What should we use to start our answer?” A student responds, “check the grammar”. Mr Smith continues “Even with grammar. However, if we're struggling for an answer or a question on how to start something, we always incorporate the question, an ecosystem is...! I've seen some good answers so far, however, remember, and moving forward when we get to year five and six, and then obviously often Middle School in high school, we don't copy exactly what the text says. We need to incorporate into our own words, we did that really well in our guided reading when there's the questions. Okay, copying something straight off sometimes it will make you learn, like when I do with 12-hour, 24-hour time, sometimes it doesn't because there's some words on there that even Smith doesn't know, some of the words on there that I don't even know, I might have to google because I don't know them. I don't think some of the Year 4's are going to know them either. You need to be making sure, putting your hand up, saying Smith, what does this big word mean? I've seen a few of the answers here”. Mr Smith then reads one of the student's responses to what an ecosystem is “A biological community of interacting organisms and physical environments made of living things. Does everyone know what an organism is here?” Some students respond “no”. Mr Smith nudges on

“So if you don't know what an organism is, and what's one thing you can do before asking, Joy?”

Lara responds, “check the meaning of the word in the dictionary”, Mr Smith comments “that’s one or you have a computer in front of you, you can search, try and make it more, I guess, child friendly for you to understand. The other thing is, we need to be working together”. Mr Smith then explains that students should help each other to understand and complete the questions. “And the other thing was, try and incorporate living and non-living things into these questions because they do actually fit, because that’s again, focusing on Biological Sciences. Mr Smith concludes “please think about those things when you are doing your work. You have 10 more minutes please do not rush this. Because we will have time tomorrow to do it. If you are up to one of the main questions, what living things would you find in a Daintree Rainforest? You need to be able to draw at least three of them for me”. Students go back to their computers reading, writing, and chatting.

Mr. Smith explains as he shows me the various pages of the book he uses for his science lessons, he also explains his assessment procedures and why he allows students to use the internet to search for information as a way of integrating technology into science. Moments later Mr Smith announces “can you please put the integrated books at the front for me. And all the iPads and laptops should go on charging, let’s go! Pencil cases in your bags, we will go again tomorrow”.

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“We are going to follow on with the ecosystem” Mr Smith announces. He informs students that they are going to watch a video to strengthen their understanding of the ‘ecosystem concept’. As Mr. Smith explains, Kim raises his hand, Mr. Smith goes on with his explanation. “Kim” calls out Mr. Smith when he finishes giving out instructions. Kim responds, “I don’t know what to do because I have been unwell”. Mr Smith goes on “yes you have been

unwell, alright, you can come with me Kim and I will chat with you ...” Mr. Smith announces, “face the board” and the video on living and non-living things begins to play. At the end of the video Mr. Smith asks, “does everyone understand the difference between a living and a non-living thing?” a chorus response “yes”. “I am setting a timer for 20 minutes...in your pairs that you were working yesterday. You should already have the questions written in your books. Kim, can you come with me?” Mr. Smith announces. “Move on and work, you have sixteen more minutes” Mr. Smith calls out. Kim smiles as he walks over to the teachers’ desk where he stands nodding as Mr. Smith talks to him.

In their pairs, students use their laptops/iPads, appear to read the screens, type and write in their integrated study workbooks while chatting. Few minutes later, Mr. Smith informs Kim to work with Lenny. Kim walks over to Lenny’s table and they begin chatting. “We will be moving on from this in 11 minutes” Mr Smith announces. He then walks around asking students how they are going while reading their work. He responds in most instances with “good”, ‘keep working’ and ‘well done’. As we strike a conversation about the lesson Mia presents her work without uttering a word, Mr Smith queries “where is the title, where are the numbers? Mia walks stealthily back to her desk and starts writing. Mr Smith engages in this kind of conversation with a few more students before he announces, “Books away, laptops away”.

### **Vignette 2: Who am I?**

“This is what we are going to do, we are going to do a guessing game. So, who am I? You write questions down in your book that are based on animals that are in the Daintree Rainforest. What I prefer is you to do a paper and actually looking into their life cycle. If you can’t find the life cycle, that’s fine, find interesting information about the animal” Mr Smith announces.

“When you are finished, you are going to make a presentation. But I do expect the drawing again. So, when you stand up to present them, you're only going to be asking the questions, people can't see your drawing, but I need to see the drawing because it will be marked, it needs to be something that is in the Daintree Rainforest because we are looking at the ecosystem in Australia, that's what we are researching on. I will take a couple of questions, and then I'm going to do my own who am I for you?” Mr. Smith declares. “Yes Theo?” Mr Smith calls out. Theo asks “Will I need to work with a partner?” “No, you will work alone, good question” Mr. Smith replies. “Do we just like first of all write and move into the diagram.” Theo asks “yep, write about animals in the Daintree Rainforest” Mr Smith responds. Theo responds “Yes”. Then Mr Smith presents his own who am I “I am a flightless bird that lives in the Daintree Rainforest, I am the third largest bird in the world and I can grow up to 1.8 metres, I am a descendant from a dinosaur, I am a frugivore, which means I mostly only eat fruits, I am the most dangerous bird in the world, my name means born dead, I am considered the guardian of the rainforest, who am I?” Mr. Smith poses. A few students raise their hands. “Maeve” Mr Smith calls out as Maeve responds, “I feel like it's the Emu” Mr. Smith comments “no, incorrect, Emu doesn't live in the rainforest”. Lara asks, “is it the Cassowary?” Mr. Smith responds “correct” as students applaud “yeah”. Mr. Smith gives further instructions then asks “listening up, does everyone understand what his expectation of *who am I* is?”

There is a roar from the students “yes”, Mr. Smith goes on “so you need to identify and research an animal, and you are not allowed to do guesswork. You need to do actually, we don't have enough computers, we can do this with our partners however, it needs to be the exact same questions. I will explain on the board” he speaks as he moves to the front of the class. Mr Smith announces as he draws the outline of the page on the board and says “what your page needs to look like for the who am I is this” while pointing at his drawing on the board. A rectangle with the title “who am I?” underlined at the top centre of the rectangle. Mr

Smith instructs “it needs to have a minimum of six questions (writes number one through six), to be done in pairs, drawing at the end”. “A neat drawing must be on a Daintree animal. Must research and not make-up stuff” Mr. Smith instructs as students giggle.

“...any questions? (waits a few seconds) off you go” Mr. Smith announces as students walk to their desks while chatting as they pick partners, laptops and settle at their workspaces. A few minutes later Mr. Smith walks over to Ella and Luna and asks, “are you guys working together as partners?” they respond in unison “yeah”. He then looks at their books and comments “write your title and number your questions” as he walks away.

“Those who finished earlier, can you please work on your drawing, actually focused on your drawing, I wouldn’t mind some details, I wouldn’t mind some arrows pointing towards the head, the tail ..... if you see a blue tongue lizard, may be you can say it has scales/tongue which it uses for protection or the tail to help it to move.....” Mr Smith instructs. A few moments later I walk over to Ella, she has written a title “who am I? Underlined with all responses numbered, the drawing is yet to be done.

“Are you guys working together?” Mr Smith asks Maya and Maeve. Maeve responds “yes” he looks at their work and comments “make sure you have your title” Maeve stares at Mr Smith who in turn points at the top of the page and says “here and then make sure you are numbering 1, 2, 3, 4, 5, 6 and you can put your name and your partners’ name at the bottom of the page” as he walks away. Maya and Maeve continue working as they chat.

Moments later Mr Smith announces “when you are done, you need to make sure that you have done everything on the board, be independent learners. Make sure it has colour (he pauses for a few seconds), make sure the date is on your work for me (pauses again for a few seconds), drawing at the end”.

“Five minutes, if you are done, re-read through your work to make sure your questions make sense (pauses for a few seconds), if you are done, can you put the computers and iPads

on charge for me” Mr Smith announces as he walks around the class. Some students take their laptops and iPads for charging while chatting “okay, if you are ready, come join me” Mr. Smith requests.

As Mr Smith walks around the class, we engage in a discussion on how he pairs students for group work. He explains that he bases group selection on: readiness level in terms of what is being covered; and friendship as well as mixed ability groups.

As he explains Kim asks “Mr. Smith, do we have to draw different animals?” Mr. Smith responds, “if you did different animals, yes”. Then Kim responds “okay, I have to draw mine” Mr. Smith clarifies “as long as you have got the date and name and actually you need to write the name of the animal at the bottom.

A few minutes later, “put your books down, thank you and make sure laptops away” some students place their laptops and books away, “excellent, good, good” Mr. Smith commends. “Did you do individual, or you did by yourself?” Mr. Smith asks Billy who responds “by myself”. Mr Smith then spends the next few minutes to organise students for the presentation. He then points at Theo and comments “you guys first”. Mr Smith then instructs “when I call upon you, the rest of you are all guests until they have finished reading out all six or seven or eight however many of those they are, okay? Then if hands are up, and the people at the front get to pick whoever they think is sitting nicely. If you are a group and have done three and the other one does the other three, okay. No guessing until they are done. Okay, when you are done go!”

Theo and Max make the first presentation, they read their findings from their workbooks in an alternating flair.

Theo: “My eyes are red”.

Max: “I live on trees”.

Theo: I ran 10 miles per hour, who am I?”

Mr. Smith “good one, select the people that have their hands up”

Max calls out: “Jayden”

Jayden responds: “Koala”

Max and Theo respond in unison: “no”

Max and Theo call out: “Billy”

Billy responds: “Rat”

Max and Theo respond in unison: “no”

“Remember they are animals in the Daintree Rainforest”, Mr. Smith gives a hint, as the guessing continues.

Theo calls out: “Lenny”

Lenny responds: “Crocodile”

Max and Theo respond in unison: “no”

Mr. Smith interjects “what is it boys?” Max and Theo respond in unison “tree frog”.

Mr. Smith comments “alright” while some students lament “oh yeah”. “Put the books on the table for me, that was a good one, I like it” Mr. Smith announces.

Mr Smith goes on “We are up to Luna and Ella. Let’s go, listen to the points, I don’t want people pulling out Elephant or Cheetah, I don’t think they are in the Daintree Rainforest. So think about the animals you have researched, and we know that they live in the Daintree Rainforest from the videos we have seen, okay? When you are ready, you can start”. Luna and Ella read their points in an alternating flair.

Luna: “males and females look different”

Ella: “it has a stocky body”

Luna: “it walks backwards”

Ella: “Who am I?”

Luna calls out: “Maeve”

Maeve responds: “dragon”

Luna and Ella smile as Mr Smith comments “Great, good job, good research, Ella, is that written somewhere in your book? Mr Smith asks. Ella responds “yes” Mr. Smith replies “good, books down there. Lara and Joy let’s go”. Lara and Joy begin reading in an alternating version just like the other students

Lara: “I am nocturnal which means I am active at night

Joy: “I am medium large”

Lara: “I have dark large eyes”

Joy: “My face is outwards” (laughter from the students on the carpet),

Lara: “who am I?”

Lara calls out: “Max”

Max responds: “Cassowary”

Lara and Joy in unison: “no”

After several attempts, Mr. Smith interjects “what is it girls?” Lara responds “Bandicoot”.

“Waooh” Chorus response from students. “Good, put your books down there for me please” Mr. Smith requests.

“Kim and Lenny, go” Mr. Smith announces. Kim and Lenny move to the front and begin reading in alternating flair.

Lenny: “its large reddish brown”

Kim: “I live up-to 9-15 years”

Lenny: “you are not allowed to hear me”

Kim: “I am 10 metres long”

Lenny: “Who am I?” (Several hands are up)

Lenny calls out: “Billy”

Billy responds: “Cricket”

Lenny replies: “no”

Mr. Smith calls out: “Ella”

Ella responds: “Cassowary”

Lenny replies “no”

After several attempts, Mr. Smith interjects “what is it boys?”

Lenny responds “Rufous owl”

“Books over there, job well done” Announces Mr. Smith. “I like how it was done, some really good points” Mr. Smith commends. Lenny places his book on the desk, as he leaves Mr Smith calls out “pick your books” Lenny takes his book, as he sits he begins to colour his drawing of the Rufous owl.

Mr Smith calls out “Remi”. Remi worked alone in this project. Remi reads “I have green blood, I am named after an ancient Greek hero, and whom am I?”

Billy shouts: “Cricket”

Remi replies: “no, Max”

Kim responds: “dragon”

Remi replies: “no”

“Right, what is it?” Interjects Mr. Smith.

Remi responds: “butterfly”

“Good job, book over there. Mr. Smith instructs.

“Billy, it’s your turn. Billy reads “I am fluffy, I have a cute long tail, I hop around trees, I have a big head, Who am I? Lenny?”

Lenny responds: “Tree Kangaroo”

Billy nods

Mr Smith announces “pencil cases away, laptops away”.

### **Vignette 3: Mutualism**

“We have been looking at the Daintree Rainforest, who remembers what we did last week? “Mr. Smith asks the students seated on the carpet. “Milly?” Mr Smith calls out. “We answered questions on what the ecosystem is” Milly responds. “Good, and what else did we do?” Mr. Smith nudges on. “We like all answered questions on the animals found in the Daintree Rainforest” Milly replies. “Excellent, so, now what we're looking at is, what is the name of the flightless bird that lives in the Daintree Rainforest?” Mr. Smith queries. There is a chorus response from the students “The Cassowary”. “The Cassowary is also known as the guardian of the rainforest” Mr. Smith clarifies.

Mr. Smith then declares “So here is a sheet that we are going to do, remember that we only have not too long because we have the cross. So, this needs to be plugged into your integrated study books. Mr Smith then reads the questions as he declares there is a little video with some quick response (QR) codes. I am going to check whether these QR codes work”. He spends time checking the QR codes, some are working and some are not working. “Yes, they do, the QR codes work, the first one does. So, this is the technology side of things that we are learning in STEM, the second one works. And the first one doesn't work as well, so we cross. So, the other three were just good. And so, these here, these QR codes, instead of going into Google and not knowing where to search, these are going to be your internet resources, okay? So, you find all the information on the base here. They help you with evidence-based questions. You should be able to name at least four things that are in the Daintree Rainforest, okay? You are probably going to be writing a lot of stuff down”. Mr. Smith explains. Mr Smith goes on “focusing on the video, describe five factors about the role of the Cassowary that is mutually beneficial relationship with other living things in the rainforest. So, we aren't going to do a video instead, I think we will move on to a PowerPoint instead. So, we are going to focus on the Cassowary which is in the Daintree Rainforest”.

“Given that we don't have the Year 5's in here, so we will use all of the iPads...so we will get one iPad between two people. And that will depend on who we sit with” Mr. Smith explains. He goes on “if there is a table with three, I will like one person being an independent learner and do it by themselves if possible. Any questions” Mr. Smith asks. As there are no hands raised Mr. Smith goes on “so you need your integrated studies books, and you need one of these sheets”. As each student receives the worksheet, they walk over to their tables as they chat. There is a QR code after each question.

A few moments later Ryan shouts “can't access YouTube” another student shouts “can't access YouTube” in few seconds several students claim that they can't gain access through the QR codes “alright, boys and girls listen up. I just realized and it came to my attention that you don't have access” Mr. Smith goes on “you don't have access to YouTube, I will put it up on the board, alright? I think that is the third QR code down”. Lara asks, “how do you even get the QR codes?” “You use the camera to scan the barcode” Mr. Smith explains. “What camera?” Lara nudges on. Mr. Smith explains “the camera at the back, turn over please” as he demonstrates how to access the camera on the iPad. “Oh, yeah” Lara laments. Lara takes her iPad, selects the camera, and then scans the QR code. Meanwhile Mr. Smith is busy working on his computer, a few seconds later “everyone watch, gather at this table quickly. He then announces as he demonstrates how to scan a QR code using an iPad. All students appear to be scanning the QR codes. A few seconds later Maeve shouts “it says cannot open page”. “Yes, there is no access to YouTube outside the video, okay?” Mr. Smith explains. More students join in as they shout, “cannot open page”. “So, I will play the video in about ten minutes, alright? Make sure you sit with your group, and you need your book” Mr. Smith directs. A few minutes later “Hello, the information on the activity is on the website, now you need to be reading it, try to write in your own words” Mr Smith announces as he points to the information on the electronic screen. Students begin to read and write the information in their

integrated study books as they chat.

Moments later, “Boys and girls, you will be sitting down, I will put the video. I will only be playing it once” Mr. Smith announces. A video on mutualism runs for the next 5 minutes showing ten examples of mutualism. Mr. Smith gives hints and emphasises important information as the video plays “humans and other animals breathe out carbon dioxide, which plants use for photosynthesis. And in return plants give off oxygen that humans and animals use for respiration”. Mr Smith comments “that’s a key point”. Mr. Smith then summarises as he guides the students on what they need to do “alright, so the question is, question 2d, the relationship between the fruit plants and the Cassowary is termed as ‘mutually beneficial’. That’s the video we have just watched and write a definition. We should all know what a definition is because we do it in word study rotation. Where can we find a definition, do you know?” Mr. Smith asks. Chorus response “dictionary”. You need to find what ‘mutually beneficial’ means. Write the definition and add three examples of what it means. Does everyone understand that? You need to google and find mutually beneficial. Write the example and explain in different ways what it means, that’s question c. Continue to work, we only have 32 minutes left” Mr. Smith announces.

A few minutes later, Remi walks over to Mr. Smith and asks, “What does mutually beneficial mean?” as she hands over her iPad to Mr Smith. Mr. Smith reads the information on Remi’s iPad “mutually beneficial is simply defined as a contract or agreement in which both parties gain some type of advantage or value”. Mr Smith concludes “It simply means the parties are satisfied. They work together”. Maeve quips “So the Cassowary and fruit plants actually they work together?” Mr Smith asks, “better now?” Maeve responds “yeah”. Mr. Smith then remarks “mutually beneficial means they both help one another” Maeve comments “oh, okay”. Mr. Smith goes on “how do they help one another? That’s not the definition”.

Moments later Billy announces, “I don’t understand” Mr. Smith replies, “come to me then” Billy walks over to Mr. Smith who explains what a definition is and what he needs to do to write a good definition of ‘what mutually beneficial’ means. Mr Smith shows Billy a video on a mutually beneficial relationship between the bear and birds. “So, the question is in relation to the Cassowary, what is mutually beneficial?” Mr. Smith asks Billy. Mr. Smith goes on “this is a relationship between fruit plants and the Cassowary, so how is the Cassowary and the fruit plant linked.” Billy responds, “the cassowary eats fruit plants” Mr. Smith commends “yep”. As Billy walks away Mr. Smith then listens to a few students explain to him what a mutually beneficial relationship is.

A few minutes later a pair of boys walk over to Mr. Smith “Smith, we can’t access the internet” they quip as they show their iPad. Mr. Smith tries to access the code using the students iPad unsuccessfully “listening, the question c, I didn’t realize the QR code wasn’t working. The second one down wasn’t working for some of you. So, there are answers that are on the board, and I will leave this here for you to come up and have a look or adding anything onto it” Mr. Smith explains. Mr Smith then spends a few seconds on his computer and announces “the answers to question d are in the second paragraph as well, you have twelve minutes to get this done” Mr. Smith announces. Moments later, “Question 4b, the answers can be found on the screen, eleven minutes remaining” Mr. Smith announces.

Milly who has been working quietly walks and hands over her book to Mr Smith who looks at Milly’s responses and gives a thumbs up. Milly, who has answered all the questions is all smiles as she walks to her desk. “Can I have books away, iPads on charge, pencil cases away please” Mr. Smith declares. Students keep their books on the tray, take iPads to the charging room and keep their pencil cases on their tables.

#### 5.4.1 *Teacher Autonomy Supportive Practices*

**Organizational autonomy support.** Mr Smith's teaching style provided many opportunities for his group of students in terms of organizational autonomy across the three vignettes. The opportunities for organizational autonomy revolved around students' choices and decision-making responsibilities regarding selection and working with partners, determining when to hand in assignments for assessment and limiting choice by choosing groups for students.

- *Opportunities to select and work with partners*

Mr Smith provided opportunities for students to choose partners to complete their learning activities across the three vignettes. The freedom to choose and work with partners was manifested when Mr Smith announced that students would complete their learning activities either in pairs or individually. Mr Smith directed students to work in pairs in the *what is an ecosystem* and *who am I* vignettes, while offering students freedom to either work in pairs or individually in the *mutualism* vignette. The directive for students to work in pairs, though prescribed, provided students with organizational decision-making responsibilities in terms of who to work with, as well as how to manage tasks. Additionally, in *mutualism*, a table with three people had extra responsibilities in terms of deciding who among them will work as an independent learner.

Students utilised their own criteria to select partners thereby demonstrating *reactive autonomy*. Billy and Jayden elected to work together, thereby demonstrating *reactive autonomy* in terms of selecting partners and *compliant autonomy* in terms of complying with Mr Smith's instructions to work with a partner in the *what is an ecosystem* vignette. However, some students chose to work individually, thereby deviating from Mr Smith's instructions. Mia and Billy worked individually in the *what is an ecosystem* and *who I am* vignettes respectively, demonstrating *reactive autonomy*. The majority of the students in the *mutualism* vignette chose to work in pairs, whereas a few students chose to work independently. Therefore, both groups

of students demonstrated *compliant autonomy* to teacher freedom to either work independently or with partners.

The analysis reveals that within the same level of freedom, students can take different actions, yet demonstrate the same level of autonomy. The analysis also shows that the majority of the students comply with teacher-prescribed instructions. Students' reactions to teacher instructions are influenced by an interplay of factors ranging from availability of resources, nature of learning task, nature of teacher instructions, and student characteristics including their interests (Little, 1991; Rannikmäe et al., 2020). Across the three vignettes, it appeared friendship, availability of resources and nature of teacher-prescribed instructions influenced students' decisions around selecting and working with partners.

- ***Opportunities to determine when to hand in assignments***

Mr Smith's teaching style provided opportunities for his group of students in terms of organizational autonomy around determining when to present their work for assessment and feedback. Mr Smith often went around the classroom checking students' work and offering instant informational feedback which students could act upon to improve their work. Some students, however, took the initiative to present their work for assessment when they felt they needed feedback or validation, thereby demonstrating *proactive autonomy*. For instance, Mia in the *what is an ecosystem* vignette and Milly in the *mutualism* vignette presented their work for assessment without Mr Smith's invitation.

The data shows that Mr Smith was approachable and willing to assess students' work and provide informational feedback that fostered students' learning (Harlen, 2013), hence bolstering their engagement with learning tasks as they addressed teacher feedback (Harlen, 2013). However, some students often waited for Mr Smith to instigate assessment. Reasons for student participation in seeking for assessment have been discussed in Chapter 4.

- ***Limiting choice: Choosing groups for students***

Mr Smith occasionally restricted students' choice for organizational autonomy, for instance, when he directed Lenny to work with Kim therefore restricting Lenny's organizational autonomy around choice to select group members in the *mutualism* vignette. Lenny complied with Mr Smith's directive thereby demonstrating *compliant autonomy*. Restricting students' freedom to determine group members may limit student's organizational autonomy (Furtak & Kunter, 2012; Rogat et al., 2014), as students comply with the teacher's directive to work with a specific partner.

It appears Mr Smith paired Kim, who had been absent, with Lenny, a gifted student, to foster peer learning (Krange et al., 2020; Obidoa et al., 2012). The complexities around group formation have been discussed in Chapter 4 for Mrs Jasmine under *limiting choice: choosing groups for students*.

**Procedural autonomy support.** Mr Smith provided opportunities for procedural autonomy throughout his lessons. The opportunities for procedural autonomy revolve around students' decision-making responsibilities around access to resources, time management, using worksheets to scaffold learning, opportunity to select an animal to investigate among others.

- ***Opportunities to access learning resources***

Mr Smith provided opportunities for students to access pre-determined resources for their learning tasks across the three vignettes. Mr Smith relinquished his responsibility of providing resources to students by requesting students gather learning resources for each learning activity. Despite these requests being prescribed, students manifested excitement as they quickly gathered the required resources as they went to their working areas.

Students responded by sourcing the learning resources such as laptops and iPads from the Year 5 classroom and the laptop charging room, thereby demonstrating *compliant autonomy*. Prescribed instructions expect compliance from students (Willison, 2020).

However, sometimes they draw on students' interests. As reflected across the three vignettes, students happily accessed the laptops for use in their learning.

- ***Opportunities to access and use resources of choice***

The nature of Mr Smith's lessons did not provide opportunities for students to access and use additional resources of choice. The access and use of additional resources of choice has been explored in Chapter 4 for Mrs Jasmine.

- ***Restricting access to resources***

The nature of Mr Smith's lessons did not provide opportunities for students to access and use additional resources of choice. As such, students complied with Mr Smith's instructions by accessing only the pre-determined resources for their learning.

- ***Opportunities to choose an animal to investigate***

Mr Smith provided students with the freedom to determine the nature of the learning output by allowing students to identify the animal to investigate in the *who am I* vignette. Mr Smith required students to utilise the internet to investigate an animal in the Daintree Rainforest. The freedom provided to students was prescribed in nature, as the animal had to be domiciled in the Daintree Rainforest, and students had to gather data in line with the mind map and the teacher model example.

Students reacted by investigating and presenting information about their animal of choice thereby demonstrating *compliant autonomy*. Students working in pairs and individually researched different animals in the Daintree Rainforest. For instance, Billy investigated the tree Kangaroo, and Lenny and Kim investigated the Rufous Owl. The data shows that prescribed instructions elicit compliance from students, as they offer minimal choice for student decision making, and students are bound to emulate teacher actions (Willison, 2020).

- ***Time management***

Mr Smith habitually determined the amount of time students spent on whole class, group or individual work. He utilised time reminders to inform students the amount of time to spend when carrying out learning tasks, especially when students were undertaking pair or individual work. Therefore he provided structure and guidance that ensured students remained engaged throughout the lesson. Mr Smith regularly, within his lessons, used time signals to mark the end of an activity or to prepare students for transition to other activities. For instance, during the second session of the *what is an ecosystem* vignette, Mr Smith announced “I am setting a timer for 20 minutes...”, similarly, in the *mutualism* vignette, after clarifying the requirements for question c, Mr Smith announced, “continue to work, we only have 32 minutes left”.

Time signals tend to inform students how much time they have left for a certain activity. Students may interpret time signals differently. For instance, some students might interpret teacher time signals as pressure to complete work quickly or end the inquiry thereby creating time pressure (Großmann & Wilde, 2020; Reeve et al., 2002). During teacher interviews Mr Smith reported that during inquiry learning, due to the cyclic nature of inquiry, it is students who determine where the inquiry ends; however, observation data shows that he frequently used time signals to indicate when students should end their engagement with learning tasks, essentially determining when students should end their inquiry. This shows that teacher self-reports do not mirror teacher actual practice. This finding shows that teacher self-reports may not portray the true picture of classroom practice as self-reports indicate what teachers intend to do, but often they may not always enact what they plan to enact (Capps et al., 2016; Mansour, 2009; Romero-Ariza et al., 2019). The observation data finding that Mr Smith determined when students stopped their inquiry is consistent with findings by Van Uum et al. (2016) that revealed that primary teachers determine when students should end the inquiry and present their

findings.

Students responded to this prescribed reminder on time signals by complying with Mr Smith's time reminders, thereby demonstrating *compliant autonomy*. Time reminders ensured students stayed focused until task completion. However, the research literature has shown that time signals can also function as time pressures on students (Großmann & Wilde, 2020) and they are characteristic of controlling teachers (Reeve et al., 2002).

- ***Using worksheets to scaffold learning***

Mr Smith utilised worksheets and Quick Response (QR) codes to scaffold learning in *mutualism* vignette as an organizing framework to scaffold learning. Students received a worksheet that contained the questions to be investigated. Each question in the worksheet had a quick response (QR) code and space for students to write answers. The worksheet provided additional structure and guidance that allowed Mr Smith to relinquish some authority allowing students to control their learning. Students had greater responsibility in completing the questions, as well as self-assessing the learning progress.

In response to the provision of a worksheet, students reacted by answering the questions as detailed in the worksheets demonstrating *compliant autonomy*. Students answered the questions in the order they appeared in the worksheet while using their own words, making their learning visible as well as being able to construct scientific knowledge and demonstrating the ability to express their ideas, although within the confines of the worksheet (Van Uum et al., 2016). Worksheets offer a structure that provides students with a point of focus on pertinent questions, and attempt to minimise the investigation of unrelated concepts (Basten et al., 2014; Eckes et al., 2018; Haruehansawasin & Kiattikomol, 2018) and facilitate *compliant autonomy*. This may be one reason a survey study indicated that students rated worksheets poorly for impact on their learning process (Choo et al., 2011). However, an experimental study of poorly performing students showed that worksheets contributed to improved learning outcomes

(Haruehansawasin & Kiattikomol, 2018). Therefore, worksheets may have varying impacts on the learning process.

**Cognitive autonomy support.** Mr Smith provided opportunities for cognitive autonomy in diverse ways in his science lessons. These practices include offering informative feedback, offering hints to extend students' exploration, encouraging students to try different ideas, questioning to scaffold students' thinking, allowing and responding to students' questions, providing rationale, responsiveness among others.

- ***Offering informative feedback***

Mr Smith utilised informative feedback to guide students to improve the quality of their learning output. For instance, in the *what is an ecosystem* vignette, following a series of questions meant to review Theo's progress, Mr Smith directed Theo to use part of the question to start off his responses. Similarly, in the *who am I* vignette, after reviewing Maeve and Maya's work, Mr Smith advised the students to title their work as well as number their questions and write the name of the animal at the bottom of the page. Teacher informative feedback provides structure that guides students' actions towards successful completion of learning tasks (Gan et al., 2021; Harlen, 2013). However, when the informative feedback is prescribed and in the form of directives, there is an expectation that students should comply. Students reacted to Mr Smith's informative feedback by completing their work as recommended thereby demonstrating *compliant autonomy*.

- ***Opportunities for thinking and planning***

Mr Smith did not provide explicit opportunities for student to think and plan their learning activities. However, during the *who am I* vignette, Mr Smith engaged students in planning through the development of a mind map that guided the information search regarding the animal of choice. Students demonstrated *compliant autonomy* by searching information about the animal of choice following the mind map.

- ***Offering hints to extend students' exploration***

Mr Smith did not provide hints to extend student exploration as students were engaged in internet research across the three vignettes. However, in the *who am I* vignette, Mr Smith suggested that the students who completed their work early should work on their drawing and make sure they label and explain the functions of the different parts of the body of their animal of choice. Billy reacted to this opportunity by drawing a tree kangaroo and labelling the different parts thereby demonstrating *reactive autonomy*.

- ***Encouraging students to try different ideas***

Mr Smith's teaching style did not provide opportunities for students to try different ideas as instructions were prescribed. However, he allowed students the opportunity to choose the animal to investigate in the *who am I* vignette (see *opportunities to determine animal to investigate*). Additionally, Mr Smith allowed students to write their answers using their own words in the *what is an ecosystem* and *mutualism* vignettes. Students reacted by seeking further assistance on how to write in their own words and subsequently developed responses in their own words thereby demonstrating *compliant autonomy*.

- ***Questioning to scaffold students' thinking***

Teacher questioning may foster learner generation and ownership of ideas, therefore promoting cognitive autonomy (Rogat et al., 2014). Mr Smith used questioning to elicit students' thinking and ideas. However, Mr Smith used predominantly closed-ended questions with few open-ended questions. Students demonstrated *compliant autonomy* to Mr Smith's questions. For instance, Mr Smith asked Theo a series of closed-ended questions with a few open-ended questions in the *what is an ecosystem* vignette. Theo demonstrated *compliant autonomy* as he answered with a yes, a no or sometimes nodding to Mr Smith's questioning. When teachers use closed-ended questions, students have limited opportunities to express their ideas as they respond with yes or no answers (Furtak & Kunter, 2012).

- *Allowing and responding to students' questions*

Mr Smith provided opportunities for students to ask questions across the three vignettes. Students' questions make visible their thinking. Additionally, student questions may provide opportunities for teachers to determine knowledge gaps and offer additional instruction and guidance to bridge the gap (Chin & Osborne, 2008). Habitually, after presenting the lesson purpose, Mr Smith provided students with opportunities to ask questions. Students normally asked clarification questions around task requirements. Questions around task requirements are important as they ensure students have a complete understanding of what is required of them, fostering a smooth embarkation (Rannikmäe et al., 2020). For instance, in the *what is an ecosystem* vignette, after presenting the lesson purpose, Mr Smith asked "...Are there questions about what is required?" Similarly, in the *who am I* and *mutualism* vignettes, Mr Smith provided students with these opportunities.

Students reacted to this opportunity by asking clarification questions. For instance, Remi asked whether she could write answers in her own words and whether partners should write the same thing, thereby demonstrating *compliant autonomy*. However, students did not immediately ask questions in the *mutualism* vignette despite Mr Smith providing an opportunity for questions, but, as the lesson progressed, students asked clarification questions around the task requirements and use of technology for research. For instance, Lara asked "how do you even get the QR codes?" showing students needed additional support in order to engage in learning.

While responding to students' questions, for instance, in the *what is an ecosystem* vignette, Mr Smith explicitly clarified that one student would assume the role of the researcher and the other student would assume the role of a scribe. Additionally, Mr Smith utilised explicit instruction to explain why and how students should write answers in their own words. Mr Smith's answering of students' questions offered clarity on student actions, providing more

structure and guidance, hence facilitating students' engagement in learning tasks. Mr Smith responded to student questions in the *who am I* vignette as well. Students complied with Mr Smith's instructions, which were prescriptive in nature, by sharing the roles of the researcher and scribe as well as completing their questions in their own words. This demonstrated *compliant autonomy*. Students equally demonstrated *compliant autonomy* in the *who am I* and *mutualism* vignettes. As evidenced, students' questions provided information about their thinking, thus influencing further teacher actions to facilitate learning (Chin & Osborne, 2008; Rannikmäe et al., 2020).

- ***Task clarification***

Mr Smith regularly sought to clarify students' understanding before undertaking tasks. For instance, in the *what is an ecosystem* vignette, following the lesson introduction, Mr Smith asked "Are there questions about what is required? (see *allowing and responding to student questions*). Additionally, Mr Smith clarified the task requirements before releasing students to engage in the research. For instance, in the *what is an ecosystem* vignette, Mr Smith explained after lesson introduction "...with this, I would like to see not only these questions answered, but I'd also like to see an explanation of a drawing". Similarly, in the *who am I* vignette Mr Smith clarified students' understanding when he asked "listening up, does everyone understand what his expectation of who am I is?" He then explained "so you need to identify and research an animal, and you are not allowed to do guesswork....". Mr Smith then developed a mind map that made the learning task clearer and offered more guidance and structure to students on the nature of information required for the guessing game. The task clarification language "...you need to" required students to follow teacher instructions (Großmann & Wilde, 2020).

Students reacted to Mr Smith's task clarification in the *what is an ecosystem* vignette by investigating the questions and writing the answers as required, thereby demonstrating *compliant autonomy*. In the *mutualism* vignette, students reacted to Mr Smith's task

clarification by investigating various animals of the Daintree, therefore demonstrating *reactive autonomy* by utilising their own criteria to determine the animal to investigate. For instance, Kim and Lenny chose a rufous owl.

The clarification of concepts is vital in fostering student learning by ensuring the learning intentions and next actions are clear (Inayat & Ali, 2020; Rannikmäe et al., 2020). When learning intentions and expectations are clear, students are able to regulate their actions better, leading to the desired learning outcomes (Inayat & Ali, 2020). However, the prescribed nature of teacher instructions implied that students were expected to comply, hence, demonstrating low cognitive autonomy (Furtak & Kunter, 2012).

- ***Encouraging self-evaluation and self-correction***

Mr Smith promoted student self-evaluation and self-correction to foster students' independent learning. Student self-monitoring, which entails self-evaluation and self-correction, fosters cognitive autonomy as it provides students with opportunities to apply their evaluation, review and correction skills (Rogat et al., 2014). While students were finalising their research on the animal of choice in the *who am I* vignette, Mr Smith instigated a self-evaluation and self-correction exercise when he announced "five minutes, if you are done, re-read through your work to make sure your questions make sense, if you are done, can you put the computers and iPads on charge for me".

Mr Smith's request sought to instigate student self-evaluation followed by self-correction to enhance the quality of their research findings. Mr Smith's time signals acted as a pressure signal for students to complete their work in five minutes. Despite offering students opportunities for self-evaluation and self-correction, the time pressure signal may have pushed the students to ignore the self-evaluation and self-correction request to comply with the second request of taking the laptops to the charging area. The time signals for students to complete their work contradicts Mr Smith's interview data in which he claimed that during inquiry, it is

students who determine when the inquiry ends.

In relation to Mr Smith's initiation for self-evaluation and self-correction, students demonstrated *underdrive autonomy* by doing nothing in relation to Mr Smith's request. This data shows that when students do not value aspects of an activity or do not have the skills to enact teacher requested actions, they may disengage from that component (Chipchase et al., 2017). Prior studies have also shown that a lack of structure or skills to self-regulate and utilise the choices offered appropriately may negatively affect student actions (Dohn, 2013). The instruction to self-correct and self-evaluate was open and beyond students' reach, as it appears students lacked the skills to self-evaluate with a higher level of autonomy. Mr Smith did not initiate self-evaluation and self-correction in other vignettes.

- ***Providing rationale***

Mr Smith provided rationale by linking content and skills to prior lessons by supporting students to recount aspects of the previous lessons across the three vignettes. Instances of Mr Smith explicitly linking prior lessons to the current lesson were identified in each of the three vignettes. By articulating to students the link between lessons in relation to content and skills teachers were developing, Mr Smith illuminated that the purpose of the lesson is grounded in prior lessons. Hence showing the link between lessons and that current lesson are related to prior lessons. Additionally, when Mr Smith showed the video on the relationship between the Cassowary and the fruit plants in the *mutualism* vignette, he announced "We should all know what a definition is because we do it in word study rotation". This implied that skills students acquire in word study rotation are applicable in science.

Mr Smith's linking of skills acquired in a different subject to science learning synchronises with his interview comments that learning areas in the case study school are linked making it easier to foster LA due to the chain effect resulting from a transfer of knowledge and skills across subjects. Due to the transfer of knowledge and skills across

subjects, students are able to quickly navigate through the learning pit as they experience minimal frustrations and experience lightbulb moments when they realise that what they learnt, for instance in HASS, is applicable in science. Linking prior skills to current and new tasks creates a feeling among students that the current tasks are linked to their learning goals, thus, important, relevant, and useful (Rogat et al., 2014). Therefore, it fosters cognitive autonomy in the sense that students have the freedom to apply skills across subjects as they perceive the activity to be important.

Students reacted by actively engaging in various learning activities across the three vignettes. For instance, in the *mutualism* vignette, students scanned QR codes, read web pages and wrote answers using their own words, demonstrating *reactive autonomy*. If Mr Smith did not communicate the rationale of the activity to students, students might have perceived the activity as less meaningful exerted minimal effort (Reeve, 2009; Rogat et al., 2014; Steingut et al., 2017). But, in this case, due to the rationale communicated by Mr Smith, students actively engaged in completing the questions in the worksheet.

- ***Responsiveness***

Mr Smith demonstrated responsiveness through several practices that included active listening and drawing on student ideas, especially on the use of QR codes (Kiefer et al., 2014; Rogat et al., 2014). Mr Smith demonstrated active listening by offering contingent replies to student questions. For instance, in the *mutualism* vignette when Maeve lamented “it says cannot open page”, Mr Smith responded “Yes, there is no access to YouTube outside the video, okay?” going beyond a basic response to giving a justification as to why YouTube was not working and demonstrating active listening. Similarly, when Lara exclaimed that she did not understand how to use the QR codes, Mr Smith explained the process, but when he realised that Lara and other students are unable to follow the explanation, he gathered the students and demonstrated the process of using QR codes. Heeding to the students’ concerns is particularly cognitive

autonomy supportive as it informs students that their concerns and ideas were heard, and that their ideas are valued and important to the lesson (Rogat et al., 2014). In this case, Lara's concern led to a teacher demonstration of the use of QR codes, creating a feeling among students that they can be initiators of key activities in the science lessons thus supporting cognitive autonomy.

In response to Mr Smith's responsiveness, in *mutualism* vignette, Lara picked her iPad, selected the camera, and then scanned the QR code, thereby demonstrating *compliant autonomy* by following Mr Smith's actions on scanning the QR codes. Responsiveness contributes to sustained student engagement in the face of frustrations that could have led to disengagement. For example, Lara's struggles with the use of QR codes could have easily worsened. However, due to Mr Smith's responsiveness, Lara's participation in learning tasks was sustained.

- ***Restricting students' discussion***

Mr Smith sometimes restricted students' contributions to discussion, therefore constricting students' cognitive autonomy. Preventing students from engaging in discussion denies students the opportunity to make their thinking visible. For instance, in the *mutualism* vignette, students engaged in a discussion on the meaning of mutually beneficial relationship between the Cassowary and the fruit plants, Maeve agreed that mutually beneficial meant 'helping one another' as summarised by Mr Smith. However, Mr Smith asked "how do they help one another?" This question sought to elicit Maeve's thinking about the definition of 'mutually beneficial'. Mr Smith's ensuing reaction restricted Maeve's freedom to make her thinking visible when Mr Smith commented "that is not the definition", almost shutting Maeve down and restricting further debate on what mutually beneficial meant. Questioning followed with negative feedback shuts down a student's willingness to contribute to debate thus restricting cognitive autonomy as students may not be willing to front their ideas for fear of

being criticised (Chipchase et al., 2017; Furtak & Kunter, 2012; Rogat et al., 2014).

In response to Mr Smith's questions, Maeve demonstrated *compliant autonomy* when she answered Mr Smith's question, however, when Mr Smith provided negative feedback, Maeve demonstrated *underdrive autonomy* as she stopped contributing to the discussion. The data shows that teacher questioning seeks compliance from students as they endeavour to answer teacher questions; however, when teacher questions are followed with negative feedback, students' desire to engage may be impacted, leading to disengagement and *underdrive autonomy* (Chipchase et al., 2017). Additionally, the data shows LAD is fluid, as Maeve's autonomy shifted from *compliant* to *underdrive*.

#### 5.4.2 *Nature of Inquiry-Based Learning*

**Embark and Clarify.** The embark and clarify facet was structured across the three vignettes. Mr Smith announced the lesson purpose in the three vignettes, for instance, Mr Smith announced that students would engage in a guessing game (who am I) in the *who am I* vignette. By referring to a guessing game, Mr Smith triggered a motivation to learn and tapped into students' interest and curiosity as they waited in anticipation for teacher instructions about the guessing game (Rannikmäe et al., 2020; Van Uum et al., 2016). Engaging students in teacher-determined focus across the three vignettes is consistent with Mr Smith's interview assertion that for his group of students, they investigate teacher-provided questions.

To ensure a smooth embarkation, Mr Smith utilised a repertoire of instructional strategies to foster students' understanding of the concept under investigation as well as the task requirements. Firstly, Mr Smith had students recount their prior knowledge through questioning and linking prior lessons to the current lesson across the three vignettes (Hopkins et al., 2015; Rannikmäe et al., 2020). Mr Smith then combined explicit instruction with YouTube videos to enhance students' understanding of what an ecosystem and mutualism are in the *what is an ecosystem* and *mutualism* vignettes, a practice that has been argued to foster

a ‘sweet spot’ in learning (Darling-Hammond et al., 2020). In the *who am I* vignette, Mr Smith combined explicit instruction with a teacher model example and a mind map to foster conceptual understanding.

Furthermore, Mr Smith clarified task requirements and the research scope for each vignette by stating what was required of students. For example, he provided the scope of the investigation in the *what is an ecosystem* vignette when he stated that besides answering the questions, students needed to provide an explanation of a drawing of the ecosystem. Similarly, in the *who am I* vignette Mr Smith utilised a mind map to guide students on the nature and type of information required. The internet-based research was stated in an open nature; however, the ensuing clarification offered additional guidance, thus shifting the problem under investigation from open to structured due to the prescribed nature of teacher instructions. Mr Smith’s provision of scope ensured students had enough guidance to successfully carry out the research without being lost or frustrated (Eckes et al., 2018). Numerous research studies have shown that most teachers prefer providing the question or problem to be investigated to students because they feel that young children are not able to generate investigable questions (Ruggeri et al., 2021; Swaboda et al., 2022).

Mr Smith facilitated a successful re-embarkation through additional clarification. When it appeared students had a false start in the *what is an ecosystem* and *mutualism* vignettes, Mr Smith fostered a re-embarkation through the use of additional YouTube videos and explicit instruction on the use of QR codes, thus enhancing students’ understanding of the concept under investigation and the use of QR codes. The embark and clarify facet is complex, thus requiring extensive clarification, and sometimes re-embarkation, to ensure sustained student engagement (Willison, 2018).

The data also showed IBL requires adequate preparation as it appears Mr Smith did not assess students’ prior knowledge on the use of QR codes in advance. Additionally, Mr Smith

should have determined the functionality of the QR codes prior to the lesson to determine their workability thus ensuring effective application during learning. ICT issues coupled with inadequate time to prepare for inquiry have been identified as some of the factors influencing adoption of IBL (Fitzgerald et al., 2019; Ozel & Luft, 2013; Roehrig & Luft, 2004). Moreover, the data shows that Mr Smith may have realised that his students struggled with embarkation, therefore offering additional guidance as reflected in the increase in the level of guidance from the first vignette to the third vignette. This finding is reflected in other studies such as Willison et al. (2017) when teachers increased the level of structure in subsequent lessons.

Mr Smith's prescribed teaching style created minimal opportunities for students to manifest their emotions when compared to Mrs Jasmine's lessons. However, some of his instructional strategies fostered student emotional engagement. For instance, he began lessons with a review of previous lessons across the three vignettes which tapped into students' attention and motivation (Rannikmäe et al., 2020). Additionally, he manifested a reassuring personality when he supported Kim, who had been absent, to catch up with learning, as Kim was seen smiling when invited for individualised instruction from Mr Smith, therefore tapping into Kim's emotional engagement. Similarly, Lara manifested inquisitiveness when she sought assistance with the use of QR codes in the *mutualism* vignette. These findings around teacher personality and students' emotional engagement show that if the teachers use lesson triggers such as a review of previous lessons, and adopt a re-assuring and welcoming personality, they can tap into students' emotions and facilitate emotional engagement and foster learning during embark and clarify (Kourti, 2019; Rannikmäe et al., 2020).

**Find and generate.** The find and generate facet was not explicitly stated in Mr Smith's facilitation of learning across the three vignettes. However, Mr Smith utilised explicit instructions, teacher questioning, and informative feedback, among other strategies, to foster the find and generate facet.

Mr Smith used explicit instruction when responding to students' clarification questions regarding data recording. He clarified that students must use their own words when developing responses to questions to avoid plagiarism in the *what is an ecosystem* and *mutualism* vignettes. To gather and present quality data, students need to comprehend internet-based text, before synthesising and generating their own original responses (Coiro, 2003, 2021). Hence, as students generate data from the internet, they enhance their reading, comprehension and writing skills. Data across the three vignettes shows that students had minimal internet data recording skills and that explicit instruction can play a fundamental role in fostering student internet data generation skills and information literacy in general (Coiro, 2003, 2021).

Teacher questioning and informative feedback instigated the finding and generation of data. Mr Smith utilised open and closed-ended questions to review Theo's data, and offered feedback requiring Theo to gather additional data in the *what is an ecosystem* vignette. As a result, Theo gathered additional data based on teacher feedback. This data shows that teachers use questions to review students' data, then offer informative feedback that guides students to gather additional relevant and quality data (Harlen, 2013). Mr Smith used the same strategy with Maeve and Theo in the *mutualism* vignette, eliciting similar student responses.

Mr Smith used a mind map and a Cassowary teacher model example to model information search in the *who am I* vignette. The mind map offered structure and guidance as it detailed the nature of information required for the learning activity. Similarly, the teacher model example provided structure on the data recording and presentation format. This data shows that when teachers model learning, learners emulate teacher actions, thus gathering relevant data in line with the teacher model. The guidance provided by modelling may restrict the openness of the data gathering activity as students have to work within the confines of the teacher model (Eckes et al., 2018; Willison, 2020). However, it ensures students stay focused and gather relevant data (Eckes et al., 2018).

Moreover, Mr Smith used worksheets, QR codes and web pages to facilitate information searching in the *mutualism* vignette. Provision of QR codes and web pages facilitated quick access to teacher-evaluated relevant information, therefore minimizing students' frustration when researching on the internet (Uçak, 2019; Willison, 2020). The use of worksheets, QR codes and web pages increases the level of structure and guidance provided to students, and they guide students through the learning pit as they ensure the struggle associated with finding and evaluating information on the internet is removed, so students can focus on pertinent information around answering the research questions. This way, the struggle within the learning pit is minimized, and students can easily reach that light bulb moment envisioned by Mr Smith during the interviews (Nottingham, 2017). As much as the QR codes and web pages support students' quick access to relevant information, they deny students the opportunity to learn about finding and evaluating information on the web.

Mr Smith fostered a transfer of skills to facilitate information generation. Mr Smith encouraged students to utilize their word study rotation skills to search for the meaning of new words before using those words in their write-ups. To gather and present quality data, students need to comprehend internet-based text, before synthesising and generating their own original responses (Coiro, 2003, 2021). It is through understanding individual words that students can comprehend full paragraphs and synthesize responses for each question. Comprehension and synthesis skills are fundamental in bolstering students' understanding of key concepts such as "mutually beneficial". Teacher interventions, in this case encouraging students to utilize word study rotation skills in science learning to facilitate meaning, had a ripple effect on how students experienced inquiry. This underscores the important role the teacher plays as a facilitator of learning (Kidman, 2017; Rannikmäe et al., 2020).

Finding relevant information, especially from the internet, requires students to be determined and skilled (Kourti, 2019; Willison, 2020). To facilitate student engagement in

information generation, Mr Smith used QR codes and mind maps to capture students' attention (Uçak, 2019). As evidenced, students exhibited interest and engagement in the use of QR codes to complete their research in the *mutualism* vignette. Students' interest was manifested by their inquisitiveness on how to use QR codes for research. When QR codes failed to work, students exclaimed 'can't access web page' showing their frustration with the use of QR codes for research. Use of technology in learning, despite spurring interest and curiosity among students, has been shown to cause frustration due to technology failure or the inability to use technology (Uçak, 2019). Feelings of frustration were similarly manifested in the *mutualism* vignette when Billy experienced comprehension difficulties around the meaning of "mutually beneficial" and exclaimed "I can't understand". To mitigate the effect of frustration, and to support learning especially with generation of data for the questions in *mutualism*, Mr Smith, due to his welcoming and responsiveness personality, showed Billy a video of the mutually beneficial relationship between the bear and birds. This video bridged Billy's knowledge gap thus facilitating conceptual understanding (Murphy, 2022). Hence, students' emotions can influence teacher facilitation of learning fostering further emotional engagement (Kourti, 2019).

**Evaluate and reflect.** Mr Smith adopted various strategies to facilitate evaluation and reflection. Mr Smith provided opportunities for students to self-evaluate and self-correct to meet the success criteria when he advised students to read and re-read their work to ensure they had all the required information in the *who am I* vignette. Students did not undertake self-correction as they proceeded took the laptops to the charging area and moved to the carpet in readiness for the guessing game. It is possible students had correctly completed their work and were in hurry to participate in the guessing game, or they did not have self-evaluation and self-correction skills. Provision of opportunities for self-evaluation and self-correction without self-evaluation skills may not lead to intended learning outcomes (Forbes et al., 2004; Ramdass & Zimmerman, 2008).

The lack of evaluation skills was illuminated across the three vignettes as students did not evaluate the credibility of the websites as sources of information (Blikstad-Balas, 2016; Guinee, 2004; Willison, 2020). The majority of the students selected the first or second link that popped up when they hit the search key, similar to reports in Guinee (2004) and Keil and Kominsky (2013) that middle school students merely glance at sites without examining their relevance. Moreover, when Mr Smith provided QR codes and web pages in the *mutualism* vignette, students accessed the information without evaluating the credibility of the sources. This implied either that students trusted the teacher as a source of authoritative and credible information, or they lacked information evaluation skills. Even though students should trust their teachers, the ability to question the credibility of information sources is essential in science learning (Blikstad-Balas, 2016; Guinee, 2004). The students may believe that all information on the web is reliable (Guinee, 2004). Furthermore, there were no opportunities for students to reflect at the end of the lessons, which could have provided opportunities for student to learn internet search and evaluation skills (Keil & Kominsky, 2013).

The difficulty with evaluating the vocabulary on the web complicated the information search process. Students experienced difficulty correctly evaluating the vocabulary on the web and this led to comprehension difficulties, for example, when Remi presented her iPad to Mr Smith to read what she had found on the web “mutually beneficial is simply defined as a contract or agreement in which both parties gain some type of advantage or value”. The language used in this definition was complex for Remi and other Year 4 students to comprehend, and they needed Mr Smith to facilitate understanding. Mr Smith’s facilitation did not eventuate in the expected outcomes because there were many words in that definition that students needed to understand before they could develop deeper understanding of ‘mutually beneficial’. Internet inquiry can be complex for young children as they may need to apply sophisticated language skills to effectively generate relevant information, and they need to

couple adequate information search skills, information sources evaluation skills, and adequate scaffolding for successful internet inquiry (Coiro, 2021; Guinee, 2004; Keil & Kominsky, 2013; Zion & Mendelovici, 2012).

The evaluate and reflect facet manifested different emotions as the lessons progressed across the three vignettes. Remi appeared anxious when she presented her iPad to Mr Smith to read. Mr Smith's support generated further uncertainty within Maeve who attempted to engage in Remi and Mr Smith's discussion, showing that she too was struggling with the meaning of 'mutually beneficial'. In the end, it appears Remi and Maeve were still uncertain as to what "mutually beneficial" meant, hence they did not get through the learning pit because they never reached the lightbulb moment of what "mutually beneficial" meant (Nottingham, 2017). Billy manifested frustration, and was at a point of giving up when he announced "I don't understand". Mr Smith, in his responsive nature, took it upon himself, and in his role as a facilitator of the learning process, scaffolded Billy's conceptual understanding of 'mutually beneficially' in the *mutualism* vignette. He guided Billy through the learning pit associated with desperation to a reassured position where Billy had developed an understanding of what "mutually beneficial" meant (Kourti, 2019; Nottingham, 2017). Billy became calm as a result of Mr Smith's explicit support, but Remi and Maeve remained uncertain as to what "mutually beneficial" meant. It appears teachers' explicit support can shift students' feelings from despair to assuredness and thus facilitate emotional engagement (Kourti, 2019). However, do students learn better when teachers question them and allow them to inquire to develop answers, as was the case with Remi and Maeve, or when they provide explicit instruction on given situations? In this case, it appears Billy learnt better with explicit instruction compared to Remi and Milly who were questioned and left to figure out the right answers on their own (Darling-Hammond et al., 2020).

**Organise and manage.** The organise and manage facet is linked to ‘data collection and analysis’ as students organise data to reveal patterns. Information organization was *structured* as students organized data based on the research questions, mind map and teacher model example.

Fostering students’ organization and management of information to make meaning requires adoption of diverse strategies. Mr Smith’s provision of questions or problems to be investigated scaffolded student data generation and recording, and, in effect, influenced data organization. This was evidenced by students having questions already developed in the *what is an ecosystem* and *mutualism* vignettes. Each question had subsequent space for students to record their answers. Therefore, the provision of questions with spaces provided a guiding framework that influenced how students generated and recorded data, essentially influencing how the data were organized. Additionally, to facilitate recording of quality data, Mr Smith instructed students to incorporate the question into the answer (linguistic scaffold), which facilitated students’ conceptual understanding and influenced how students organized the information they gathered in the *what is an ecosystem* vignette (Heppt et al., 2022). The questions used for the internet-based research acted as the organizing framework for students to collate the information. Moreover, the questions created a structured learning environment that may promote student engagement and thriving, as students were aware of the task requirements and learning direction (Eckes et al., 2018; Inayat & Ali, 2020).

In addition to questioning as a guiding framework, Mr Smith used a mind map and teacher modelling to facilitate data collection and organization. When guiding students to gather data for the animal of choice in the *who am I* guessing game, Mr Smith utilised a mind map that illuminated the nature of information students needed to gather. Students utilised the mind map as a guiding framework to organise information generated in themes based on the key concepts on the mind map. Additionally, students mirrored Mr Smith’s model presentation

when making their own presentation on the animal of choice. Therefore, the mind map, combined with the teacher-modelled example, influenced how students gathered, organized and presented information. This data shows that teachers can adopt mind maps and examples to provide structure that facilitates students' information organization (Hopkins et al., 2015; Van Uum et al., 2016). This prescribed nature of organizing information ensures students organize data as per teacher instructions, as students emulate the teacher example (Eckes et al., 2018; Willison, 2020). This can be useful in the short term as students can achieve the learning intention, but then students may fail to apply the critical thinking skills involved when students synthesise information to generate themes and patterns to answer research questions (Inayat & Ali, 2020; Willison, 2020).

Mr Smith utilised pair/group work to manage and organize learning tasks and resources. Due to scarce ICT resources, students were paired to ensure each student had access to an iPad or laptop across the three vignettes. However, as indicated in the interviews, some students were paired based on mixed ability to support peer tutoring during science lessons (Kutnick & Blatchford, 2014). For instance, Kim, who had been absent and was lagging behind, was paired with Lenny, a gifted and talented student, in the *what is an ecosystem* vignette. Assigning Lenny extra responsibilities, in this case peer tutoring, ensured he was continuously engaged in productive learning activities as well as ensuring struggling students were supported to realise their goals (Obidoa et al., 2012). Lenny was observed working harmoniously with Kim to complete the learning tasks. This data shows that pair work is an important teaching strategy that can be utilised to support organization and access to scarce resources, as well as to promote learning (Burke, 2011; Obidoa et al., 2012).

**Analyse and synthesise.** Mr Smith utilised a series of strategies to instigate student analysis and synthesis. Provision of opportunities for students to participate in identifying the animal in the guessing game required analysis and synthesis of the information presented. To

correctly identify the animal presented in the *who am I* vignette, students needed to analyse and synthesise the presented facts/characteristics and link the facts to a specific animal in the Daintree Rainforest. Students incorrectly identified majority of the animals presented during the game. Inability to correctly identify the animal would have resulted from incorrect analysis and syntheses of the various characteristics or a lack of prior knowledge about the animal in the guessing game. The lack of prior knowledge about animals in the Daintree Rainforest might imply the lack of a chain effect alluded to Mr Smith during the interviews where students could transfer knowledge from other subjects as subjects were linked across the curriculum in the case study school. For instance, when Lenny and Kim presented information about the rufous owl, Ella identified the animal as a Cassowary. A cassowary is a bird just like rufous owl, but a Cassowary is not reddish brown and do not live 9-15 years. Ella may have utilised only one characteristic to identify the animal in question. This implied that Ella did not take into consideration the other presented characteristics to identify the animal, thus failing to synthesise all the mentioned characteristics to identify the animal in question. She was either in a hurry to respond or did not have capacity to synthesise all the identified characteristics of the animal in question.

The data in the above episode may imply that students did not possess adequate analysis and synthesis strategies (Glancy et al., 2017). They were unable to utilise their prior knowledge to analyse and synthesise the characteristics of animals presented (Rannikmäe et al., 2020). However, other students quickly identified the animals presented, for instance, Maeve quickly identified the dragonfly presented by Luna and Ella, probably signifying that the complexity of the information presented and the nature of the animal influenced student's ability to analyse and identify the animal in question.

Students appeared to have struggled with synthesising information from the web to develop their research products. This difficulty created frustration and feelings of anxiety

among students. For instance, Billy, Maeve and Remi appeared worried when they struggled with the meaning of “mutually beneficial” in the *mutualism* vignette. Ella appeared to have rushed to analyse and present data on the cassowary, showing that he might have been competing with other students to see who was the first to answer. Accessing information from the web can be frustrating due to a sea of online information as well as reading and comprehension difficulties (Coiro, 2003, 2021). However, many students were excited about the prospect of using computers for learning (Rannikmäe et al., 2020).

**Communicate and apply.** Mr Smith’s teaching style afforded students numerous opportunities to communicate and apply knowledge and skills across the three vignettes. Mr Smith’s questioning strategy instigated student communication and the application of knowledge. For example, when Theo and Mia presented their work for assessment in the *what is an ecosystem* vignette, Mr Smith asked Theo a series of questions that Theo answered. Through the questions, Theo made visible his ideas and the challenges he encountered while undertaking the internet-based research. Mia and Theo, presenting their work for assessment, exposed themselves to criticism as Mr Smith made suggestions for improvement. As a result, Theo improved the quality of his answers following Mr Smith’s informative feedback. Teacher questioning, coupled with informational feedback, bolsters student learning as well as promoting student communication of ideas (Gan et al., 2021).

Provision of formal opportunities for students to present information about the animal of choice offered a platform for students to make their research findings visible. Student presentation of information about the animal of choice, and inviting other students to identify the animal in question, exposed students to potential criticisms. Mr Smith rightly offered criticism when students incorrectly identified the animal being presented by suggesting “listen to the points, I don’t want people pulling out elephant or cheetah, I don’t think they are in the Daintree Rainforest...” This suggestion, coupled with feedback, offered students opportunities

to think and reflect before they communicated their ideas about the animal being presented (Van Uum et al., 2016). It is vital that students communicate their ideas in a clear and understandable style (Van Uum et al., 2016). This data shows that formal presentation opportunities coupled with teacher feedback scaffold students' ability to communicate as well as offering opportunity for teacher feedback (Gan et al., 2021; Van Uum et al., 2016).

Mr Smith required students to record their findings in their integrated study books. The recording of findings offers students the opportunity to provide written reports, hence making their learning visible (Van Uum et al., 2016; Willison, 2020). Across the three vignettes students recorded their findings based on already established questions in the *what is an ecosystem* and *mutualism* vignettes and in line with the mind map in the *who am I* vignette. The data shows that utilisation of already established questions, a worksheet and a mind map provided guidance and structure for student written communication (Van Uum et al., 2016).

## 5.5 Chapter Summary

This chapter explored Mr Smith's inquiry-based learning (IBL) practices whilst teaching the ecosystem unit to Year 4 students.

The findings revealed that Mr Smith had a *narrow* knowledge of IBL and limited knowledge of learner autonomy (LA). Mr Smith utilised diverse autonomy supportive practices to foster LA: cognitive autonomy, procedural autonomy, and organizational autonomy. Mr Smith adopted both high and low autonomy supportive practices in his teaching. However, the majority of Mr Smith's autonomy supportive practices were categorised as low autonomy support as they were highly prescribed, hence providing learners with limited opportunities for choice. Low autonomy support led to low levels of LAD ranging from *underdrive autonomy* to *compliant autonomy*. High autonomy support led to diverse LA demonstrated as ranging from *compliant autonomy*, to *reactive autonomy* to *proactive autonomy*. Because the majority of Mr Smith's autonomy supportive practices were highly prescribed, the range of LAD was

equally limited.

Mr Smith facilitated structured internet inquiry across the three vignettes. Students experienced three essential features of inquiry (questioning, data collection, and communication) across the three vignettes. Therefore, students did not experience the full range of IBL practices in Mr Smith's lessons. Mr Smith combined IBL and explicit instruction in his teaching while predominantly using explicit instruction.

It appears Mr Smith's knowledge, and beliefs influenced how he facilitated science learning, adopting a highly structured teaching approach with prescribed instructions and low autonomy support thus facilitating students to demonstrate limited levels of LAD. However, there was a complex relationship between his knowledge of IBL and the nature of IBL facilitated.

## Chapter 6 Cross-Case Analysis and Discussion

This chapter presents a cross-case analysis and discussion of the key findings about teacher knowledge and practices relating to inquiry-based learning (IBL) and learner autonomy (LA) that are drawn from each case presented in Chapter 4 and Chapter 5. This cross-case analysis provides a unique window into teacher understanding and practice because each teacher is responsible for the same class of students on different days of the week. Emerging themes that depict the divergent teaching styles of the two teachers are discussed in line with the research literature and the conceptual framework guiding this study. The conceptual framework unpacked and illustrated in Figure 2.1 has been replicated in Figure 6.1 for ease of reference.

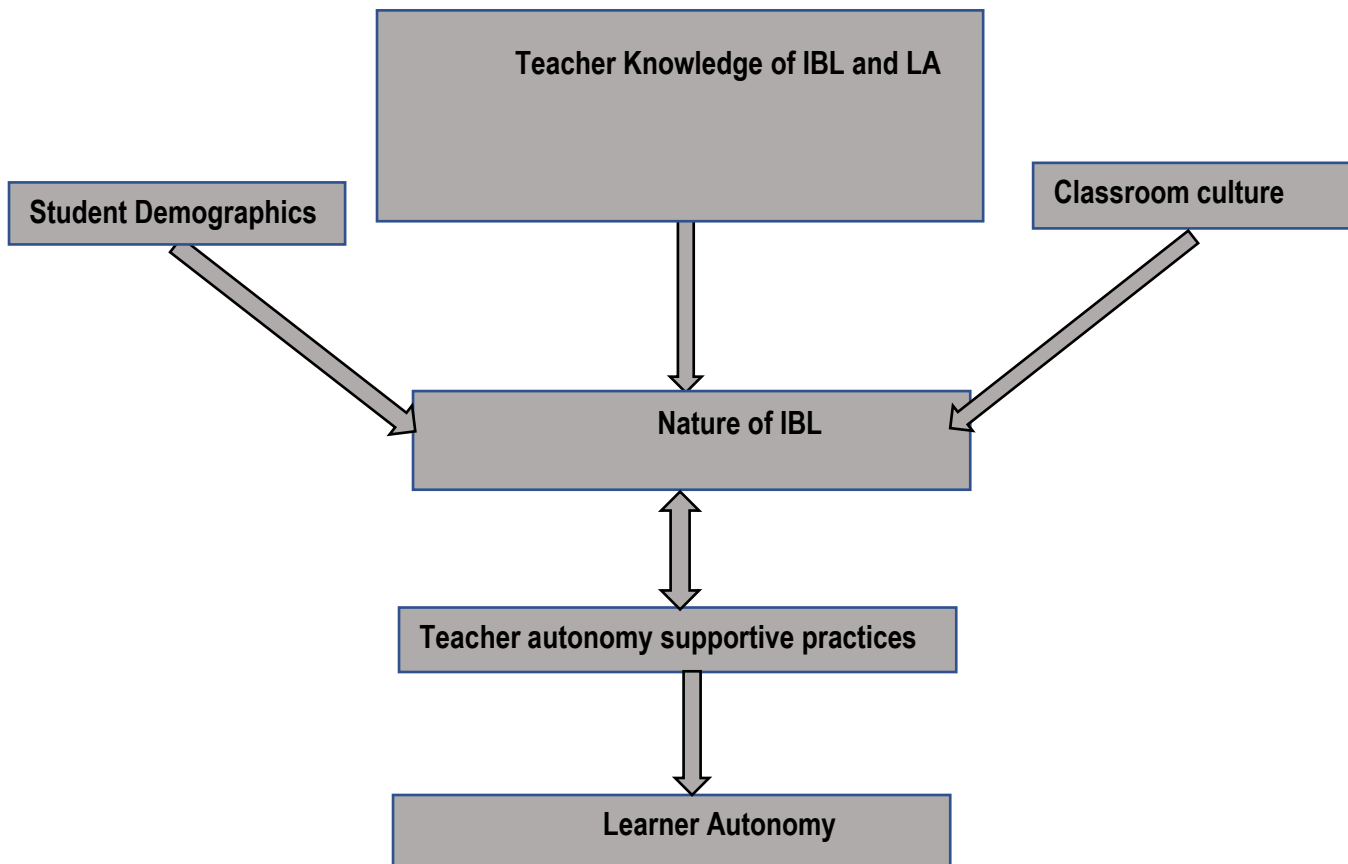
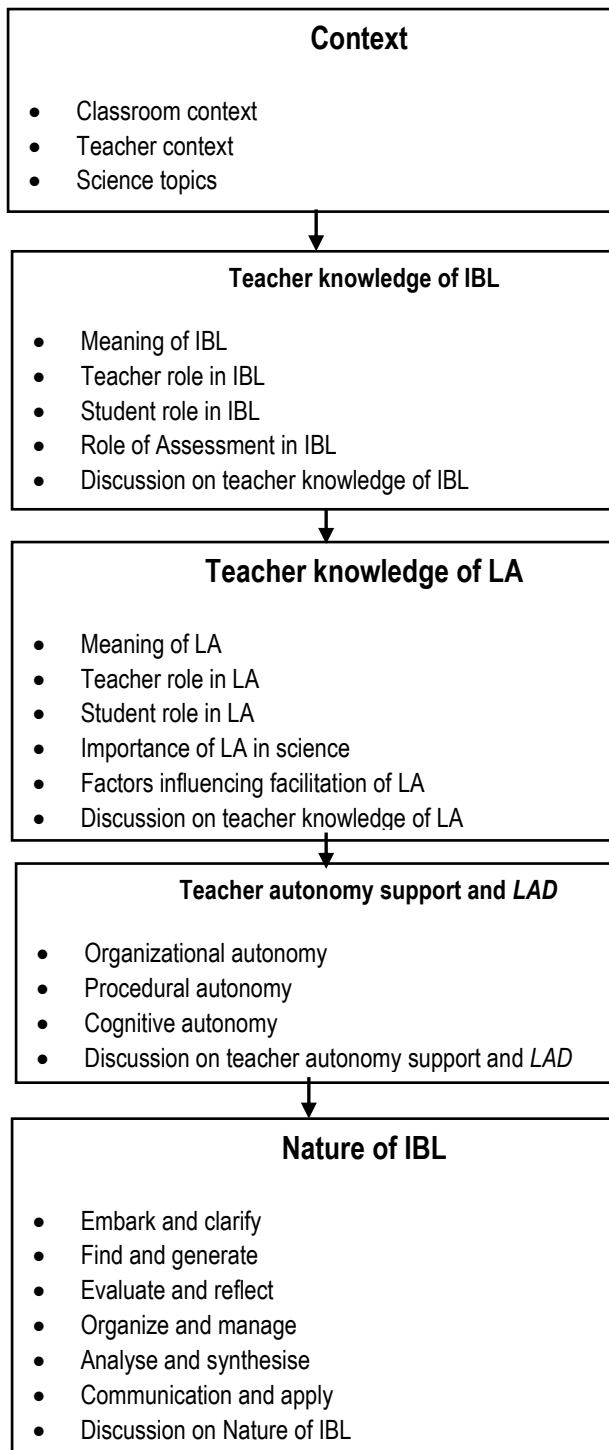


Figure 6.1. Conceptual Framework

Following the conceptual framework, the ensuing sections compare the context, teacher knowledge of IBL and LA, teacher autonomy supportive practices including learner autonomy demonstrated (LAD), and nature of IBL.

The cross-case analysis addresses the following research questions:

1. What are the effects of primary teachers' knowledge of IBL on nature of IBL facilitated in science classrooms?
2. What are the teacher autonomy supportive practices employed in science classrooms?
3. How does the nature of IBL facilitated influence the teacher autonomy supportive practices facilitated and the learner autonomy demonstrated by students?



*Figure 6.2.* Main themes for the cross-case analysis and discussion

## **6.1 Context**

The relationship between the contextual factors and social processes forming part of the cases being studied should be considered when undertaking the cross-case analysis approach (Denscombe, 2017). The contextual factors influencing the case study teachers' IBL practices and teacher autonomy supportive practices are compared: teachers' characteristics, classroom context, and science topics taught.

Broadly, Mrs Jasmine's and Mr Smith's case studies were contextually similar because they were teaching Science in the same Year 4 classroom, in the same school within the same research study period. However, there were considerable differences within the nature of science topics taught, the media of instruction and teaching experience. Teacher comparison has been organized into teacher context, classroom context and the science topics taught.

### **6.1.1 *Teacher Context***

Both case study teachers were generalist trained primary school teachers with different qualifications, teaching backgrounds, and science teaching experience. Both teachers hold bachelor's degrees in teaching. However, Mrs Jasmine holds a Bachelor of Teaching and a Bachelor of Special Education whereas Mr Smith holds a Bachelor of Education in History and Physical Education. Although they are not trained as science specialist teachers, both teachers are qualified to teach in South Australia (TRB, 2018). Non-science specialist teachers teaching science in primary schools in Australia has been an ongoing concern (Bentley et al., 2022; Prinsley & Johnston, 2015), as they are argued to have a low science interest and knowledge, and they may struggle with teaching science (Appleton, 1992, 2003; Timms et al., 2018).

The case study teachers had different science teaching preparations and experiences. During the study, Mrs Jasmine was in her 25<sup>th</sup> year teaching primary schools and had been teaching science ever since she started teaching, whereas Mr Smith was in his first year teaching. Teaching experience may influence how teachers facilitate learning.

### 6.1.2 Classroom Context

While there were clear similarities in Mrs Jasmine's and Mr Smith's class contexts, there were also differences despite having the same students on their class roll. The teachers were both teaching the same Year 4 class, therefore the students' knowledge and abilities and the Year 4 instructional space were similar. However, the number of student visitors attending the science lessons, the number of teachers instructing the students, and the instructional space varied from one week to another as illuminated in the vignettes. These are important differences that may influence how teachers facilitate learning (Hirsh et al., 2022), which may include how teachers facilitated IBL and LA. The Year 4 students varied in ability from gifted and talented to children within the Autism Spectrum Disorder as detailed in Chapter 3. However, the students had strong interpersonal relationships, were motivated and had great interest in science as reported by both case study teachers.

Student numbers varied by teacher in the same space. Mr Smith taught science on his own to between 16 and 18 Year 4 students, and no students attended from another class. Mrs Jasmine and the Year 5 teacher sometimes combined their classes and co-taught science lessons to a total of up to 35 students, following the Kluth and Straut (2003) duet model of co-teaching. Learning activities took place either in the Year 4 or Year 5 classroom during co-teaching.

Mrs Jasmine taught Science when students rotated between Science and other learning activities such as drama, slime and dance, therefore reducing the number of students to a minimum of four in the *Christmas tree* and *tree house* vignette and a maximum of 35 in the *my straw musical instrument performance* vignette. For instance, as detailed in the *Christmas tree* and *tree house* vignette, students were split into three groups, drama, slime, and Science. Half-way through the lesson, the groups rotated between drama, slime, and Science. This arrangement affected the number of students attending Science at a particular time, the duration students participated in Science activities, how Mrs Jasmine facilitated Science, as well as how students managed their Science outputs. Notably, due to the rotation model, Milly, Ella and

Lara working on the Christmas tree had less time for Science as a group, and were unable to effectively complete their structures. Although pairs and group members in Mr Smith's class worked collaboratively and continuously, group members in Mrs Jasmine's class were sometimes split, affecting their group work arrangements. Splitting group members to work on their project in different sessions may have influenced the group dynamics and product output at the end of the lesson.

The time allocated for Science for the two cases differed considerably. While Mrs Jasmine taught Science for 90 minutes on Thursdays, Mr Smith taught science on Mondays and Tuesdays for 90 minutes each day. Despite Mrs Jasmine being allocated 90 minutes for Science on Thursdays, Science shared the allocated time with other Thursday afternoon activities. Therefore, students experienced approximately 45 minutes of Science with Mrs Jasmine every week, whereas students experienced approximately 180 minutes of science learning per week in Mr Smith's class. Generally, students experienced 225 minutes of science every week compared to the national average of 120 minutes per week reported by primary school principals in Australia (Mullis et al., 2020). This is above the 90-150 minutes hours per week mandated by the Australian Curriculum (ACARA, 2017). Both teachers sometimes lost science lesson time to other school activities such as 'the cross' and 'assembly'. Mr Smith indicated that science was pushed to the back whenever there was time needed for other school activities, therefore time available for science was less when compared to other subjects such as Mathematics and Literacy (Bassok et al., 2016). The variability in science lesson time experienced in this study has been reported in other countries. For example, the USA reported that the number of hours fourth grade students experienced science learning varied from one state to another. In some states in the USA students experienced fewer than 2 hours per week, while in other states they experienced up to 4 hours of science learning per week (Blank, 2013). This time variability may influence how teachers facilitate IBL and support learner autonomy.

### **6.1.3 Science Topics**

Both case study teachers indicated that they had a discussion with each other, and the person they were sharing the job with, to select topics to teach. Mr Smith indicated that during the research study period, the school was focusing on Australia and Australian States and Territories, therefore the science topics revolved around Australia. During the study, Mrs Jasmine was teaching sound and building structures using straws, whereas Mr Smith focused on the greater Ecosystem unit focusing on the Daintree Rainforest.

The different science topics taught by case study teachers varied in content, level of abstractness and cognitive demand. Mrs Jasmine focused on hands on activities which were cognitively and creatively demanding. Students engaged in hands on sound production using straw musical instruments and building structures using straws. In contrast, Mr Smith taught students different topics around the greater unit ‘the ecosystem’ in which students focused on the Daintree Rainforest. Students engaged in internet inquiry on various concepts of the ecosystem including what an ecosystem is, animals in the Daintree and mutualism. Mrs Jasmine’s science topics can be linked to the Science Understanding strand and physical sciences sub-strand of the AC: Science whereas Mr Smith’s science topics can be linked to Science Understanding strand, Biological Sciences sub-strand -living things in the AC: Science.

These topics were sometimes abstract and cognitively demanding, as students had to synthesise information from the internet to make meaning. Some concepts within these topics were less visible to learners due to their complex nature. However, Mr Smith scaffolded students’ information search to promote students’ conceptual understanding. The science topics taught may have influenced teachers’ selection of teaching approaches (de Jong et al., 2023; NRC, 2000) and may have influenced how these teachers facilitated and scaffolded learning.

#### **6.1.4 Discussion on Context**

Contextual factors are fundamental variables that should be taken into consideration when comparing teacher practice across states, countries and internationally (Denscombe, 2017). However, when comparing teachers within the same school, same classroom, same subject but teaching different science topics, the contextual factors become more subtle yet still very crucial for investigation as they offer the potential to identify factors influencing the learning process due to the significant similarities in terms of class size, student demographics and school science philosophy. Contextual factors such as school context, school philosophy (Hackling et al., 2017), students' demographics, knowledge and abilities (Hackling et al., 2014; Hirsh et al., 2022), classroom culture (Alexander, 2008) and physical instructional space (Hackling et al., 2014; Hirsh et al., 2022) may influence how teachers facilitate learning and how students respond to learning opportunities.

Each case in this study was associated with a unique set of contextual factors. Contextual factors such as the school science focus, class year level, students' ability and knowledge, and instructional space were similar. However, training background, teaching experience, the area of science being taught, instructional media used in teaching, number of teachers per lesson, and the number of lessons per week set the two cases apart, and may have led to differences in how Mrs Jasmine and Mr Smith facilitated IBL and the teacher autonomy supportive practices they adopted in science lessons which, in turn, may have influenced LA demonstrated. Hackling et al. (2017) has discussed several localised contextual factors that can influence science learning in diverse cultural contexts. In this study, the localised contextual factors that influence learning especially factors that influence the nature of IBL, teacher autonomy supportive practices and learner autonomy demonstrated include school science focus, instructional space, classroom culture, teaching experience and science topic being taught, student demographics, knowledge, and abilities and teacher knowledge of IBL and LA. These factors may cumulatively influence how teachers facilitate IBL and LA and how learners

experience learning. These factors can be organized in circular rings similar to the contextual factors organized by Hackling et al. (2017). The contextual factors around teacher knowledge of IBL and LA are discussed in subsequent sections.

## **6.2 Teacher Knowledge of Inquiry-Based Learning**

Despite the contextual nuanced differences, the overlaps of context provide a position from which to compare and contrast the two teachers' attitudes and implementation of IBL and support of LA. Previous research has indicated that teacher knowledge of inquiry-based learning (IBL) has considerable influence on teacher implementation of IBL (Capps et al., 2016; Ozel & Luft, 2013). The analysis of the teachers' knowledge of IBL in the current study was based on the analytical framework detailed in Table 3.4 whose findings are presented in Chapter 4 for Mrs Jasmine and Chapter 5 for Mr Smith. Teacher knowledge of IBL was categorised into four themes: meaning of IBL, teacher role, student role and role of assessment in IBL. The cross-case analysis compares teacher knowledge of IBL across the four themes and the findings revealed that case study teachers had a similar knowledge level in each category. However, there were numerous differences within each category, illuminating their understanding of IBL.

### **6.2.1 Meaning of IBL**

Based on the analytical framework, Mrs Jasmine's and Mr Smith's knowledge regarding the meaning of IBL was *narrow* because each mentioned only two essential features of inquiry in their definition of IBL: questioning and investigating. While Mrs Jasmine understood IBL as a question-and-answer method, Mr Smith understood IBL as students searching for information. In contrasting approaches to IBL, Mrs Jasmine emphasised student constructing and generating their own data whereas Mr Smith had students collecting others' data/information to address questions. Both teachers began their interview by indicating that students investigated teacher-provided questions or foci, yet Mrs Jasmine went on to report that

students investigated both teacher- and student-generated questions, whereas Mr Smith indicated that for his students' level of education, students investigated teacher provided foci. Mr Smith's statement is consistent with findings in literature that reports teachers indicated that young children are not ready to generate investigable questions (Ruggeri et al., 2021; Swaboda et al., 2022).

Both case study teachers did not mention all the essential features of inquiry in their definitions of IBL, for example, students engaging in data analysis, developing explanations and communicating results (Capps et al., 2016; NRC, 2000, 2012; Ozel & Luft, 2013). This finding is consistent with other findings that teachers mentioned the common essential features of IBL while missing the less common essential features of inquiry (Capps et al., 2016; Ozel & Luft, 2013).

Both case study teachers revealed that they acquired knowledge about IBL through their teaching experience. Whereas Mrs Jasmine acquired knowledge about IBL from her IBL-experienced colleague, Mr Smith acquired knowledge about IBL while he worked as an Education Support Officer (ESO), and observed different teachers use IBL in their teaching. Zhao and Fan (2022) reported that teachers' experience, reflection and exchanges with teacher colleagues are some of the crucial sources of teachers' knowledge for development.

### **6.2.2 *Teacher Role in IBL***

Based on the analytical framework, Mrs Jasmine's and Mr Smith's knowledge of the role of the teacher in an IBL lesson is *broadened*. Mrs Jasmine indicated that her role is to guide and support students to arrive at answers and solutions. Similarly, Mr Smith opined that his role is to guide and facilitate learning (Gelmez-Burakgazi, 2020; Keiler, 2018).

Both case study teachers believe in supporting learners to realise lesson objectives, rather than doing things for the learners. Both teachers indicated that they do not provide answers to students but provide opportunities for students to do things for themselves.

### **6.2.3 Student Role in IBL**

Based on the analytical framework, both case study teachers' knowledge of the role of students in IBL is *broadened* because the teachers believe that the student is an active learner and investigator. Both teachers believed that a student should be an active participant in the learning process, and someone who investigates and generates new information (Rannikmäe et al., 2020). This belief is in line with constructivism theories that recommend students' active participation in the learning process and co-construction of new knowledge (Ahn & Class, 2011; Peters et al., 2003; Rannikmäe et al., 2020).

### **6.2.4 Role of Assessment in IBL**

Based on the analytical framework, both case study teachers had *moderate* knowledge on the role of assessment in learning. Mrs Jasmine engaged in informal assessment *for* learning because she used students' questions and discussions to guide and support learning. Mr Smith engaged in both assessment *of* learning and assessment *for* learning. He used unit pre-assessment and end-of-unit assessment to determine student knowledge acquisition, hence engaging in assessment *of* learning. Additionally, Mr Smith utilised feedback he obtained from assessment to determine students' current knowledge level to develop strategies to extend their learning, therefore engaging in assessment *for* learning. This finding concurs with findings in literature that teachers used assessment *for* learning and assessment *of* learning in IBL (Harlen, 2013; Willis, 2011). However, the case study teachers did not use assessment to challenge students' claims and evidence in inquiry (Ssempala, 2017).

### **6.2.5 Discussion on Teacher Knowledge of IBL**

Teachers must have a clear understanding of instruction to effectively implement instruction (Rosenshine, 2012), and, as such, teachers must have a clear understanding of IBL to effectively implement IBL (Capps et al., 2016; Demir & Abell, 2010). Both case study teachers had a *narrow* knowledge of the meaning of IBL. This finding is consistent with literature that teachers had limited understanding of IBL (Capps et al., 2016; Ozel & Luft,

2013). Teachers reported that they acquired knowledge about IBL through work experience, especially from their colleagues. Zhao and Fan (2022) reported that teachers' experience, reflection and exchanges with teacher colleagues are some of the crucial sources of teachers' knowledge for development.

Both case study teachers had *broadened* knowledge about the role of the teacher in an IBL lesson. They reported that a teacher's role in IBL is to facilitate learning. These findings concur with extant literature that teachers should assume the role of facilitators, mentors and guides in IBL (Keiler, 2018; Kidman, 2017). As facilitators, teachers create opportunities for students' active participation in the knowledge construction process (Rannikmäe et al., 2020).

Case study teachers had *broadened* knowledge of students' role in IBL. Both teachers believed that students should be active learners and investigators. Previous studies reported that students should be active participants in IBL (Capps & Crawford, 2013; Capps et al., 2016). Similarly, government documents recommending the adoption of IBL suggest that teachers should ensure students are active participants in the knowledge construction process, as espoused in constructivism theories where learners are co-constructors of new knowledge (ACARA, 2023b; Government of Kenya, 2017; MOE.Singapore, 2014; NRC, 2012).

Case study teachers had *moderate* knowledge of the role of assessment in IBL lessons. Whereas Mrs Jasmine used assessment *for* learning, Mr Smith used both assessment *for* learning and assessment *of* learning. Assessment *for* learning helps teachers to adjust instruction to better teach the students (Harlen, 2013; Willis, 2011). However, in IBL, besides using assessment *of* learning and assessment *for* learning, teachers should also use assessment to challenge ideas, data and claims by students to foster critical thinking (NRC, 2012; Ssempala, 2017).

Research evidence has shown that teacher knowledge dynamically affects their practice (Abell, 2007; Capps et al., 2016; Demir & Abell, 2010). Teachers who lack broadened

knowledge of inquiry may struggle to enact a recognisable form of IBL (Crawford & Capps, 2016). Hence, the way teachers construe IBL would influence how they implement IBL in science lessons. Neither case study teacher possessed *broadened* knowledge of IBL in all the four themes investigated. This is well reflected in the implementation of IBL in their science lessons, as the teachers did not involve students in all the essential features of inquiry, such as connecting evidence to scientific knowledge.

### **6.3 Teacher Knowledge of LA**

Previous research that explored teacher knowledge of learner autonomy (LA) revealed that teachers' knowledge of LA has a significant influence on teacher support of LA (Penh, 2016; Trần, 2019). In this study, teacher knowledge of LA was categorised into three themes: meaning of LA, teacher role in promoting LA and student role in LA. Findings revealed that the case study teachers had diverse understandings in each category of LA. The cross-case analysis compares teacher knowledge of LA across the three themes.

#### **6.3.1 Meaning of LA**

Mrs Jasmine's conceptualisation of LA as students assuming responsibility and control of their learning suggested that she understood LA as *proactive autonomy* whereby students initiate actions to take control of their learning. This shows that Mrs Jasmine believes that learner motivation is a prerequisite for LA (Okumus, 2021). Mr Smith's description of LA showed that he knew about the concept of LA, but not the LA terminology. This finding is consistent with literature that reveals that the LA definition is problematic because different researchers, scholars and teachers have used different words, such as LA, self-regulated learning, independent learning, and self-directed learning, to mean the same thing (Morrison, 2011; Murase, 2015).

### **6.3.2 *Teacher Role in Promoting LA***

Mrs Jasmine believed that her role is to provide opportunities for learners to experience LA, whereas Mr Smith believed that his role is to facilitate LA. The teacher should be a facilitator, task setter, counsellor and resource person while promoting LA (Camilleri, 1999; Yan, 2012). As learners take more responsibility to search for information, they seek clarification, guidance, and feedback from the teacher (Alonazi, 2017; Camilleri, 1999; Yan, 2012).

Both case study teachers adopted diverse strategies to promote LA. Mrs Jasmine indicated that she gave learners a voice to express their ideas and involved students when planning learning activities (Großmann & Wilde, 2020; Rogat et al., 2014). Mr Smith indicated that he provided students with opportunities to ask questions and monitor their learning. He likened LA to planting seeds in the minds of children which meant providing ideas and suggestions for students to use to expand their learning (Rannikmäe et al., 2020).

### **6.3.3 *Student Role in LA***

Learning as a challenging, fun and rewarding activity. Both teachers indicating that learners should be active participants in the learning process who are responsible for their own learning (Alston et al., 2020). Mr Smith's likening of LA to learners learning through the learning pit implied that learning is challenging and rewarding, and students must brace themselves through the learning challenge to construct new understanding of the phenomena under investigation (Nottingham, 2017). However, Mrs Jasmine believed that learning should be enjoyable, as she took students' interests into consideration when planning for learning.

### **6.3.4 *Importance of LA in Science Learning***

Both case study teachers reported that LA is important in science learning. Mrs Jasmine reported that LA enhances student motivation, engagement and the development of self-regulation skills which are key foundational aspects for students' success in learning (Großmann & Wilde, 2020; Rogat et al., 2014; Roth et al., 2007). Mr Smith stated that

independent learning within the classroom provides students with opportunities to gain lifelong learning skills (Oates, 2019), including skills to climb out of the learning pit such as persistence, resilience, and researching, which are applicable in diverse spheres of life (Beauchamp & Parkinson, 2008; Howlett & Waemusa, 2019; Oates, 2019).

### ***6.3.5 Factors Influencing the Promotion of Learner Autonomy***

**Factors promoting facilitation of LA.** Both case study teachers identified different factors that promoted the facilitation of LA. Mrs Jasmine stated that teacher passion about LA (Serin, 2017) and their provision of valuable feedback would influence teacher facilitation of LA (Kahn et al., 2013). Mr Smith reported that access to adequate resources and students possessing sufficient background knowledge would foster the facilitation of LA (Rannikmäe et al., 2020). Additionally, Mr Smith reported that the curriculum in his school was linked across subjects, hence facilitating the transfer of knowledge across subjects. The transfer of knowledge from Humanities and Social Sciences (HASS) to science created a chain effect that contributed to better learning in science, thus fostering facilitation of LA (Nottingham, 2017; Rannikmäe et al., 2020). Science and HASS were linked as students covered similar concepts. However, Mr Smith noted that students addressed topics in HASS before they did in science, implying that by the time they went to science, they had an adequate background knowledge about the aspects covered in science, making it easier for students to assimilate new knowledge. This was Mr Smith's chain effect from HASS to science. Whereas Mr Smith linked the influence of the chain effect across subjects to the facilitation of LA, Mrs Jasmine did not refer to any synergistic relations across subjects related to science. This difference may be related to the earlier difference observed, that Mrs Jasmine did not link the student investigations to external scientific knowledge, whereas Mr Smith's investigations relied on that link.

**Factors hindering the promotion of LA.** Mrs Jasmine stated a number of hypothetical factors that she thought would hinder the facilitation of LA in school science. These factors included teachers wanting to take control of the learning process (Furtak & Kunter, 2012), undesirable student behaviour and students' lack of resilience (Ma, 2021). In contrast, Mr Smith referred to a classroom experience whereby the laptops were not charged, leading to a change in lesson facilitation that limited students' opportunities for independent learning (Beauchamp & Parkinson, 2008).

### **6.3.6 Discussion on Teacher Knowledge of LA**

Research findings revealed that case study teachers had diverse understandings about LA. Whereas Mrs Jasmine understood LA as students taking charge of their learning, Mr Smith was not aware of LA (terminology), but had knowledge about the concept (Camilleri, 1999; Hamad, 2018).

The case study teachers' descriptions of teacher and student roles revealed that they had varying knowledge levels about LA. Mrs Jasmine's knowledge varied from *overdrive autonomy* to *reactive autonomy* whereas Mr Smith's knowledge about LA varied between *reactive* and *compliant autonomy*. These findings concur with prior studies which reported varying understanding about LA among their participants (Hamad, 2018; Marsh et al., 2001). Additionally, this finding illuminates the multifaceted and complex nature of LA, which has been well documented in the literature (Benson, 2012; Lamb, 2017). Benson (2013c, p. 1) for instance, asserted "autonomy is in essence multidimensional and takes different forms in different contexts of learning" implying that there are expectations for diverse understandings and interpretations of LA. The diverse teacher knowledge of LA implies there would be diverse ways teachers practice and promote LA, which could ultimately influence learner autonomy demonstrated (LAD).

In her definition of LA, Mrs Jasmine mentioned that learners take responsibility and control of their learning. These are important tenets of LA which are well discussed in literature (Benson, 2013c; Hamad, 2018). This shows that Mrs Jasmine is aware of the various dimensions of LA, and may, as a result, offer students diverse opportunities to demonstrate LA.

The analysis of teachers' knowledge of LA reveals factors that may restrict or facilitate the promotion of LA in school science. The major inhibitor would be teachers wanting to take control of the learning process (Furtak & Kunter, 2012), undesirable student behaviour and students' lack of resilience (Ma, 2021). However, there are numerous factors that would promote the facilitation of LA, such as teacher passion, teacher beliefs that LA is important in science learning and the availability of resources (Rannikmäe et al., 2020; Serin, 2017). These findings suggest that to promote the facilitation of LA, teacher preparation programmes should ensure teachers have an in-depth understanding of LA and LA processes to better facilitate it by regulating the level of their classroom control.

## **6.4 Teacher Autonomy Supportive Practices**

### **6.4.1 *Organizational Autonomy Support***

There were considerable similarities and differences in the ways the case study teachers supported organizational autonomy. The opportunities extended to students within organizational autonomy were freedom to select and work with partners, limiting choice by choosing groups for students and freedom to determine when to hand in assignments for assessment.

- ***Opportunities to select and work with partners***

Both case study teachers provided students with opportunities to work either individually or with partners. Students had the responsibility of deciding whether to work alone or with a partner, as well as which partner to work with in both case studies. These opportunities were manifested when teachers announced how students would complete learning tasks.

Mr Smith occasionally determined student roles while working in groups when he answered a student clarification question by suggesting that one student should work as a scribe and another as a researcher in the *what is an ecosystem* vignette. Mrs Jasmine did not participate in determining student roles during group work. Clarifying students' roles during learning may facilitate student collaboration and enhance learning (Van Uum et al., 2016). Despite students having the freedom to work individually or in pairs, Mrs Jasmine recommended that students should work with at least one other person in the *my straw musical instrument* vignette, but in groups of twos or threes in the *my straw musical instrument performance* vignette. Mr Smith required students to work in pairs in the *what is an ecosystem* and *who am I* vignettes, while offering students freedom to either work in pairs or individually in the *mutualism* vignette.

The nature of teacher instructions and learning tasks may influence the nature of learner autonomy demonstrated (LAD). Billy and Jayden began working as partners in Mrs Jasmine's *my straw musical instrument* vignette, thereby demonstrating *compliant autonomy*; however, as the lesson progressed, they went their separate ways and completed their straw instruments individually demonstrating *reactive autonomy*. While working as partners in Mr Smith's *what is an ecosystem* and *mutualism* vignettes, Billy and Jayden worked together throughout the lesson thereby demonstrating *compliant autonomy*. The data shows LAD by Billy was fluid in Mrs Jasmine's class but static in Mr Smith's class. The shift in LAD may have resulted from the nature of teacher instructions, as Mr Smith provided prescribed instructions or the nature of the learning task that required students to work together using computers to access information from the internet in Mr Smith's class unlike Mrs Jasmine's class that required students to create straw instruments. This finding is similar to findings by Willison et al. (2017) and assertions by Little (1991) that LA is fluid and dependent on teacher instructions and student progress (Reeve, 2009).

Sometimes students contradicted teacher recommendations on working with partners. Despite Mr Smith offering prescribed instructions for students to work in pairs across the three vignettes, except the *mutualism* vignette where students had a chance to work individually, occasionally students deviated from Mr Smith's instructions. For instance, Mia and Billy worked individually in the *what is an ecosystem* and *who I am* vignettes respectively, thereby demonstrating *reactive autonomy* by taking actions that deviated from Mr Smith's instructions of working in pairs. Largely, students did not contradict Mrs Jasmine's general instructions as they were generally open and flexible.

- ***Limiting choice: Choosing groups for students***

Whereas both case study teachers provided opportunities for students to work with partners, they also limited students' freedom to choose partners when they directed students to work with specific partners. Both case study teachers limited Lenny's freedom to select partners to work with by directing him to work with Theo in the *Christmas tree and tree house* vignette for Mrs Jasmine, and to work with Kim in the *mutualism* vignette. Both teachers facilitated peer learning by pairing Lenny, a talented and gifted student, with students who needed additional support to complete their learning tasks.

Lenny demonstrated *compliant autonomy* by complying with both teachers' prescribed instructions. The data shows that even though teachers can be autonomy supportive, sometimes they can practice autonomy restrictive behaviours (Furtak & Kunter, 2012; Großmann & Wilde, 2020; Rogat et al., 2014).

Additionally, the data shows that when teachers issue directives or prescribed instructions, they limit the opportunities for choice leading to student compliance (Großmann & Wilde, 2020). As such, Lenny had no option other than complying with teacher directives on group formation. The benefits around teacher and student selected groups in terms of performance are well contested in literature (Felder & Brent, 2001; Pociask et al., 2017; Post

et al., 2020). This is the case even though in terms of organizational autonomy support students need the freedom to determine which group members or partners to work with (Rogat et al., 2014; Stefanou et al., 2004).

- ***Opportunities to determine when to hand in assignments***

Provision of opportunities for students to determine when to hand in assignments for assessment creates a sense of responsibility, control, and ownership of the learning environment (Rogat et al., 2014; Stefanou et al., 2004). Both case study teachers often walked around the classroom checking students' work and offering informative feedback. Some students, however, chose to present their work for assessment without teacher instigation. Both teachers assessed and provided feedback when students presented their work for assessment. Mia, in the *what is an ecosystem* vignette, and Milly, in the *mutualism* vignette, presented their work for assessment without Mr Smith's invitation, thereby demonstrating *proactive autonomy*. Similarly, Maeve's group as well as Mia and Remi presented their instrument or played their instrument for Mrs Jasmine to assess in the *my straw musical instrument* vignette and Remi in the *my straw musical instrument performance* vignette.

When students presented their work for teachers to assess, students demonstrated *proactive autonomy*; however, when teachers asked questions regarding students' work, students demonstrated *compliant autonomy* when they answered teacher questions. For instance, when Maeve's group presented their instrument to Mrs Jasmine, she asked them how they were going to play the instrument, Maeve responded that they would go from one end to another, therefore beginning with *proactive autonomy* when they presented their instrument and shifting to *compliant autonomy*. Similarly, when Mia presented her work to Mr Smith, Mr Smith provided informative feedback in terms of questions around the actions Mia needed to undertake to make her work better. Whereas Mrs Jasmine asked Maeve's group open-ended questions and made open-ended suggestions, Mr Smith was very specific in his questions

around Mia's work.

This data shows that LAD is an attribute that depends on the nature of classroom task, teacher instructions and learning progress (Little, 1991). The data shows that both case study teachers were approachable and willing to assess students work and provide informative feedback that fostered student learning (Harlen, 2013), hence bolstering their engagement with learning tasks as they addressed teacher feedback (Harlen, 2013; Rogat et al., 2014). However, some students often waited for teachers to instigate assessment. Research has shown that students are not used to seeking feedback (Baartman et al., 2022), indicating that high performing students are intrinsically motivated to seek feedback as they have positive perceptions of feedback (Baartman et al., 2022).

#### **6.4.2 Procedural Autonomy Support**

Case study teachers provided opportunities for procedural autonomy across the six vignettes. Opportunities for procedural autonomy allow students to develop a sense of ownership of the form of the learning output (Rogat et al., 2014; Stefanou et al., 2004). These opportunities include freedom to access resources, freedom to determine the design of their learning outputs, time management, and the use of worksheets to scaffold learning among others.

- ***Opportunities to access learning resources***

Both case study teachers provided opportunities for students to access pre-determined resources for their learning tasks across the six vignettes. Whereas Mr Smith requested the students to access the predetermined resources such as laptops from the charging area, Mrs Jasmine placed the predetermined resources such as straws, masking tape, scissors, and pipe cleaners in a box on the bench next to the teacher's desk, except in the *my straw musical instrument performance* vignette when she asked Remi and Ryan to gather the resources. Students reacted to this opportunity by accessing the resources thereby demonstrating

*compliant autonomy*. The freedom to access predetermined resources to complete learning tasks offered minimal opportunities for choice, therefore, students had no option other than to comply with teacher instructions. Similarly, the instructions to access resources were highly prescribed, hence expected compliance (Reeve & Cheon, 2021). However, they offer students opportunities for ownership of the learning environment and the form of the learning output (Rogat et al., 2014).

- ***Opportunities to access and use resources of choice***

Mrs Jasmine provided students with opportunities to use additional resources of choice during science lessons. Despite Mrs Jasmine not being explicit that students could use additional resources to complete their learning tasks, students accessed additional resources. For instance, Maeve accessed and used a mini-whiteboard to plan her instrument thereby demonstrating *reactive autonomy* in the *my straw musical instrument* vignette. Students in Mr Smith's lessons did not access additional resources other than the prescribed and predetermined resources.

The data shows that Mrs Jasmine adopted a safe and supportive learning environment in which students experienced ownership of the learning environment, and hence had the confidence and willingness to access additional resources. This fostered students' engagement and participation in undertaking learning tasks as they felt a sense of ownership of form of the learning output (Rogat et al., 2014; Stefanou et al., 2004). The nature of learning tasks may have influenced students' decisions about whether to access additional resources or not. Engaging in hands-on activities may require students to apply their creative abilities and utilise any resources available to advance their learning outputs compared to internet inquiry which is minds-on learning where students use computers to access information from the internet (Van Uum et al., 2016).

- ***Restricting access to resources***

Despite Mrs Jasmine's support for the access and use of resources of choice, sometimes she constricted students' opportunities to use resources of choice. Notably, in the *Christmas tree and tree house* vignette, Mrs Jasmine directed Milly and Ella to return the mesh nets to the cabinet without allowing them to explain why they had the mesh nets. Milly and Ella complied with Mrs Jasmine's direction by returning the nets to the cupboard thereby demonstrating *compliant autonomy*. Mr Smith did not restrict students' use of resources, probably because students were carrying out internet inquiry and did not need additional resources to complete their learning tasks. The data shows that Mrs Jasmine demonstrated autonomy restrictive behaviour despite having demonstrated autonomy supportive behaviour. Teachers demonstrating both autonomy supportive and autonomy restrictive styles has been discussed in Chapter 4 (see Chapter 4 *restricting access to resources*).

- ***Freedom to determine the nature of learning output***

Both case study teachers often provided students with opportunities to determine the nature of their learning output. Students had the freedom to determine the nature of the straw musical instrument in the *my straw musical instrument* and *my straw musical instrument performance* vignettes, and the nature of structure to build in the *Christmas tree and tree house* vignette facilitated by Mrs Jasmine. Similarly, students had the freedom to determine the animal to investigate in the *who am I* vignette facilitated by Mr Smith. Mr Smith provided structured instructions as students were required to identify the animal from the Daintree Rainforest and follow a prescribed format when gathering and presenting information about the animal of choice. However, Mrs Jasmine's instructions across the three vignettes were open and flexible.

Students complied with Mr Smith's instructions by investigating an animal in the Daintree following the prescribed format provided thereby demonstrating *compliant autonomy*.

Billy investigated a tree kangaroo, Lara and Joy investigated a bandicoot. Students manifested a diverse range of LAD in Mrs Jasmine's lessons ranging across *compliant autonomy*, *reactive autonomy* and *overdrive autonomy*. Milly, Ella and Lara created a horizontal Christmas tree that deviated from Mrs Jasmine's instructions of creating a tall structure with a big base thereby demonstrating *reactive autonomy*. Billy's group were compliant when they built a tree house in the *Christmas tree and tree house vignette*.

The data shows that Billy's group were compliant in both Mrs Jasmine's and Mr Smith's lessons represented in the vignettes. However, the data shows that whereas Ella and Lara were compliant in Mr Smith's classes, they were reactive in Mrs Jasmine's lessons. Moreover, Ella manifested *overdrive autonomy* in Mrs Jasmine's lessons. The findings show that when teachers provide prescribed instructions, they expect compliance as students comply or emulate their instructions unlike when teachers provide flexible and open instructions that provides students with a wide array of choices to make, thereby demonstrating a diverse range of LAD (Little, 1991; Reeve & Cheon, 2021; Willison, 2020).

- ***Time management***

Mr Smith habitually used time reminders to manage time spent on learning tasks across the three vignettes he facilitated. As discussed in Chapter 5, time signals inform students of the amount of time remaining before they transit into another activity. This may put time pressure on students and the effect may lead to sustained attention or frustration associated with anxiety, and slapdash behaviour in completing learning tasks. Mr Smith's use of time signals to inform students when to stop an activity was akin to telling students when the inquiry should stop, and was contrary to Mr Smith's interview comments in which he indicated that it is students who determined when the inquiry stops (see discussion in Chapter 5 time management). Mrs Jasmine did not regularly use time signals during her teaching. Across the three vignettes, she used time signals once, in the *my straw musical instrument performance vignette* when she

informed students that they had 15 minutes before they could play their tunes to the class.

Students responded to the prescribed time signals to complete learning activities by complying with Mr Smith's and Mrs Jasmine's time signals thereby demonstrating *compliant autonomy*. Mr Smith's frequent use of time signals showed that students completed much of their work when compared with Mrs Jasmine's minimal use of time signals and the observation that students did not regularly complete their lesson tasks in the lessons observed. Time reminders ensured students remained engaged so they could complete their learning tasks on time.

- ***Using worksheets to scaffold learning***

Whereas Mr Smith used worksheets to provide structure and guidance in his lesson as detailed in Chapter 5, Mrs Jasmine did not use worksheets in her teaching. Mr Smith's use of worksheets synchronised with his structured teaching style whereas Mrs Jasmine's intentional lack of worksheets synchronises with her open and flexible teaching style and literacy-free science lessons. The use of worksheets demonstrated that the use of increased structure facilitates completion of learning tasks, unlike when teachers use minimal structure and students do not necessarily complete their learning tasks efficiently. In this case, students did not sufficiently realise the learning goal in the *my straw musical instrument performance* vignette facilitated by Mrs Jasmine.

### ***6.4.3 Cognitive Autonomy Support***

The case study teachers provided opportunities for cognitive autonomy in diverse ways. The practices for cognitive autonomy support included offering informative feedback, using relevant examples, providing opportunities for thinking and planning, offering hints to extend students' exploration, encouraging students to try different ideas, questioning to scaffold students' thinking, providing rationale, responsiveness, restricting students' discussion, limiting students' ownership of ideas, allowing and responding to student questions, task

clarification, task modification to extend students' learning, supporting peer scaffolding to promote learning, and encouraging self-evaluation and self-correction. This cross-case analysis compares and contrasts Mrs Jasmine and Mr Smith's cognitive autonomy supportive practices and students' responses to the teacher autonomy supportive practices.

- *Offering informative feedback*

Both case study teachers utilised informative feedback to support students' learning. Whereas Mrs Jasmine adopted open-ended feedback, Mr Smith adopted prescribed and structured feedback. For instance, when Mrs Jasmine assessed Maeve's group about their musical instrument in the *my straw musical instrument* vignette she recommended that the group rethink their plan because they have to create a tune with the instrument. Following this open-ended feedback, Lara sought help from Billy and created a straw that produced sound thereby demonstrating *reactive autonomy*.

Mr Smith offered informative but prescriptive feedback when he assessed Theo's work by directing Theo to use part of the question to start off his response to the question 'what is an ecosystem' in the *what is an ecosystem* vignette. Theo reacted by completing his response in keeping with Mr Smith's directive, thus demonstrating *compliant autonomy*. Both teachers' feedback was consistent with their interview statements when they reported that they do not give students answers but support them to realise lesson goals.

Whereas Maeve's group received open-ended feedback that gave them the freedom to determine the next steps in their learning, Theo received prescribed feedback that directed the next steps in completing the learning tasks. The nature of the informative feedback provided influenced how students responded. Based on Mrs Jasmine's open-ended feedback, Lara demonstrated *reactive autonomy* by independently determining the next steps. Theo complied with Mr Smith's instructions thereby demonstrating *compliant autonomy*. As much as teacher informative feedback provided structure that guided students' actions towards successful

completion of learning tasks (Gan et al., 2021; Harlen, 2013), the nature of the informative feedback, in this case teacher instructions, appeared to have an influence (Little, 1991).

- ***Providing opportunities for thinking and planning***

Mrs Jasmine provided opportunities for deliberate planning and thinking time for students in the *my straw musical instrument* vignette when she allowed students some time off to plan their musical instruments. Maeve demonstrated *proactive autonomy* when she used a mini whiteboard to plan her straw instrument and sketched a diagrammatic representation of the group's instrument. Mr Smith was not observed providing students with deliberate opportunities to think and plan their learning outputs. However, during the *who am I* vignette, Mr Smith worked with students to develop a mind map that illuminated the key concepts for students to investigate. Students reacted by following the mind map in developing their presentations thereby demonstrating *compliant autonomy*.

When students are provided with open planning time, students demonstrate *proactive autonomy* as they decide their own way of planning for the learning activities. However, when teachers provide structured planning, such as the use of a mind map, students comply with the plan, thus limiting creativity as they demonstrate *compliant autonomy* (Reeve & Cheon, 2021).

- ***Offering hints to extend students' exploration***

Both case study teachers utilised hints to support students' exploration of ideas. The nature of teacher hints may influence the nature of LAD. When both Mrs Jasmine and Mr Smith utilised open and flexible hints, students demonstrated *reactive autonomy*, unlike when teachers utilised prescribed hints when students demonstrated *compliant autonomy*. For instance, Billy demonstrated *reactive autonomy* when Mrs Jasmine suggested that Billy should try different straw sizes in the *my straw musical instrument* vignette by creating a multi-straw instrument, Billy also demonstrated *reactive autonomy* after drawing and labelling a tree kangaroo when Mr Smith suggested that those who had finished their work to extend their work in the *mutualism* vignette. However, Billy demonstrated *compliant autonomy* when Mrs Jasmine requested Billy try to move the straw up and down in the *my straw musical instrument* vignette. The data shows that Billy demonstrated *reactive autonomy* to open and flexible hints and *compliant autonomy* to prescribed hints. When students interpret teacher hints and suggestions as directives, they comply (Reeve, 2009; Reeve & Cheon, 2021).

- ***Questioning to scaffold students' thinking***

Teacher questioning may foster learner generation and ownership of ideas, thereby promoting cognitive autonomy (Rogat et al., 2014). Both case study teachers used questioning to elicit student thinking and ideas. The nature of teacher questioning shows that Mrs Jasmine adopted a less structured teaching style with open-ended questions whereas Mr Smith adopted a highly structured teaching style with predominantly closed-ended questions and few open-ended questions. Students demonstrated *compliant* and *reactive autonomy* when answering Mrs Jasmine's questions whereas they demonstrated *compliant autonomy* when answering Mr Smith's questions.

Mrs Jasmine utilised a series of open-ended questions to extend Milly's and Ella's thinking as they constructed the Christmas tree in the *Christmas tree and tree house* vignette.

Students demonstrated *compliant autonomy* when they responded to Mrs Jasmine's questions, but demonstrated *reactive autonomy* when they placed the baubles inside the lower cone of the Christmas tree. When Mr Smith asked Theo a series of largely closed-ended questions with a few open-ended questions in the *what is an ecosystem* vignette, Theo demonstrated *compliant autonomy* as he answered with a yes, a no or sometimes nodding to Mr Smith's questioning.

This data shows that the nature of questioning coupled with the nature of the learning task may influence LAD. Whereas students provided diverse answers in response to Mrs Jasmine's open-ended questioning, Theo provided one word answers to Mr Smith's closed-ended questioning. Open-ended questions foster cognitive skills as they encourage students to express and elaborate their thinking (Lee et al., 2012), hence they may influence the diversity of students' responses (Çakır & Cengiz, 2016).

- ***Providing rationale***

Both case study teachers linked lesson purpose to prior lessons to provide a rationale for the current lesson. Whereas Mr Smith referenced skills in another subject to provide rationale for a current lesson, Mrs Jasmine referenced skills and learning processes in a previous lesson to provide a rationale for the current lesson. For instance, in the *my straw musical instrument performance* vignette, Mrs Jasmine referred to the previous lesson, in this case the *my straw musical instrument* vignette, when she mentioned that students struggled in the previous lesson to create a straw that produced sound. Mr Smith provided a rationale when he requested students to use their word study skills learnt in a prior literacy lesson to complete the mutualism task. Mr Smith seemed to rely on the chain effect he referred to during interviews to expect student learning and foster transfer of skills across subjects. Ryan, Billy and Remi created recorders following the previous lesson's procedures and the procedures demonstrated in the current lesson, thus demonstrating *compliant autonomy* in Mrs Jasmine's class whereas Billy and Milly demonstrated *reactive autonomy* in Mr Smith's class by searching word

meanings and recording them in their books. It appeared Mr Smith provided a stronger rationale therefore generating *reactive autonomy* compared to Mrs Jasmine's rationale that elicited *compliant autonomy*.

- ***Responsiveness***

Both case study teachers exhibited numerous responsive practices in support of cognitive autonomy such as active listening, answering student questions, and drawing on student ideas when teaching. Mrs Jasmine exhibited active listening in the *Christmas tree and tree house* vignette, when she asked Milly and Ella what their Christmas trees at home normally have and they responded 'bauble and tinsels'. Mrs Jasmine commented 'fix them somewhere', showing that she was actively listening to student ideas. Ella responded by fixing the baubles on the lower cone thereby demonstrating *reactive autonomy*.

Similarly, Mr Smith demonstrated active listening by offering contingent replies to student questions. For instance, when Lara claimed that she did not understand how to use the QR codes, Mr Smith explained and demonstrated the process of using QR codes. This showed that students' concerns are important and can influence the learning process. In response to Mr Smith's responsiveness, Lara picked her iPad, selected the camera, and then scanned the QR code, thereby demonstrating *compliant autonomy* by following Mr Smith's actions on scanning the QR codes. Lara demonstrated *compliant autonomy* in response to Mrs Jasmine's and Mr Smith's responsiveness by taking actions in line with teacher questions or suggestions. This shows that student characteristics and the nature of teacher instructions may influence LAD.

- ***Restricting students' discussion***

Restricting students' discussion prevents students from expressing their ideas and may limit the thinking and application of their creative abilities. This restriction may negatively impact students' motivation. Both case study teachers restricted students' engagement in discussion. Mrs Jasmine restricted Maeve's discussion with her group members when they

were planning straw instruments in the *my straw musical instrument* vignette. Maeve stopped contributing when Mrs Jasmine interjected into their conversation thereby demonstrating *underdrive autonomy*. Mr Smith equally restricted Maeve from contributing to the discussion on the meaning of mutually beneficial in the *mutualism* vignette. While Maeve responded to Mr Smith's questions around "mutually beneficial", she demonstrated *compliant autonomy*; however, when Mr Smith provided negative feedback, Maeve demonstrated *underdrive autonomy* as she stopped contributing to the discussion. The data shows that Maeve stopped further discussion when both Mrs Jasmine and Mr Smith provided negative feedback. Teacher questioning risks eliciting compliance from students as they seek to answer teacher questions; however, when teachers provide negative feedback, students may disengage from further participation and demonstrate *underdrive autonomy* (Chipchase et al., 2017). Additionally, the data shows LAD is fluid as Maeve's autonomy shifted from *compliant to underdrive*.

- ***Allowing and responding to students' questions***

Whereas Mr Smith provided opportunities for students to ask questions across the three vignettes, Mrs Jasmine did not provide explicit opportunities for student questions. However, whenever students asked questions both teachers answered the questions. Even though both teachers indicated during interviews that they do not provide answers to students, teachers answered students' clarification questions therefore clarifying tasks and fostering smooth embarkation (Rannikmäe et al., 2020). For instance, Maeve asked whether they were going to work with partners in the *my straw instrument* vignette thereby demonstrating *compliant autonomy*. Mrs Jasmine clarified that students would work with partners, but they should complete the thinking and planning task first (see *opportunities to select and work with partners in organizational autonomy*) whereas Mr Smith clarified student roles by declaring that one student will be a scribe and the other a researcher (see *allowing and responding to student questions* in Chapter 5). As evidenced, students' questions provided information about

their thinking, thus influencing further teacher actions to facilitate learning (Chin & Osborne, 2008; Rannikmäe et al., 2020).

Despite teachers indicating they do not provide answers to students, it is necessary for teachers to offer responses to students' clarification questions. Clarification ensures students have adequate information for a smooth embarkation (Rannikmäe et al., 2020). However, both teachers at some point in their lessons provided conceptual answers contrary to their stated beliefs. For instance, Mrs Jasmine stated at the end of the *my straw musical instrument performance* that "length does matter to pitch" effectively providing the answer to the main variables under investigation. Similarly, when Mr Smith asked Billy a series of leading closed-ended questions, he provided answers to some of the questions. This finding shows that teacher beliefs as self-reported by teachers might contradict teacher practice, as teachers believed that they should not provide answers but in actual practice they provided answers (Capps et al., 2016; Romero-Ariza et al., 2019).

- ***Task clarification***

Both case study teachers regularly clarified task requirements before releasing students to undertake learning tasks. Mrs Jasmine clarified that students needed to plan their instrument before they began the instrument-making process in the *my straw musical instrument* vignette. Similarly, Mr Smith clarified that he needed students to not only answer the questions but also provide an explanation of a drawing in the *what is an ecosystem* vignette.

Teacher clarification guided students' ensuing actions as students followed teacher instructions to plan their instruments in the *my straw musical instrument* vignette for Mrs Jasmine, and investigated the questions and wrote answers as required in the *what is an ecosystem* vignette for Mr Smith thereby demonstrating *compliant autonomy* in both cases. The clarification of concepts is vital in fostering student learning by ensuring the learning intentions and next actions are clear (Rannikmäe et al., 2020). When learning intentions and expectations

are clear, students are able to regulate their actions better, hence leading to desired learning outcomes (Inayat & Ali, 2020). However, both case study teacher instructions were prescribed, therefore requiring compliance from students, hence, demonstrating low cognitive autonomy (Furtak & Kunter, 2012; Reeve & Cheon, 2021).

- ***Encouraging self-evaluation and self-correction***

Both case study teachers fostered self-evaluation and self-correction. Whereas Mr Smith explicitly encouraged students' self-evaluation and self-correction, Mrs Jasmine sometimes implicitly encouraged students to self-evaluate and self-correct. For instance, in the *my straw musical instrument performance* vignette, Mrs Jasmine suggested to Maeve and her group to think how they are going to create an instrument to create a tune when they presented their instrument for assessment, essentially implicitly asking the students to self-evaluate and self-correct. Lara reacted by approaching Billy to support her in the creation of a functional straw instrument thereby demonstrating *compliant autonomy*.

For his part, Mr Smith explicitly asked students to self-evaluate and self-correct while students were finalising their research on the animal of choice in the *who am I* vignette. In relation to Mr Smith's initiation for self-evaluation and self-correction, students demonstrated *underdrive autonomy* by doing nothing in relation to Mr Smith's request. Students may disengage from activities they do not perceive as important (Chipchase et al., 2017). It appeared students did not have sufficient self-evaluation skills to self-evaluate at higher levels of autonomy.

#### **6.4.4 Discussion on LAS and LAD**

The current study utilised two frameworks to analyse LAS and LAD. The LAS framework proposed by Stefanou et al. (2004) was used to classify the teacher autonomy supportive practices utilised by the two case study teachers: organizational autonomy, procedural autonomy and cognitive autonomy. Student reactions to teacher autonomy support

practices were analysed based on the LAD framework modified and extended by the researcher: *underdrive autonomy*, *compliant autonomy*, *reactive autonomy*, *proactive autonomy* and *overdrive autonomy*.

Findings revealed that both case study teachers provided teacher autonomy support in the three different categories as described by Stefanou et al. (2004). However, students demonstrated diverse levels of autonomy within each category. While students remained comparatively *compliant* with organizational autonomy in Mr Smith's lessons, they demonstrated diverse levels of LAD in Mrs Jasmine's classes ranging from *compliant autonomy* to *reactive autonomy* to *proactive autonomy*. Mr Smith adopted a highly structured teaching style, and LAD across the three categories ranged between *underdrive autonomy*, *compliant autonomy* and *reactive autonomy*, whereas in Mrs Jasmines' lessons, adopting a more open (less structured) teaching style, LAD varied between *underdrive autonomy* and *overdrive autonomy*.

*Compliant autonomy* in organizational autonomy can be explained by the fact that students had minimal choice in accessing predetermined resources, as they had to comply with teacher instructions (Furtak & Kunter, 2012; Großmann & Wilde, 2020). Some students, however, determined when to be assessed while others waited for the teacher to determine when to assess them. This implies that student characteristics may influence the nature of LAD (Little, 1991; Willison et al., 2017). Therefore, teachers should not only give students choice, but should also offer other opportunities, such as the opportunity to understand the importance of choice to learning goals (Assor et al., 2002), and to learn to make and pursue choices (Bozack et al., 2008; Großmann & Wilde, 2020; Stefanou et al., 2004).

There was more diverse LAD in procedural and cognitive autonomy support than in organizational autonomy support. This greater variation can be explained by both teacher and student factors. Firstly, there was strong teacher support to engage students in learning,

especially in an IBL environment which supports learner active participation in the learning process and co-construction of knowledge (Furtak & Kunter, 2012; Rannikmäe et al., 2020; Rogat et al., 2014). This implies that supporting learners to participate in learning activities (procedural support) and develop their understanding (cognitive autonomy support) may be receiving more attention than supporting learners to organize learning activities (organizational autonomy support). Observation data revealed that teachers supported learners more in the learning procedures (such as accessing resources and determining nature of learning output), and in the acquisition of knowledge (completing learning tasks, and answering questions) than in organizing the classroom. Hence, this led to diverse reactions to teacher support ranging from *underdrive* to *overdrive autonomy*.

The findings in this study have shown that a teacher can be highly autonomy supportive, but still manifest some autonomy controlling behaviours. Whereas Mrs Jasmine tends towards highly autonomy supportive, she manifested some autonomy controlling behaviour. Mr Smith tends to the autonomy controlling side, but still manifested some autonomy supportive behaviour. This finding is consistent with other research studies that reported teachers as manifesting both autonomy supportive and autonomy inhibitive behaviours (Furtak & Kunter, 2012; Großmann & Wilde, 2020; Rogat et al., 2014; Stefanou et al., 2004).

Findings show that students had different reactions in the three types of teacher autonomy support and the evidence reveals that LAD is fluid in nature and is not linear. A learner may present a *proactive action* in one instance, and, within the same lesson, they can demonstrate *compliant autonomy* or *underdrive autonomy*, and before the end of the lesson demonstrate *overdrive autonomy*. Three examples of students' experiences illuminate this fluidity.

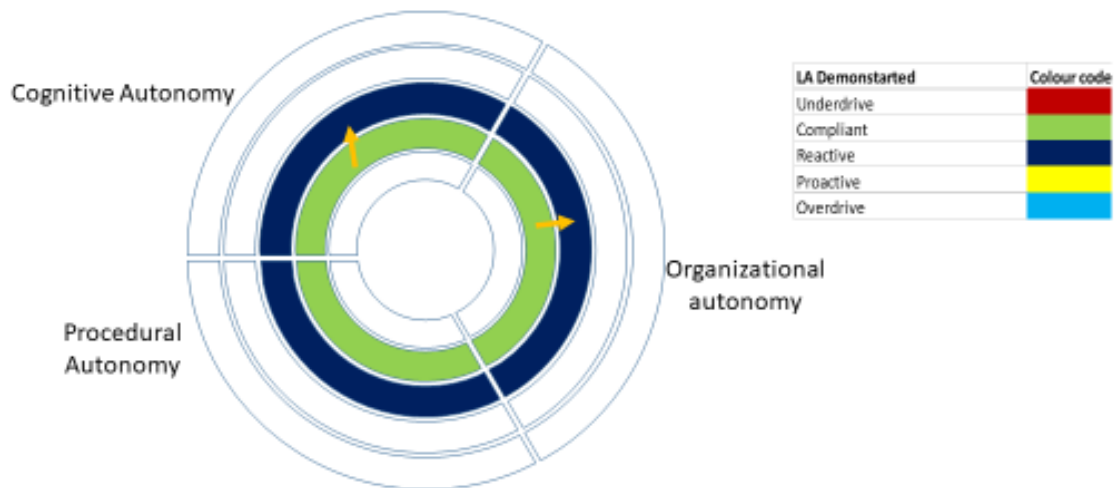


Figure 6.3. Billy's LAD in my straw musical instrument vignette

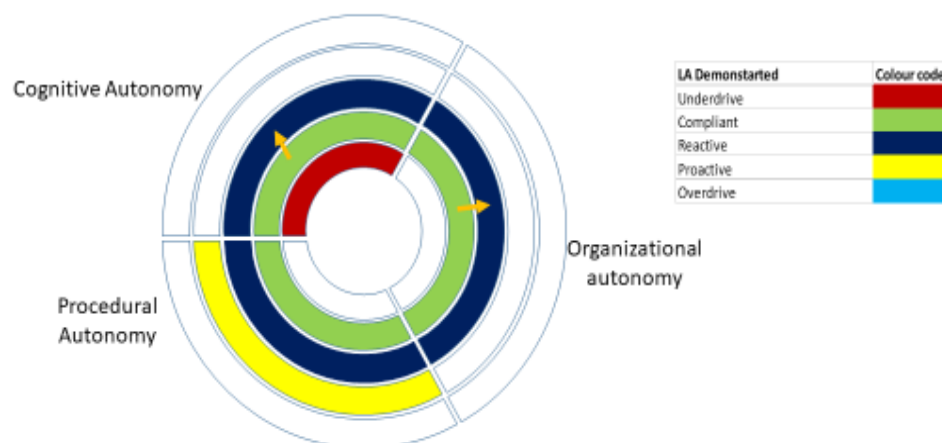


Figure 6.4. Lara's LAD in my straw musical instrument vignette

Figure 6.3 and Figure 6.4 shows Billy's and Lara's cognitive, procedural and organisational autonomy demonstrated in *my straw musical instrument* vignette when undertaking different learning tasks. The arrows show that Billy's and Lara's LAD in organizational and cognitive autonomy shifted from *compliant* to *reactive* autonomy.

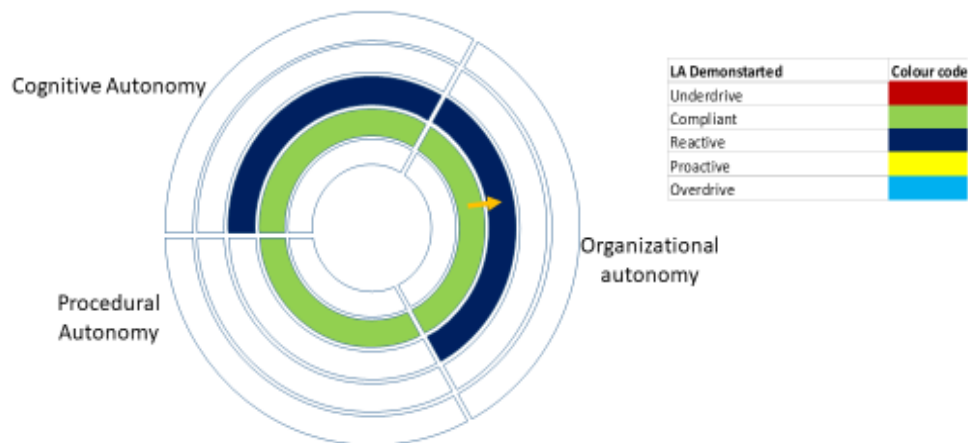


Figure 6.5. Billy's LAD in what is an ecosystem vignette

Figure 6.5 shows Billy's LAD was only fluid in organizational autonomy as the arrow shows a shift from *compliant* to *reactive autonomy*. Therefore, the nature of the activity, the teacher request and the student characteristics may influence the nature of LAD. This finding concurs with Benson (2013c) and Willison's (2020) claim that LAD is fluid and non-linear in nature.

The study also revealed that Mr Smith's provision of LA diminished progressively from the first vignette to the third vignette. During the first vignette (*what is an ecosystem*), the nature of learning was less structured as students researched teacher-provided open-ended questions. In the second vignette (*who am I*), Mr Smith utilised a mind-map and teacher model example which provided increased structure. During the third vignette (*mutualism*), Mr Smith utilised a worksheet with questions, QR codes and later a website, hence significantly increasing the level of structure and guidance. Therefore, Mr Smith progressively reduced the extent of learner autonomy supported across these lessons. The progressive increase in structure may imply that Mr Smith realised his students were struggling with greater autonomy, hence students required additional support to thrive in learning tasks. This finding on teachers increasing the level of structure in subsequent lessons is similar to findings in a study conducted by Willison et al. (2017) that revealed that teachers reduced autonomy in subsequent lessons.

The discrepancies noted above, such as the difference between interview statements and classroom practice about answering questions, have implications for the complex nature of teaching and for research methodology. Teachers may have decided to provide answers, despite their beliefs, to minimise students' struggles and to realise the lesson purpose. Additionally, there may be a need to use multiple data collection approaches, such as interviews and classroom observation, to determine what teachers think and do (Capps et al., 2016). Moreover, to investigate complex constructs such as LA, researchers may need to gather data from multiple perspectives (Patton, 1999).

## **6.5 Nature of Inquiry-Based Learning**

Mrs Jasmine facilitated hands-on learning whereas Mr Smith facilitated internet-based inquiry. Mrs Jasmine's hands-on learning varied from one lesson to the next. Whereas she facilitated hands-on inquiry learning in the *my straw musical instrument* and *my straw musical instrument performance* vignettes, she facilitated hands-on learning without inquiry in the *Christmas tree and tree house* vignette. Mr Smith facilitated internet-based research in all the three vignettes. However, in the *what is an ecosystem* and *mutualism* vignettes students engaged in answering questions whereas they engaged in a guessing game in the *who am I* vignette.

### **6.5.1 Embark and Clarify**

Both case study teachers provided questions/problems to be investigated across the six vignettes. Whereas students investigated scientifically oriented problems in Mrs Jasmine's two vignettes (*my straw musical instrument* and *my straw musical instrument performance* vignettes), students investigated fact/knowledge-based questions across the three vignettes facilitated by Mr Smith. However, students did not explore any scientific concepts in Mrs Jasmine's *Christmas tree and tree house* vignette.

Provision of questions or problems to be investigated by Year 4 students as discussed in Chapter 4 for Mrs Jasmine and Chapter 5 for Mr Smith shows that both case study teachers may have believed that the Year 4 students were not ready to generate scientifically oriented questions/problems for investigation (Ruggeri et al., 2021; Swaboda et al., 2022). However, Van Uum et al. (2016) showed that students in primary school can generate investigable questions with guidance. The nature of questions/problems provided by the case study teachers differed in structure and scope. Whereas Mr Smith provided highly structured questions, Mrs Jasmine provided generally open-ended problems that offered greater opportunities for student responsibility (Rannikmäe et al., 2020). While Mrs Jasmine's provision of questions for investigation was inconsistent with her interview findings, Mr Smith's provision of questions for investigation was consistent with his interview findings in which he stated that students investigated teacher-provided questions. This finding shows that the relationship between teachers' self-reports and actual classroom practice is complex, as teachers sometimes do what they say and sometimes they do not (Romero-Ariza et al., 2019).

Case study teachers facilitated embarkation using similar strategies. Firstly, both teachers had students recount their prior knowledge, whereas Mrs Jasmine utilised open-ended questioning to access students' prior knowledge, Mr Smith used both closed and open-ended questions, with a strong inclination to closed-ended questions to review previous lessons. Secondly, both teachers fostered students' conceptual understanding of phenomena under investigation by combining explicit instruction, YouTube videos and examples. Mr Smith further utilised teacher modelling and mind maps to facilitate understanding, whereas Mrs Jasmine provided students with thinking and planning time to plan for embarkation. The additional strategies adopted by Mr Smith increased the structure and level of guidance students received due to their prescribed nature, whereas Mrs Jasmine utilised an open-ended suggestion for student engagement in thinking and planning for embarkation, thereby offering students

more opportunities to think and participate in the knowledge construction process (Rannikmäe et al., 2020). Combining different teaching approaches such as IBL and explicit instruction is well discussed in literature due to the variability in effectiveness, the clashing teaching philosophies and the possibility of complementarity (Darling-Hammond et al., 2020; de Jong et al., 2023; Denoël et al., 2017).

Both case study teachers facilitated structured inquiry in all three vignettes for embark and clarify. Whereas Mrs Jasmine maintained the same structure in her teaching across the three vignettes, Mr Smith increased the level of structure from the first vignette to the third vignette. The increasing level of structure in Mr Smith's teaching may imply that Mr Smith realised his students were struggling with embarkation, hence he opted for the provision of increased guidance and clarification through the mind map, teacher model example and worksheet. This finding concurs with findings by Willison et al. (2017) who reported that teachers increased the level of structure and guidance in subsequent lessons to support students to excel in learning tasks.

Case study teachers utilised diverse strategies to tap into students' emotions. Mrs Jasmine and Mr Smith used lesson triggers to tap into students' curiosity and interest across the six vignettes, a practice that is well documented in literature and linked with constructivism theories (Rannikmäe et al., 2020). Mrs Jasmine's open, flexible, warm and approachable teaching style created a safe and supportive learning environment that may have elicited excitement and happiness among her students. Mr Smith's prescribed teaching style elicited minimal student emotions; however, he was approachable and re-assuring. Despite Mrs Jasmine creating an environment that fostered enjoyment of science, the nature of learning exposed students to the fluid nature of emotions. For instance, Ryan was excited to be using straws in the *my straw musical instrument performance* vignette; however, he experienced frustration when he was unable to create a straw that produced sound. Following the assistance

of a peer, he successfully created a straw that produced sound, and was excited as he played his instruments around the class. This data shows that students' emotions are fluid in nature and can shift depending on students' progress and the nature of support they receive (Kourti, 2019). Students can experience pleasant emotions at the beginning of tasks, go through a struggle when in the learning pit, and then, through support, realise success and excitement. However, emotions were rarely elicited explicitly or evident in Mr Smith's lessons, even though in the interview he identified the learning pit that students may go through, emotionally, when learning.

### **6.5.2 Find and Generate**

Both case study teachers used both open-ended and closed-ended questions to foster data generation. Mrs Jasmine had a strong inclination for open-ended questions with minimal closed-ended questions, while Mr Smith had a strong inclination for closed-ended questions. Mr Smith used additional strategies to foster data generation such as mind-map and QR codes. These strategies increased the level of teacher guidance and structure, therefore limiting students' opportunities for choice. The impact of these strategies on learning has been discussed in Chapter 5 for Mr Smith. Mrs Jasmine did not use these strategies to facilitate student data generation as she facilitated hands-on learning. The effect of less structure in Mrs Jasmine's facilitation of data generation is depicted in the reduced work completed by students as well as some students not reporting their findings in the *my straw musical instrument* and *my straw musical instrument performance* vignette.

Untimely fading of teacher support influenced student data generation. Mrs Jasmine's untimely fading support while facilitating data generation in the *my straw musical instrument* performance vignette led to Remi and Billy not reporting their findings (van de Pol et al., 2019). However, Mr Smith was persistent in his support to ensure students gathered requisite data. For instance, he utilised extended questioning to facilitate Theo gathering requisite data in the

*mutualism* vignette.

Both case study teachers' teaching styles facilitated learning in a way that allowed students to experience both happiness and uncertainty in find and generate facet. Lara, Mia and Ryan underwent moments of frustration as they were unable to create a functional straw instrument in the *my straw musical instrument* and *my straw musical instrument performance* vignettes facilitated by Mrs Jasmine. However, peer and teacher-explicit support scaffolded students' successful creation of a functional straw instrument, leading to feelings of excitement and happiness. The data in Mrs Jasmine's lessons shows that when peers and teachers work together, they can bolster success which in turn fosters happiness and student engagement (Kourti, 2019).

Similarly, Remi, Billy and Maeve manifested frustration and anxiety when the QR codes failed to work and they experienced difficulty with comprehending online information in the *mutualism* vignette facilitated by Mr. Smith. However, with varied levels of teacher support, in this case Billy received explicit instruction coupled with videos, he developed an understanding of the meaning of "mutually beneficial", and his emotions shifted from frustration to contentment. In contrast, Maeve and Remi, who were questioned and left to figure the answer for themselves, were still uncertain as to what "mutually beneficial" meant at the end of the lesson. Feelings of uncertainty may degenerate and lead to student disengagement (Kourti, 2019). Hence, teachers should facilitate learning through the learning pit to ensure that even if students struggle, they have adequate support to succeed in learning (Nottingham, 2017).

### **6.5.3 Evaluate and Reflect**

The evaluation and reflection facet was less prominent in both case study teachers' teaching styles. Case study teachers adopted diverse strategies that facilitated evaluation and reflection.

Teacher questioning facilitated student data generation. Both case study teachers used teacher questioning to facilitate data generation. Naturally, data generation led to data evaluation. Lara's and Remi's data evaluation has been discussed in Chapter 4 for Mrs Jasmine, showing how Lara adopted repeatability of measures.

Teachers provided explicit opportunities for self-evaluation and self-correction to extend student learning. Whereas Mrs Jasmine did not provide explicit opportunities for self-evaluation and self-correction, Mr Smith provided explicit opportunities for self-evaluation and self-correction to extend student learning. Data revealed that students did not take up the self-evaluation and self-correction opportunities. This may have resulted from the way Mr Smith presented the opportunities. He combined instructions for self-evaluation and self-correction with instructions for taking the laptops to the charging area, and it is possible that students did not have skills for self-evaluation and self-correction for that component of learning. Provision of opportunities for self-evaluation and self-correction without teaching students how to self-evaluate may not lead to the intended learning outcomes (Forbes et al., 2004; Ramdass & Zimmerman, 2008).

Students treated teachers as trusted sources of information therefore influencing the data evaluation. Students treating teachers as trusted sources of information may have influenced the evaluation of data sources. When Mr Smith provided students with QR codes and web pages to access relevant information, students did not evaluate the websites. Similarly, when Mrs Jasmine provided students with a website to search how to make straw instruments during the *my straw musical instrument* vignette, students did not evaluate the website. Students may have treated their teachers as credible sources of information. Even though students should trust their teachers, the ability to question the credibility of information sources is essential in science learning (Blikstad-Balas, 2016; Guinee, 2004). It appeared that the Year 4 students may have lacked website evaluation skills or students may have believed that all

internet information is reliable (Guinee, 2004).

Both case study teachers did not provide reflection opportunities across the six vignettes. Reflection opportunities may facilitate better conceptual understanding of the phenomena under investigation as students evaluate the learning process (Van Uum et al., 2016). Inability to reflect in the *my straw musical instrument* vignette was demonstrated in the *my straw musical instrument performance* vignette as Ryan and Mia encountered similar difficulties and needed peer and teacher support to create a straw that produced sound. Similarly, in Mr Smith's lessons, students did not evaluate websites but selected the first link that popped up when they hit the search key (Guinee, 2004; Keil & Kominsky, 2013). Students across the six vignettes would have benefited from reflection activities, including coming up with a report on their findings, documenting the straw creation process and the internet search process, drawing sketches of instruments and stating what they could have done better (Van Uum et al., 2016). This finding, that students did not engage in reflection, contradicts other findings that have shown that teachers engage students in reflection activities at the end of a learning exercise (Van Uum et al., 2016).

Teacher facilitation of the evaluate and reflection facet led to a manifestation of diverse emotions. In both case study teachers' lessons, students experienced both pleasant and unpleasant emotions depending on the learning progress. Both teachers facilitated students' shift in emotion from anxiety to calmness or happiness. The data shows that explicit support led to a shift from unpleasant emotions to pleasant emotions, unlike when students are left to figure things out for themselves. For instance, Ryan experienced frustration when he struggled to create a straw that produced sound; however, Mrs Jasmine's explicit scaffolding led to Ryan creating a straw that produced sound, shifting Ryan's emotions from frustration to jubilation as he played his straw while moving around the class. Similarly, Remi and Billy manifested anxiety and frustration when they could not understand the meaning of "mutually beneficial"

in the *mutualism* vignette (see find and generate how Mr Smith facilitated a shift in students' emotions). As explored in Chapter 5, it appeared Billy learnt better with explicit instruction when compared with Remi who was questioned then left to find the answer for herself (Darling-Hammond et al., 2020).

#### **6.5.4 Organise and Manage**

Both case study teachers used questioning to instigate data generation and subsequent data organization to reveal patterns. Mrs Jasmine used both open-ended and closed-ended questions to facilitate data generation, thus influencing how students organized data to reveal patterns (see *organize and manage* in Chapter 4 for Lara and Remi). Whereas Mrs Jasmine utilised oral questions to facilitate organization of data to reveal patterns, Mr Smith provided written questions in the *what is an ecosystem* and *mutualism* vignettes. Students gathered and recorded data in the order the questions were presented (see *organize and manage* in Chapter 5). The questions used for the internet-based research acted as the organizing framework for students to organize the information gathered. Moreover, the questions created a structured learning environment that may have promoted student engagement and thriving, as students were aware of the task requirements and learning direction (Inayat & Ali, 2020).

Mr Smith used a mind map and teacher modelling to facilitate data organization. As detailed in Chapter 5, Mr Smith's use of a mind map and teacher modelling provided increased structure for students to emulate while organizing and presenting data in the *who am I* vignette (Hopkins et al., 2015; Van Uum et al., 2016; Willison, 2020). Emulation can be useful in the short term as students can achieve the learning intention, but then students may fail to apply the critical thinking skills involved when students synthesise information to generate themes and patterns to answer research questions (Inayat & Ali, 2020; Willison, 2020). Mrs Jasmine did not utilise mind maps and teacher modelling in her teaching. The less structured nature of Mrs Jasmine's lessons may have contributed to the minimal data gathered in the *my straw*

*musical instrument* and *my straw musical instrument performance* vignettes.

Emotional engagement was manifested in diverse ways as students organized and managed the learning resources. Lara worked harmoniously to combine the different data sets to report her findings in the *my straw musical instrument* vignette (Willison, 2020). However, she experienced frustration when trying to fix the disfigured Christmas tree in the *Christmas tree and tree house* vignette, because she could not figure how to fix the tree. Feelings of frustration can lead to disengagement, and hence poor learning outcomes (Kourti, 2019).

### **6.5.5 Analyse and Synthesis**

Both case study teachers adopted diverse teaching styles that influenced how students engaged in analysis and synthesis. Teacher questioning, evaluation and subsequent suggestions instigated student data analysis and synthesis. Mrs Jasmine's questions, evaluation and subsequent suggestions of students' straw instruments often instigated students' analysis and synthesis. The data analysis episodes for Lara and Remi are discussed in Chapter 4 for Mrs Jasmine.

Untimely fading impacted data collection subsequently impacting data analysis. While Mrs Jasmine facilitated students' creation of straw instruments in the *my straw instrument performance* vignette, she did not question students in ways that fostered students' presentation of data as she did in the *my straw musical instrument* vignette. As detailed in Chapter 4 (analysis and synthesise), due to untimely fading, students did not report their findings. Without adequate structure, students may not generate requisite data as they may continue playing with the straw instruments without making visible their analysis and synthesis capabilities (van de Pol et al., 2019; Van Uum et al., 2016). However, Mr Smith's teaching style provided students with structure that ensured they recorded data either in the form of questions or worksheets, rather than merely engaging in exploration of the hands-on activities (Fernandez et al., 2023). It appears Mrs Jasmine was focused on students creating instruments and tunes for

presentation, rather than exploring the effect of length on pitch as this was explored in what is the *my straw musical instrument* vignette (lesson).

Provision of opportunities for analysis and syntheses fostered analysis and synthesis. Both case study teachers presented learning opportunities that required students to analyse and synthesise. For instance, the tune presentation the *in my straw musical instrument performance* vignette facilitated by Mrs Jasmine provided opportunities for students to analyse the musicality of the tunes and determine the song. Similarly, students' participation in identifying the animal in the guessing game in the *who am I* vignette presented opportunities for students to analyse and synthesise the presented facts to correctly identify the animal. The outcome of the two exercises showed that sometimes students got the answer correct but most of the time the answer was incorrect. The data revealed that students did not synthesise all the information presented to identify the animal in the guessing game. Additionally, this data revealed that the students may not be possessing adequate analysis and synthesis strategies (Glancy et al., 2017).

Analysis and synthesis is complex and, as such, students may experience diverse emotions as they analyse the data and their learning. Mrs Jasmine's facilitation of hands-on learning activities around straws was highly engaging and interesting to students. As evidenced, students engaged in data analysis with minimal anxiety. As detailed in Chapter 4, students manifested diverse emotions ranging from uncertainty, willingness, determinedness, and thoroughness as they engaged in data analysis and synthesis (Kourti, 2019; Willison, 2020). However, students struggled with synthesising information from the website in the *what is an ecosystem* and *mutualism* vignettes facilitated by Mr Smith. They manifested feelings of frustration and anxiety as they attempted to comprehend internet information. Teacher support facilitated comprehension of information, essentially influencing how students organized information.

### 6.5.6 *Communicate and Apply*

Communication and application were influenced by a series of factors. The factors include teacher questioning, the provision of a safe and supportive learning environment, and the provision of opportunities for presentation of the learning outputs.

Teacher questioning instigated student communication and application of knowledge. Both case study teachers utilised questioning to facilitate student communication across the six vignettes. Mrs Jasmine utilised open and closed ended questions to instigate student communication, whereas Mr Smith used open-ended and closed-ended questions and had a strong inclination towards closed-ended questions. Teacher questioning to instigate communication is discussed in detail in Chapter 4 for Mrs Jasmine and Chapter 5 for Mr Smith. Whereas Mrs Jasmine's questions were scientifically oriented and required Lara to analyse data before reporting, Mr Smith's questions were recall-type open- and closed-ended questions that required Theo to provide yes/no or one-word answers.

Opportunities to present their learning outputs, either their tunes or facts about animals of choice, exposed students to potential criticism. Mr Smith offered criticism and feedback when he realised that students were providing answers not related to facts being presented. The feedback provided offered students the opportunity to think and reflect before they communicated their ideas about the animal being presented (Van Uum et al., 2016). It is vital that students communicate their ideas in a clear and understandable style (Van Uum et al., 2016). However, as students presented their tunes in the *my straw musical instrument* vignette, they did not communicate whether the variables under exploration, that is length and pitch, were related. It appears Mrs Jasmine was focused on the hands-on and performance components of the lesson, and not the inquiry part. The students missed potential learning opportunities across the six vignettes to acquire scientific content and inquiry skills. An inquiry framework such as the 5E or MELT would provide a guiding framework for teachers to follow to ensure such opportunities are not missed (Van Uum et al., 2016; Willison, 2020). Moreover,

the data show that formal presentation opportunities, coupled with teacher feedback, may scaffold students' abilities to communicate as well as offering opportunities for teacher feedback (Gan et al., 2021; Van Uum et al., 2016).

Communication and application, just like other facets, generated mixed emotions for both case study teachers. Lara was a joyous and constructive student, who communicated her findings effectively when questioned by Mrs Jasmine in the *my straw musical instrument* vignette. She communicated her needs throughout the lesson, for instance, when she needed support to create a straw that produced sound, she approached Billy and asked "how did you make it?" She demonstrated good judgement by seeking support from an experienced peer (Kutnick & Blatchford, 2014). Remi experienced worry and uncertainty when preparing to present her tune in the *my straw instrument performance* vignette as she kept saying "mine can't work" as she presented her tune. Remi's self-efficacy was low as she was not sure about her tune, hence she experienced anxiety (Kourti, 2019). Similarly, Remi was unsure of what to make of the definition of "mutually beneficial" when she presented her iPad for Mr Smith to read; Mr Smith's guidance, however, did little to alleviate Remi's worry and uncertainty in the *mutualism* vignette. The majority of the students appeared to be confident while presenting their animals of choice in the *who am I* vignette. Reading facts about their animal of choice from their books might have given them the confidence to present the information without concerns.

## **6.6 Discussion on the Nature of IBL**

### ***6.6.1 Inquiry-Based Learning and Explicit Instruction (Complementary Teaching Approaches)***

In describing the nature of Inquiry-Based Learning (IBL) using the Models of Engaged Learning and Teaching (MELT) framework, the evidence revealed that both case teachers used IBL and explicit instruction in the same lesson, although to varying levels in science instruction. IBL is based on constructivism theories, especially social constructivism learning theories, in which teachers use social interaction and dialogue to lead, scaffold and guide students to construct their own knowledge and understanding of specific phenomena (Driver, 1995; Hodson & Hodson, 1998; Rannikmäe et al., 2020). The revelation that teachers use IBL side-by-side with explicit instruction contributes to the debate on science teachers' instructional practices by showing that IBL and explicit instruction are not competing instructional approaches, but are complementary teaching approaches that, when combined, strategically lead to facilitation of high quality science learning (de Jong et al., 2023; Denoël et al., 2017). This is contrary to previous debates that portray IBL and explicit instruction as competing teaching approaches (Hmelo-Silver et al., 2007; Kirschner et al., 2006).

The research and debate on the strategic use of IBL and explicit instruction in science teaching has been gaining momentum in recent years (Darling-Hammond et al., 2020; de Jong, 2019; de Jong et al., 2023; Denoël et al., 2017; Zohar, 2023). The researchers have argued for the possibility of effective science teaching when these two teaching approaches are strategically combined when teaching science. de Jong (2019), while investigating the optimal combinations of instructional approaches for student learning in STEM, recommended “balanced and smart combinations of direct instruction with more engaged forms of learning such as inquiry” (p. 162). As a result, three models depicting an IBL and explicit instruction combination are discussed. Firstly, Denoël et al. (2017) recommended that teachers should adopt more explicit instruction with some IBL. Secondly, Martin and Evans (2019) described

the implementation of explicit instruction followed by IBL to give learners prior knowledge and skills which students can use for inquiry learning. Lastly, researchers described teachers providing explicit instruction ‘just in time’ to offer explanations before, during and after inquiry (Hulshof & De Jong, 2006; Lazonder et al., 2010; Rieber et al., 2004).

The desirable balance between IBL and explicit instruction where students experience positive learning gains has been described as the ‘instructional sweet spot’ by Denoël et al. (2017). It has also been revealed that instructional equilibrium has a positive relationship with student outcomes and science dispositions (Denoël et al., 2017). However, based on the three models described above, the desirable IBL and explicit instruction combinations for effective science learning have not been determined (de Jong et al., 2023; Denoël et al., 2017).

Both case study teachers implemented IBL, although the nature of IBL adopted varied from one vignette to another. Whereas Mrs Jasmine adopted hands-on guided inquiry learning with elements of structured and open inquiry in some facets, Mr Smith facilitated internet-based structured inquiry. Along with IBL, both case study teachers adopted explicit instruction. The combination of instructional approaches in science teaching may have been influenced by recent research findings reporting that too much inquiry has a curvilinear relationship with student achievement (Teig et al., 2018). Teig et al. (2018) reported that IBL was associated with higher student achievement until an optimum level of inquiry instruction, after which, increasing the frequency of IBL was linked with decreased student achievement. Therefore, teachers’ adoption of inquiry and explicit instruction may have served to limit overuse of inquiry, thus facilitating effective science learning (Darling-Hammond et al., 2020; de Jong et al., 2023; Denoël et al., 2017).

Jerrim et al. (2019), while investigating the link between inquiry instruction and student achievement in the UK, caution against the overuse of IBL. Jerrim’s study reported a weak relationship between inquiry and student achievement which vanished as the frequency of

inquiry increased. Romero-Ariza et al. (2019) provided further insights into the links between inquiry frequency and student achievement. It was reported that specific features of IBL have different effects on student achievement that range from positive, to negative and curvilinear. Therefore, teachers have a sole responsibility to determine the ‘sweet spot’, when to maximise the implementation of inquiry to ensure enhanced student achievement, and when to use other teaching approaches to facilitate learning (Darling-Hammond et al., 2020). During the interviews, Mr Smith reported that he used explicit instruction during lesson introduction to ensure students were clear about lesson goals and tasks before embarking on IBL. Therefore, he illuminated the teacher’s role in striking a desirable balance between inquiry and other instructional approaches.

The case study teachers adopted different IBL and explicit instruction combinations while facilitating science learning. Mr Smith adopted minimal inquiry with a predominantly explicit instruction, consistent with Denoël et al. (2017) who proposed that teachers should predominantly adopt explicit instruction with some IBL. Mrs Jasmine adopted mainly hands-on inquiry learning with some explicit instruction. Mrs Jasmine’s model of combining IBL and explicit instruction was consistent with the model described in Zohar (2023) who stated that teachers who use IBL sometimes use short lectures and explanations to create a strong foundation for IBL. Both case study teachers adopted the IBL and explicit instruction combination, demonstrating that teachers provide explicit instruction ‘just in time’ to offer explanations before, during and after inquiry (Lazonder et al., 2010; Rieber et al., 2004). Teachers used lectures, explanations, and YouTube videos to facilitate students’ conceptual understanding of phenomena under investigation (Lazonder et al., 2010; Rieber et al., 2004; Zohar, 2023), such as mutualism, ecosystem, and the effect of length on pitch. These explanations offered students strong foundational science knowledge they could use in future to interpret and incorporate new knowledge and experiences (Rannikmäe et al., 2020; Zappe

et al., 2009).

The case study teachers' adoption of IBL and explicit instruction aligns with findings by Crawford (2014); (Danaia et al., 2013) who reported that teachers frequently adopted different teaching strategies when teaching science, despite the Australian Curriculum prominently featuring inquiry learning (ACARA, 2016, 2023a). Explicit instruction appeared fundamental in offering foundational knowledge which facilitated students' use of inquiry to enhance deeper conceptual understanding (Darling-Hammond et al., 2020). When explicit instruction is combined with IBL in science lessons, and analysed in the perspective of inquiry and explicit instruction, it signals a new component to pedagogical theory as the balance between inquiry and explicit instruction (Darling-Hammond et al., 2020; de Jong et al., 2023). The possibility of a desirable balance between IBL and explicit instruction to create a universal 'instructional sweet spot' may not be possible. However, each teacher might need to create their own sweet spot based on the nature of the topic and student characteristics to foster positive learning gains (de Jong et al., 2023; Denoël et al., 2017; Zohar, 2023).

The case study teachers adopted different combinations of IBL and explicit instruction while teaching science to the same Year 4 students. The possibility of the students optimising the strengths of the two case study teachers' combinations of IBL and explicit instruction for deeper science learning led to the researcher conceptualising a new model of IBL and explicit instruction combination. Each teacher adopted a unique combination of IBL and explicit instruction as already described. Whereas Mr Smith taught science on Mondays and Tuesdays, Mrs Jasmine taught science on Thursdays. Students experiencing Mr Smith's IBL and explicit instruction combination and Mrs Jasmine's IBL and explicit instruction combination reaped the benefits of IBL and explicit instruction in unique ways that have not been described in literature before. This unfolding combination of IBL and explicit instruction (EI) may be known as EI-IBL Blended framework. This model may be unique to the case study class, other

classes or other schools having two teachers teaching the same class the same subject on different days of the week. Additionally, the model may be unique to teachers intentionally using blended complementary teaching approaches. The instructional sweet spot emanates from the complementary nature of the case study teachers' teaching styles to facilitate effective science learning. The instructional sweet spot could lead to a chain effect similar to the one referred to by Mr Smith from HASS to science, but in this case from one teacher's teaching to another, optimising learning opportunities for students.

Mr Smith's teaching style utilised predominantly explicit instruction combined with internet inquiry. During Mr Smith's lessons, students were consistently engaged, and were guided and completed their learning tasks. However, Mr Smith provided students with minimal autonomy with more teacher-talk time. Mrs Jasmine facilitated hands-on IBL with minimal explicit instruction just in time to support students' learning. During Mrs Jasmine's lessons, as much as students were engaged, students did not always sufficiently complete their learning tasks. Mrs Jasmine provided students with greater autonomy and less teacher-talk time. Therefore, in the Year 4 class, the instructional sweet spot appears to be the balance between Mrs Jasmine's facilitation of hands-on learning with numerous opportunities for autonomy where fewer learning tasks are completed and Mr Smith's facilitation of internet inquiry and literacy strategies with limited opportunities for learner ownership of their own learning where more learning tasks are completed. This new model optimises the strengths of the case study teachers to maximise learning opportunities for the Year 4 students. This essentially created the Year 4 instructional sweet spot.

Despite the data showing the optimisation of the case study teachers' strengths to create the Year 4 instructional sweet spot, the case study teachers' inability to facilitate evaluation and reflection may hamper the benefits of the instructional sweet spot. The current study proposes that in a situation where two teachers teach the same group of students on different

days of the week, there should be adequate planning to ensure the instructional sweet spot is created and its potential maximised. Based on the findings in the current study as detailed in Chapter 4 and Chapter 5, case study teachers may have attained for the students an instructional sweet spot if they facilitated the same science/STEM topic, for instance sound. Whereas Mrs Jasmine would facilitate literacy free hands-on IBL where students constructed knowledge from scratch, Mr Smith would facilitate literacy-rich internet inquiry and involve students in researching the scientific knowledge of sound and drawing sketches of the different wavelengths and instruments. The synergistic relationship would have facilitated deep conceptual learning (Zohar, 2023), and strengthened the instructional sweet spot.

The complementary teaching styles adopted by the case study teachers utilised diverse media for instruction. Whereas Mrs Jasmine used hands-on Mr Smith utilised internet inquiry. As a result, while students in Mrs Jasmine's lessons gathered empirical data, students in Mr Smith's lessons gathered existing information on the internet. Students benefited from both the processes of gathering empirical and literature data as both processes are essential in developing inquiry skills. This further strengthened the complementary nature of the case study teachers' teaching styles.

### ***6.6.2 Relationship between Hands-On Inquiry Activities and Conceptual Understanding***

According to NRC (2000), students develop and acquire scientific skills and knowledge when they engage in scientific investigations. During scientific investigations, students collect and analyse data, connect explanations to scientific knowledge, and communicate findings to the wider community. Mrs Jasmine engaged students in hands-on inquiry activities that required students to investigate the effect of length on pitch produced by straw musical instruments in the *my straw musical instrument* vignette.

The data shows that Mrs Jasmine engaged students in hands-on activities and manipulation of conceptual ideas concurrently. That is, as students created their straw musical instruments, they manipulated the length of the straw musical instrument to determine how it influenced the sound produced. These findings are similar to findings by Van Uum et al. (2016) who reported that primary teachers in Finland combined hands-on activities with ‘minds-on reflections’ (Van Uum et al., 2016, p. 456).

The combination of hands-on activities and manipulation of science conceptual ideas seek to support students to develop links between their observations and science concepts. These links may facilitate students’ conceptual understanding of phenomena under investigation (Van Uum et al., 2016). Engaging in hands-on activities may lead to the development of transferable skills such as information literacy and scientific literacy which are important life skills (Dorfman et al., 2020). However, in the *my straw musical instrument performance* and *Christmas tree and tree house* vignettes, Mrs Jasmine did not explicitly link hands-on activities to science concepts. It was unclear which conceptual ideas she was developing in her students especially in the *Christmas tree and tree house* vignette. The absence of explicit instruction on the links between hands-on activities and the science concepts being developed can be detrimental to student learning (Zhang & Cobern, 2021). As evidenced, students were engaged in manipulation of materials without exploring scientific concepts in the *Christmas tree and tree house* and *my straw musical instrument performance* vignettes (Fernandez et al., 2023).

Even though students explored the link between length and pitch in the *my straw musical instrument* vignette, Mrs Jasmine did not facilitate students’ linking of evidence to scientific ideas. For instance, after Lara and Remi discovered that the short, thin straw had a higher pitch, students did not develop explanations as to why the short, thin straw had a higher pitch. Had students explained the rationale behind that finding, they would have linked

wavelength and sound production. This finding is consistent with Seung et al. (2014) who revealed that teachers did not encourage students to connect explanations to evidence.

Even though Mrs Jasmine did not link hands-on learning to scientific content, her way of facilitating science fostered strong dispositions towards science. Her science lessons were interesting and highly engaging. Students' expressions demonstrated that science was fun and enjoyable. Her facilitation mirrored her declaration during interviews that she endeavoured to create a fun and enjoyable learning environment that created interest towards science (Skamp & Preston, 2017).

### ***6.6.3 Literacy (Free) Science Lessons: Complementary Teaching***

Mr Smith integrated literacy development into his science lessons while guiding students to conduct internet-based research focused on teacher-generated questions. Mr Smith scaffolded students' development of answers through explicit instruction and teacher modelling. He encouraged students to read websites, synthesise the information, and then write their answers using their own words. He further guided students to incorporate the questions in their answers. Anderson et al. (2017) argued that through writing, students delve deeper into the science content because writing provides a space for students to learn and make connections. Therefore, Mr Smith's facilitation of a literacy-rich science learning fostered students' conceptual understanding of phenomena under investigation.

Mrs Jasmine, while facilitating hands-on learning, adopted literacy-free science lessons in which students did not focus on literacy strategies. As students tackled the challenges provided, they presented their findings orally. Literacy-free science seeks to remove the anxiety associated with language learning, and create a perception that, in science, there are no technical terms thus motivating and enhancing students' attitudes towards science learning. Does it matter, however, whether it is literacy-free or literacy-incorporated? There is an associated anxiety with literacy science being a technical subject and students having to learn

new words. However, to eliminate the anxiety, Mrs Jasmine adopted literacy-free science to ensure science learning was fun and less stressful. Did students miss the opportunity to learn language skills in literacy-free science? Students did not benefit from writing and reading, however, they benefited from speaking and listening. Therefore, Mrs Jasmine's literacy 'free' science complemented Mr Smith's literacy-rich science learning. However, many studies have argued that a combination of hands-on activities with reading may contribute positively to science learning (Cervetti et al., 2012; Hattan & Lupo, 2020).

Mrs Jasmine's literacy-free science and Mr Smith's literacy-rich science could have complemented each other in unique ways to facilitate science learning and literacy development. Following Mrs Jasmine's hands-on learning on straw musical instruments, Mr Smith may have engaged students in internet research on wavelength, sound and length of straws. The ensuing links between wavelength and sound, including writing the explanations and drawing sketches, would have facilitated both language development and conceptual understanding (Capitelli et al., 2016). These levels of complementarity would have fundamentally changed how the Year 4 students experienced science learning and contributed to the new form of the instructional sweet spot discussed in 6.6.3.

#### ***6.6.4 Learner Autonomy Supported, Nature of IBL and Student Interest***

Building on the benefits of literacy-free science is drawing on student interest towards science. The results from the study showed students manifesting diverse emotions during science. Mrs Jasmine facilitated hands-on inquiry learning with high autonomy support, and students manifested pleasant emotions while undertaking science activities. Moreover, her autonomy supportive style facilitated students' shifts in emotions from unpleasant to pleasant which may foster student engagement and interest in science. As evidenced, students were thrilled, highly engaged and motivated throughout her hands-on learning activities (De Loof et al., 2021; Skamp & Preston, 2017).

Despite Mr Smith's lessons not manifesting diverse emotions in comparison with Mrs Jasmine's lessons, and although he adopted a highly prescribed teaching style, students did manifest a deep engagement in science activities. This contradicts studies reporting that autonomy inhibitive practices have a negative relationship with students' interest in science (De Loof et al., 2021). It also shows that there might be other factors influencing student interest towards science, other than teacher motivating styles. Mr Smith's use of ICTs, internet inquiry and the nature of science topics covered especially the Daintree Rainforest might have spurred student interest in science.

#### **6.6.5 *ICT integration in teaching***

The Substitution Augmentation Modification and Redefinition (SAMR) model was used to analyse case study teachers' ICT integration in their teaching of science. The SAMR describes four levels of ICT integration, the bottom two levels, substitution and augmentation are considered under the enhancement category (Puentedura, 2013). The top two levels, modification and redefinition are considered under the transformation category. Within the substitution level, the applicable technologies replace previous learning tools without any change in their application in learning (Puentedura, 2013). The augmentation level entails teachers replacing previously used resources with technology while adopting substantial change in the application of the ICT resources in learning. Modification level entails teachers using ICTs to modify learning therefore offering learners more opportunities for decision making such as online collaboration (Puentedura, 2013). Redefinition level involves teachers using technology to create and facilitate learning in unique ways such as creation of electronic portfolios.

The analysis of Mr Smith's integration of technology in teaching using the SAMR framework shows that Mr Smith used technology as a substitute to his previously used teaching resources. Students used laptops/iPads to search for information from the websites, then

transferred the synthesised information into their workbooks by answering teacher-provided questions/foci in the three vignettes. Additionally, Mr Smith used YouTube videos as well as website links to enhance teaching and learning (Puentedura, 2013). Similarly, Mrs Jasmine used YouTube videos to enhance students' procedural understanding of the straw making process. The data shows that ICT integration was low among the case study teachers. Both teachers used the interactive whiteboard to display learning content and instructions as well as YouTube videos. A study by Rae et al. (2017) focusing on three teachers integrating ICT in New Zealand using the Bring Your Own Device practice showed that teachers predominantly operated between substitution and augmentation while integrating ICTs in teaching. Therefore, showing that there was a need for increased technological content knowledge.

## 6.7 Conclusion

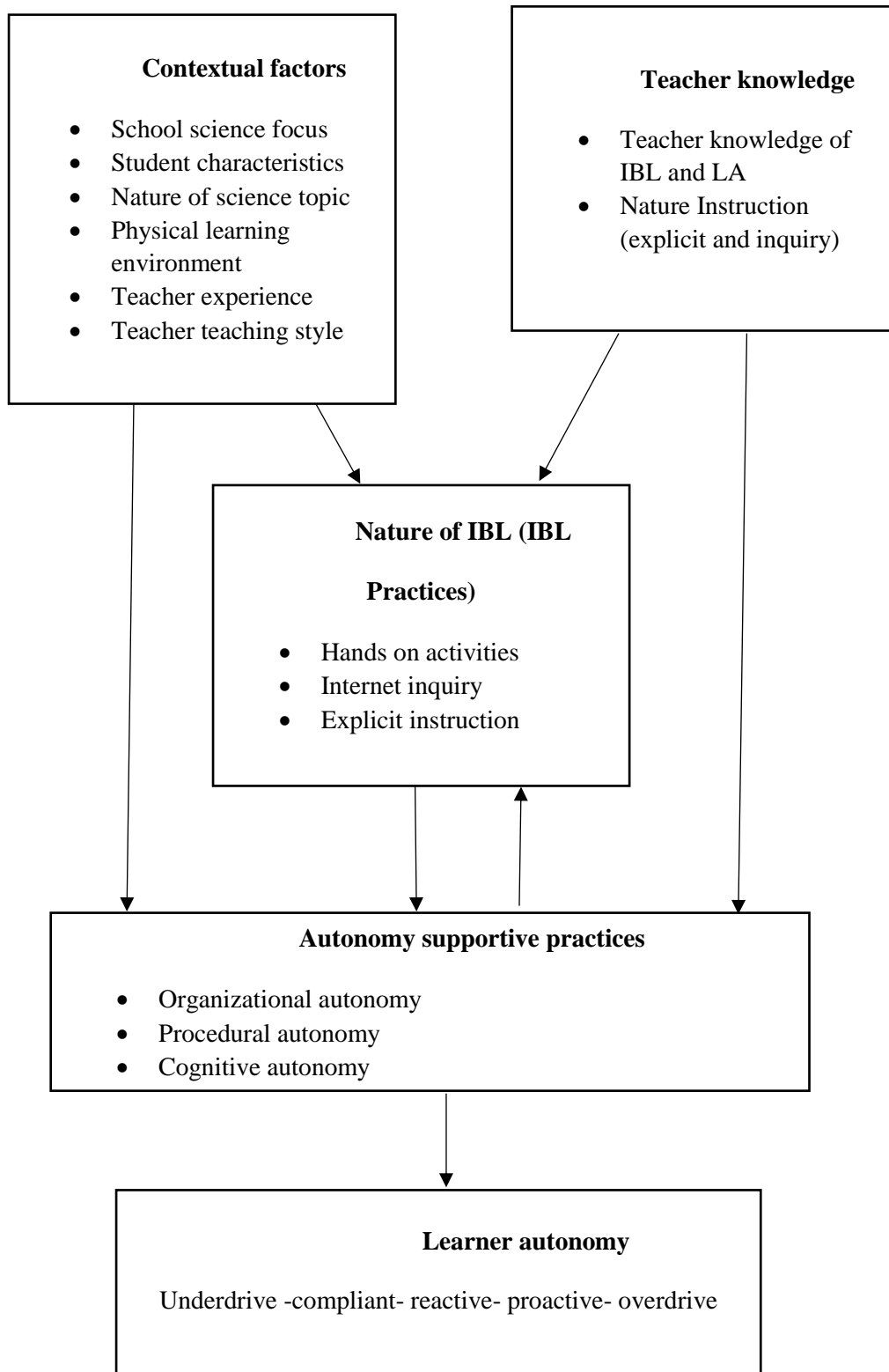


Figure 6.6. Complex interrelationship among factors influencing LAD

The cross-case analysis focused on contextual factors, teacher knowledge of IBL and LA, learner autonomy supported (LAS), and learner autonomy demonstrated (LAD).

Classrooms are complex environments, and facilitation of IBL and LA can be complex. The main themes from the cross-case are presented in Figure 6.7 which shows how the factors are related as well as how they influence LAD.

The nature of the IBL facilitated is influenced by a combination of factors: contextual factors, teacher knowledge of IBL and LA, LAS. LAD is influenced by the nature of the IBL facilitated and LAS. Contextual factors influence the nature of IBL and LAS, which in turn influence LAD.

The framework depicts alternative pathways of influence. For instance, contextual factors and teacher knowledge of IBL and LA can directly influence LAS, which in turn influences LAD. LAS can be traced back to the nature of the IBL facilitated and, similarly, the nature of the IBL facilitated can be traced within LAS.

Figure 6.7 provides insight into the complex relationship among the interacting factors (teacher knowledge of IBL and LA, contextual factors, nature of IBL, LAS and how they influence LAD).

Chapter six compared case study teachers' knowledge of IBL and LA, and their autonomy supportive practices and nature of IBL. Whereas there were differences in their practices, there were similarities as well. The contrasting teaching styles appeared to complement each other as the teachers were teaching the same group of students. The complex relationship between teacher knowledge of IBL and LA, and LAS and LAD has been summarised in figure 6.7. Conclusions emanating from the study follow in Chapter 7.

## Chapter 7 Conclusion

The study investigated how primary science teachers' knowledge of inquiry-based learning (IBL) and learner autonomy (LA) influences the nature of IBL and LA facilitated, including learner autonomy demonstrated. The study investigated how two Year 4 primary teachers in one metropolitan Catholic school in Adelaide conceptualised and implemented IBL and LA while teaching science to the same group of Year 4 students on different days of the week. This final chapter is divided into four sections: summary of the main findings, conclusions, implications, and contributions and recommendations for future research.

### 7.1 Summary of the Research

The following key findings were generated:

- The two case study teachers had a *narrow* knowledge of the meaning of IBL as they only mentioned two essential features of inquiry in their definitions of IBL, missing the other essential features of inquiry such as data analysis, connecting evidence to scientific concepts and communicating findings.
- There seemed to be a complex link between teacher knowledge of IBL and the nature of IBL facilitated in the two case studies. Both case study teachers had equivalent knowledge of IBL in the four aspects of IBL: meaning of IBL (*narrow*), teacher role in IBL (*broadened*), student role in IBL (*broadened*) and role of assessment in IBL (*moderate*). However, case study teachers facilitated different forms of IBL. The data shows there was a complex relationship between teacher knowledge of IBL and the nature of IBL facilitated.
- The case study teachers implemented a diverse range of IBL. Whereas Mrs Jasmine implemented hands-on inquiry learning with a maximum of four essential features of inquiry, Mr Smith implemented internet inquiry with a maximum of three essential features of inquiry. Therefore, students in both case study teachers' lessons did not

experience the full range of inquiry practices. Both case study teachers combined IBL with explicit instruction to facilitate students' conceptual understanding. Whereas Mrs Jasmine facilitated structured, guided and sometimes open inquiry in her lessons, Mr Smith facilitated structured and sometimes guided inquiry. The teachers' understanding, experience and teaching style seem to be the primary drivers that influenced the nature of IBL that they facilitated.

- The case study teachers had different conceptualisations of LA. Whereas Mrs Jasmine defined LA as students taking responsibility and control of their learning, Mr Smith reported that he had never heard of LA. However, based on their description of the teacher's role in LA, Mrs Jasmine conceptualised LA in a *proactive sense* whereas Mr Smith conceptualised LA in a *compliant sense*. When describing the role of the student in LA, both case study teachers conceptualised LA in a *reactive* sense. The different interpretations of LA illuminate the complex and multifaceted nature of LA which may influence teachers' diverse ways of facilitating LA (Hamad, 2018).
- Both case study teachers adopted autonomy supportive and autonomy controlling behaviours. Whereas Mrs Jasmine adopted predominantly autonomy supportive behaviour with minimal autonomy controlling behaviours, Mr Smith adopted predominantly highly prescribed autonomy controlling behaviour with some autonomy supportive behaviours. Mr Smith adopted a highly structured teaching style that provided minimal opportunities for LA, whereas Mrs Jasmine adopted a largely open and flexible teaching style that afforded many opportunities for LA.
- Learner autonomy demonstrated (LAD) is fluid and is dependent on the nature of teacher instruction, teacher purpose, learning progress and student characteristics (Little, 1991; Willison et al., 2017). In Mrs Jasmine's lessons, the range of LAD was broad as students demonstrated all levels of LA, but mostly *compliant autonomy*,

*reactive autonomy* and *proactive autonomy*. In Mr Smith's class, the range of LAD was restricted as students demonstrated LA that was largely *compliant*, with few instances of *underdrive*, *reactive* and *proactive autonomy*. *Compliant autonomy* was predominant across the six vignettes.

- There was a complex relationship between learner autonomy supported (LAS) and learner autonomy demonstrated (LAD) in this study. Firstly, students demonstrated varying levels of autonomy across the three types of autonomy supported: organizational, procedural and cognitive autonomy, revealing no clear relationship between LAS and LAD. Secondly, LAS and LAD might be incompatible, for instance, when teachers offer high quality autonomy support and students fail to take up the opportunities or demonstrate low level autonomy such as *compliant autonomy*. Thirdly, there was an evident link between low autonomy support and LAD. When teachers restricted autonomy, students reacted by either complying with teacher directions or not taking any actions, thereby demonstrating either *compliant* or *underdrive autonomy*. High autonomy support generated a wide range of student reactions ranging from *compliant autonomy* to *overdrive autonomy*.
- There was a complex relationship between teachers' knowledge of IBL and LA, and the nature of IBL and LAS facilitated and LAD. Mr Smith's *narrow* knowledge of IBL contributed to a highly structured inquiry approach to teaching science. The highly structured inquiry approach comprised of a highly prescribed teaching style implying that he adopted a low autonomy supportive teaching style. The low autonomy supportive teaching provided students with minimal opportunities to manifest autonomy, as such, students demonstrated low levels of LAD ranging from *underdrive* to *reactive autonomy*. Mrs Jasmine had a *narrow* knowledge of IBL with a more open-ended inquiry approach to teaching science which meant she adopted a highly

autonomy supportive teaching style. The highly autonomy supportive teaching style provided students with opportunities to manifest autonomy, and, as such, students demonstrated diverse levels of LAD ranging from *underdrive* to *overdrive autonomy*.

- The case study teachers facilitated science in ways that fostered students' interest in science learning. Mrs Jasmine adopted a highly autonomy supportive teaching style facilitated by hands-on learning in which students manifested enjoyment in the use of straws to create straw instruments and structures. Similarly, despite adopting a highly structured teaching style, Mr Smith's use of laptops/iPads to facilitate internet inquiry on the Daintree Rainforest fostered student engagement and interest in learning. However, Mr Smith's highly structured teaching style did not elicit diverse emotions associated with learning despite his references to the learning pit.

## 7.2 Contributions

This study distinguished two LA constructs that are commonly used in classrooms. The first term is learner autonomy supported (LAS) which refers to the freedom extended to students, in this case the teacher autonomy supportive practices, and these practices can be high autonomy supportive or low autonomy supportive. The second term is learner autonomy demonstrated (LAD) which refers to the student responses to LAS. This distinction brings clarity when using these two constructs.

This study contributes to the refinement and extension of a framework to categorise the level of *learner autonomy demonstrated* (LAD) in students' learning. Littlewood's (1999) autonomy framework of *reactive* and *proactive* autonomy formed the basis for the LAD framework. This framework was modified by Trần (2019) who introduced one additional level *compliant* before *reactive* and *proactive autonomy*. The framework proposed in this study describes five levels of LAD. *Underdrive* describes a situation in which students do not do anything in relation to the teacher's instructions. *Compliant* describes a situation in which

students closely follow the teachers' instructions. *Reactive* describes a situation in which students initiate some actions in order to follow another person's initiated learning agenda. *Proactive*, describes a situation in which students initiate significant actions to complete the teacher-initiated learning goal. *Overdrive* refers to a situation in which students initiate and complete an agenda that is different from the teacher's instructions but is learning oriented.

Using this framework, the study revealed a complex relationship between LAS and LAD. This is because LAD is fluid, and fluctuates across levels depending on a set of complex factors such as LAS, nature of task, level of comprehension of task and student characteristics. The findings show that LA is a variable closely linked to the task being undertaken, teacher instructions and students' efforts. Hence, teachers can organise the context to facilitate the demonstration of high levels of LA.

Findings revealed that learners participate at different levels within similar LAS, further illuminating the significant influence of students' personal attributes as influencing LAD. Teachers facilitated LA in diverse ways; Mrs Jasmine was flexible in nature with guided or open-ended instructions, whereas Mr Smith was highly structured with highly prescribed instructions and learning activities. Teacher teaching style influenced LAD. Mrs Jasmine's open challenges contributed to LAD ranging from *compliant autonomy* to *overdrive autonomy*. Mr Smith's structured teaching style focusing on questions contributed to LAD ranging from *underdrive autonomy* to *reactive autonomy*. The data from Mr Smith implies that structured teaching did not offer a learning autonomy enhancing environment for students to experience high levels of LAD. However, it appeared students completed more work with structured and highly prescribed teaching when compared with the open and flexible teaching facilitated by Mrs Jasmine.

The current research also adds to the literature on factors contributing to LAS. Such factors include teachers' limited understanding of IBL, LA, the role of assessment in IBL and

learning in general, and teachers' limited understanding of strategies to promote and support LA. Teachers' negative feedback contributed to the restriction of LAD, for example when Mrs Jasmine asked Maeve's group whether colour was important when they were undertaking planning and thinking for their straw instruments; this led to low levels of LAD.

The current study contributes to the debate on the IBL and explicit instruction combination in science teaching. Besides findings re-affirming that teachers combine IBL and explicit instruction in their teaching, the current study describes a blended model of IBL and explicit instruction combination. Whereas other models entail individual teachers using IBL and explicit instruction, the new model entails a combination of two individual teachers' combinations of IBL and explicit instruction while teaching science to the same Year 4 students on different days of the week. The model created 'EI-IBL Blended framework' described in Chapter 6 optimises the strengths of the case study teachers' IBL and explicit instruction to maximise the potential for science learning. This conceptualisation may need to be investigated further to determine if such a blend of learning could optimise the benefits accruing from the different combinations of IBL and explicit instruction.

This study uniquely utilised a qualitative case study to investigate two teachers teaching Science to the same Year 4 students. This was a rare occurrence, and it opened a unique window to investigate, qualitatively, the complex and multifaceted constructs of IBL and LA. Evidence from this study shows that teaching styles fundamentally influence how students experience learning and how they respond to learning opportunities. Additionally, findings show that different teaching styles can complement each other as learners can benefit from the strengths of the different teaching styles, essentially creating an effective teaching style that facilitates efficient and effective learning.

Numerous pedagogical implications can be drawn from the current study findings. Firstly, teachers had a *narrow* knowledge of IBL, but implemented different forms of IBL. If

educational policy makers develop a clear notion about the range of recommended IBL practices, would this make it easier for teachers to understand and enact IBL effectively and efficiently? Secondly, teachers had a limited understanding of LA which may have impacted how teachers facilitated and promoted LA in school science. Would the provision of an explicit and clear notion of the concept of LA by educational policy makers ensure a more consistent interpretation of LA that is nevertheless adaptable to each context? Lastly, can the provision of diverse opportunities for learners to make decisions, especially as they pertain to cognitive autonomy lead to higher levels of LAD? Since LAD is fluid and non-linear, should teachers provide appropriate range of structure and openness during teaching?

### **7.3 Implications**

There is a growing appreciation and popularity of IBL. Mrs Jasmine and Mr Smith both reported that they love IBL, and would use it frequently in its different forms in future. Both case study teachers reported that they learnt about IBL through colleagues at school and this is evident in the literature (Zhao & Fan, 2022). Should the science education community and schools recognize this form of teaching and learning about IBL and train more teachers in IBL as a way of fostering widespread adoption of IBL in school science?

Should the meaning of IBL be reviewed? Despite the case study teachers demonstrating similar levels of teacher knowledge of IBL, their definitions illuminated similar, yet different, understandings of IBL. The diverse understandings, coupled with the nature of IBL implemented, confirm that there is ambiguity in how teachers understand and interpret IBL. Both teachers understood IBL as teachers providing questions, problems, or challenges for students to address. However, they did not mention other, less common but essential, features of IBL as enshrined in the NSE (NRC, 2012). Many documents recommending the adoption of IBL do not specify teaching approaches to be adopted by teachers, therefore compounding the difficulties teachers have in understanding and interpreting how to teach IBL. NRC (2012)

states that teachers must utilise effective instructional strategies while using IBL and consider resources, students, teachers and other classroom attributes (NRC, 2000, 2012), posing significant challenges for teachers to plan their teaching through IBL. This might have contributed to the diverse nature of IBL observed between the two case study teachers. Can the review of the meaning of IBL to provide a full picture of IBL ease IBL interpretation by teachers and lead to high quality facilitation of IBL?

Is it essential to prepare learners for IBL and LA? It appears learners may need to be prepared to learn through IBL and LA. While some researchers advocate for students to be ‘thrown in at the deep end of the learning pit’ with high levels of learning autonomy required, such as in full Discovery Learning (Ozdem-Yilmaz & Bilican, 2020), it seems that high LA demands do not guarantee LA will be developed by students. On the other hand, as shown by Mr Smith’s case analysis, requirements of low learning autonomy may produce *underdrive*, *compliant* or, at best, *reactive autonomy*. Therefore, neither high nor low levels of autonomy are guaranteed to facilitate the development of student learning autonomy. Hurd (1998) emphasised that without training learners for autonomy, investment in terms of resources would not foster the capacity for active involvement and conscious choice, although, as students utilise resources, it may appear that they are experiencing LA. The current study concurs with Hurd and recommends adequate learner preparation for learning through inquiry and progressively/incrementally taking more responsibility for their learning.

Similar to findings in the study, the literature reveals that the majority of primary teachers of science are generalist teachers, even though there is a growing trend towards specialist science teachers in primary schools. Both case study teachers reported that they were not IBL trained. Despite Prinsley and Johnston (2015) recommending in 2015 that there was need to raise the prestige and preparedness of STEM teachers, it appears that eight years later Australia has not achieved this goal. As Bentley et al. (2022) noted, Australia is unable to

provide STEM specialist teachers in primary school science. Only 16 percent of Year 4 students were taught by a science specialist teacher in 2011 in Australia (Thomson et al., 2012). As reported in this study, case study teachers were not science specialist teachers nor were they IBL trained. Similar to Bentley et al. (2022), the case study teachers were teaching science which was outside their specific subject specialisation. Consequently, should teacher education programmes integrate student-centred teaching approaches, such as IBL, in the curriculum for primary generalist teachers as they are the predominant group teaching science in primary schools? If teacher education programmes foster specialisation in primary teacher training, can this lead to a large pool of trained primary teachers of science? Or should teacher willingness and passion for teaching science take precedence in determining who teaches science in primary schools?

Can the utilisation of IBL frameworks lead to facilitation of high quality science lessons? Teaching IBL without a recognisable IBL framework can contribute to restricted IBL being facilitated as students may not experience all the essential features of inquiry. This study demonstrated how students missed potential learning opportunities and this may be because teachers did not adopt a recognisable IBL framework. Teachers may facilitate improved IBL in the context of an IBL framework, though in a flexible manner so as not to limit teachers' exploration of scientific concepts. The use of flexible frameworks such as 5E and MELT may be considered as they may contribute to the facilitation of high quality IBL (Bybee et al., 2006; Willison, 2020).

#### **7.4 Recommendations for Future Research**

The findings from this study have important implications for future research in science instruction as they form a rich foundation which can be utilised by science education researchers, policy makers, school principals and teachers as a basis for their decisions in their pursuit of improved science teaching and learning. Findings from this research contribute to

science education research, science education practice, science education scholarship and education in general, as the rich case studies provide a clearer sense of the nature of inquiry-based learning and learning autonomy in primary level science.

The participants in the current research were two classroom teachers who volunteered, which presents a limitation of the current study as they may not be representative of the general teacher population. Despite the teachers sharing virtually identical teaching contexts, each was very different in terms of age, teaching experience, media for learning (hands-on versus internet), concepts of IBL of taught, LA and beliefs. However, both teachers were passionate about the teaching and learning of science. Future research should involve a larger number of teachers from different school sectors with diverse experiences, hence offering a more holistic representation of science inquiry instruction in primary school science. The LAS and LAD frameworks may prove useful, either as guides to teacher PD around facilitating autonomy or as an analytical framework to understand teacher IBL practice.

The current study investigated teacher facilitation of IBL and LA and student reaction to teacher facilitation. A significant limitation of the study was it did not explicitly investigate student understanding of scientific concepts. Should future studies investigate teacher facilitation of IBL and LA as well as student demonstration of LA and IBL and student development of scientific concepts? Can such a detailed study provide a complete picture of science learning in primary school science?

There is need for a longitudinal case study to investigate long-term changes in teacher knowledge of IBL and LA, as well as the nature of IBL and LA facilitated. This is because the current study was constrained by COVID-19 restrictions as data collection was stopped due to COVID-19 lockdown. Additionally, a replication of this study with teachers in different stages of their teaching careers in different schools is recommended to gain additional insight into how teacher knowledge of IBL and LA influence the nature of IBL and LA facilitated. The

current study investigated students' overt actions. Can a study that combines students' overt actions and student commentary on their actions offer a complete picture on LAD?

In this study, primary teachers' knowledge of inquiry-based learning and learner autonomy in science fundamentally changed the experiences for the same class of students, even when the context and overarching curriculum were primarily the same. Mr Smith's emphasis included a prescribed approach to IBL in Science, providing more obviously for the 'chain-effect', his way of describing the linkages between Science and HASS, which he valued highly. Mrs Jasmine's more open-inquiry approach was tuned to the learning in the moment, not particularly connected to either the canon of science or to HASS, literacy or numeracy. Each teacher's beliefs, philosophies and knowledge of IBL and the nature of science were fundamentally different, and so students' experiences of IBL in terms of the facets of research, their learning autonomy demonstrated, and the very nature of science learned was correspondingly altered.

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# Appendices

## Appendix A: Teacher Interview

<b>Teacher Interview Protocol</b>	
Date of interview _____ Gender of interviewee _____ <b>Interview Goal:</b> To explore teachers' knowledge and practice of Inquiry-based learning and Learner Autonomy.  <b>Type of Interview:</b> Semi-structured	
<b>A.</b>	<b>Background information</b>
	1. Tell me a little bit about yourself (education-what was you major in college, how long have you been teaching science-in this grade?)
<b>B.</b>	<b>Teacher Knowledge and Practice of IBL</b>
	1. Tell me about a favourite science lesson you have taught this term? Why is it the most favourite? 2. What does Inquiry Based Learning mean to you? (What are the aspects of the lesson that make it inquiry?) Include in this description: 3. Teacher role 4. Student role (how much choice do the students have?) 5. How are resources used? 6. How do you assess learning (What is the role of assessment in IBL lesson?). 7. What science practices do you engage/develop your students? (How do you support them in each practice?) 8. How do students communicate their results?  9. Do you use other teaching methods other than Inquiry-based learning? why and how frequently 10. Do you think IBL helps you to prepare learners to do what you want them to do? 11. Do your students generate their own questions to investigate? If not, do you ever give students questions to investigate? When they are investigating, how do you help them to connect what they are investigating with scientific knowledge? 12. Do you have your students work with data? When your students collect data, what do they do with it? (Prompts do they graph it, do they use it as evidence? How? Can you give an example?) 13. Do you ever have your students share their findings with others? If so, how does this work? Do you have students engage in discussion about their findings? What does this look like? 14. How do you know when learning is occurring in your science lessons? 15. Are there times and situations where inquiry teaching is not a useful method? (What are its advantages and disadvantages) (Tell me about these).

	<p>16. Do you feel like you have been prepared to implement IBL? Experience? Training?</p> <p style="text-align: center;"><b>Factors influencing IBL.</b></p> <ol style="list-style-type: none"> <li>1. What are the factors that motivate you to use inquiry-based learning in your science lessons (Prompt: class size, resources, other teachers, education background, curricular framework curriculum, knowledge of Inquiry Based Learning, teaching experience, school administration etc)?</li> <li>2. What constraints do you feel you have to using inquiry-based learning? (prompt factors mentioned in 1).</li> </ol> <p style="text-align: center;">What do you think should be done to enhance the use of inquiry-based learning in science classrooms in your school?</p>
<b>C.</b>	<b>Learner Autonomy</b>
	<ol style="list-style-type: none"> <li>1. What do you understand by learner autonomy in science lessons?</li> <li>2. What do you think is your role in enhancing/supporting learner autonomy?</li> <li>3. In your science lessons, what strategies do you use to support and promote learner autonomy? (Is it important for you to support/promote learner autonomy?)</li> <li>4. How would you describe a learner who is demonstrating autonomy? What are they doing?</li> <li>5. How will you manage the classroom if the children have different levels of autonomy? (Do you take in mind learner autonomy when you plan your lessons?)</li> <li>6. Do you think learner autonomy is important in science learning? Why? Why not?</li> <li>7. What factors hinder promotion of LA? What factors support the promotion of LA?</li> <li>8. How have you come to develop these views about Learner Autonomy (teacher training, professional experience)?</li> </ol>

## Appendix B: Ethics Approval



RESEARCH SERVICES  
OFFICE OF RESEARCH ETHICS, COMPLIANCE  
AND INTEGRITY  
THE UNIVERSITY OF ADELAIDE

LEVEL 4, RUNDLE MALL PLAZA  
50 RUNDLE MALL  
ADELAIDE SA 5000 AUSTRALIA

TELEPHONE +61 8 8313 5137  
FACSIMILE +61 8 8313 3700  
EMAIL [hrec@adelaide.edu.au](mailto:hrec@adelaide.edu.au)

CRICOS Provider Number 00123M

Our reference 34347

22 July 2021

Dr John Willison  
School of Education

Dear Dr Willison

**ETHICS APPROVAL No:** H-2020-067  
**PROJECT TITLE:** Kenyan and Australian Science Teachers' Knowledge of Inquiry Based Learning and Learner Autonomy

Thank you for the submitting the amended application, revised on the 13th of July 2021, requesting additional science observational-studies to the protocol. This amendment has been approved.

The ethics amendment for the above project has been reviewed by the Executive, Human Research Ethics Committee and is deemed to meet the requirements of the *National Statement on Ethical Conduct in Human Research 2007 (Updated 2018)*.

You are authorised to commence your research on: 06/05/2020  
The ethics expiry date for this project is: 31/05/2023

#### NAMED INVESTIGATORS:

Chief Investigator: Dr John Willison  
Student - Postgraduate Doctorate by Research (PhD): Mr Nemwel Nyakenyanya Aringa  
Associate Investigator: Dr Brendan Paul Bentley

Ethics approval is granted for three years and is subject to satisfactory annual reporting. The form titled Annual Report on Project Status is to be used when reporting annual progress and project completion and can be downloaded at <http://www.adelaide.edu.au/research-services/orec/human/reporting/>. Prior to expiry, ethics approval may be extended for a further period.

Participants in the study are to be given a copy of the information sheet and the signed consent form to retain. It is also a condition of approval that you immediately report anything which might warrant review of ethical approval including:

- 
- serious or unexpected adverse effects on participants,
  - previously unforeseen events which might affect continued ethical acceptability of the project,
  - proposed changes to the protocol or project investigators; and
  - the project is discontinued before the expected date of completion.

Yours sincerely,

Professor Paul Delfabbro  
Convenor

The University of Adelaide

## Appendix C: CESA Approval



**Adelaide** Catholic Education Centre  
116 George Street, Thebarton SA 5031  
PO Box 179, Torrensville Plaza SA 5031  
**T** +61 8 8301 6600 **F** +61 8 8301 6611  
**E** director@cesa.catholic.edu.au  
**W** www.cesa.catholic.edu.au

Dear Namwel Aminga's

Email: [nemwel.amingas@adelaide.edu.au](mailto:nemwel.amingas@adelaide.edu.au)

**RE: Kenyan and Australian Science Teachers Knowledge of Inquiry Based Learning and Learner Autonomy**

Thank you for your email of 6 October in which you seek permission to conduct research in South Australian Catholic schools.

I am pleased to advise your research proposal has been approved subject to the following conditions:

- copies of any questionnaires or surveys have been provided to the Principal
- the active consent of parents and teachers/school staff - if applicable - has been obtained
- the research complies with the ethics proposal approved by of the university or the research organisation's generally accepted ethics requirements
- the research complies with any provisions under the Privacy Act that may require adherence by researchers in gathering and reporting data
- no comparison between schooling sectors is made
- the researcher will be carrying out the research within view of the class teacher or authorised school observer, where students are involved
- sector requirements relating to child protection and police checks are met by researchers:
  - where researchers obtain information in relation to a student which suggests or indicates abuse, this information must be immediately conveyed to the Director of Catholic Education SA
  - all researchers and assistants, who in the course of the research interact in any way with students or student data, are required to provide evidence of an acceptable police clearance direct to the school.

At the conclusion of the study a copy of the research findings should be forwarded to:

**Director**  
**Catholic Education Office**  
**PO Box 179**  
**TORRENSVILLE PLAZA SA 5031** or  
**director@cesa.catholic.edu.au**

Please accept my very best wishes for the research process.

Yours, sincerely

  
Bruno Vieceli  
Assistant Director  
23 October 2020  
REF: 202021

## **Appendix D: School recruitment email**

### **Co-Investigator Introductory Email**

Dear (Principal)

I am writing on behalf of my PhD student Nemwel Aming'a to inquire about the possibility of undertaking data collection for his PhD research at your school. The research requires Nemwel to interview and observe Year 4 science teachers in relation to their use of inquiry based learning in their teaching practice. All teachers involved in the research will be voluntary and can withdraw at any time. They will also be invited to complete a questionnaire at the commencement of the project and will involve a series of lesson observations. The research has formal approval through the University of Adelaide's ethics committee (approval number H- #####). I have attached a detailed overview of the procedure and other relevant documentation. Further Department for Education system approval will be necessary but this can only be obtained after support has been acquired from a school.

I look forward to your response and am very happy to answer any further questions.

Yours sincerely

Brendan Bentley

***Dr Brendan Bentley* FACEL**

Senior Lecturer

Director of Partnerships and Engagement

## **Appendix E: Teacher Interview-Observation Participant Information Sheet**

**PROJECT TITLE: Kenyan and Australian Science Teachers' Knowledge of Inquiry Based Learning and Learner Autonomy**  
**HUMAN RESEARCH ETHICS COMMITTEE APPROVAL NUMBER: H-2020-067**  
**PRINCIPAL INVESTIGATOR: Dr. John Willison**  
**STUDENT RESEARCHER: Mr. Nemwel Aming'a**  
**STUDENT'S DEGREE: PhD in Education**

Dear Participant,

You are invited to participate in the research project described below.

### **What is the project about?**

This research project is about Kenyan and Australian Science Teachers' knowledge of Inquiry Based Learning and learner autonomy. Additionally, the study will seek to determine the factors influencing adoption of inquiry based learning in science classrooms in Kenya and Australia.

### **Who is undertaking the project?**

This project is being conducted by Mr. Nemwel Aming'a as part of the PhD Degree in Education at the University of Adelaide under the supervision of Dr. John Willison and Dr. Brendan Bentley.

### **Why am I being invited to participate?**

You are being invited to participate in this study because you indicated in the teacher survey that you are willing to participate in the second stage of the study that will entail participating in teacher interview, classroom observation and completion of the VASI questionnaire.

### **What am I being invited to do?**

If you are still interested and consent to participate in this study, you will be invited to participate in the following research activities:

- Having your teaching observed and audio-recorded and your written work (e.g lesson plans analysed and worked examples on whiteboard photographed). The researcher will *observe a* series of your Year 4 science lessons at mutually agreed days. The lesson observations will be as unobtrusive as possible and will be conducted by the Researcher while you and your class are engaging in your usual teaching and learning activities. Additionally, your lesson plan will be checked.
- By participating in two face to face interviews. The first interview will be conducted before the classroom observation sessions begin, it will last approximately 45 minutes. The second interview will be conducted at the end of the four lesson observation sessions and will last approximately 20 minutes. The interviews will focus on knowledge of inquiry based learning, practice of inquiry based learning, learner autonomy and factors influencing adoption of inquiry based learning.
- You will also complete the views about scientific inquiry (VASI) questionnaire which will take approximately 20 minutes.
- You will also be requested to distribute participant information sheets and consent forms to students and parents.

**How much time will my involvement in the project take?**

You will participate in a series of lesson observations at mutually agreed times. The interviews will take approximately 45 minutes whereas the second interview will take approximately 20 minutes. The VASI questionnaire will also take approximately 20 minutes to complete. The lesson observations, interviews and VASI questionnaire will be conducted at a mutually agreed time.

***Are there any risks associated with participating in this project?***

The burden on participants will be the time taken to complete the VASI questionnaire, participate in interviews and having an observer in your science classrooms.

Being observed and interviewed while being audio-recorded may put pressure on you because you may be worried that your ideas and practices may be revealed to the Head of School. This may force you to perform differently.

You are advised that participation in this study is voluntary. Should you feel that you do not want to respond to some questions during the interview, you are free to decline to respond. Additionally, should you feel that you no-longer wish to continue participating in the study, you may ask the researcher to stop any interview or lesson observation without any explanation or consequence.

If you experience discomfort as a result of any aspects of this study, you can contact the Chief Investigator, your Head of school, or the Department of Education, South Australia, whose contact details have been provided.

**What are the potential benefits of the research project?**

This study may give you an opportunity to reflect upon your knowledge of inquiry based learning and how your knowledge influences your practice of inquiry based learning and facilitation of learner autonomy in science lessons. Findings from this study may offer insights into Kenyan and Australian science teachers' knowledge of inquiry based learning, their practice of IBL and facilitation of learner autonomy as well as factors influencing adoption of inquiry based learning. These insights besides contributing to the body of knowledge of inquiry based learning and teaching practices, may provide knowledge that may inform teacher education and teacher professional development policy and practice.

**Can I withdraw from the project?**

Participation in this project is voluntary. Even if you have agreed to participate, you can withdraw from the study at any time. You may ask to withdraw any unprocessed data that you have contributed one month after the data collection exercise.

**What will happen to my information?**

Confidentiality and anonymity: Responses from the VASI questionnaire will be received without participant names. However, codes will be used to label the data thus ensuring anonymity and confidentiality. Pseudonyms will be used to identify research participants in lesson observation and teacher interview audio recordings. Additionally, observation rubrics and field notes taken during interviews will utilize codes and pseudonyms. All efforts will be made to remove any identifying information.

Storage: All data collected in this study will be stored on a password protected computer at the University of Adelaide, North Terrace Campus. Hardcopies of questionnaires will be stored in a lockable cabinet at the School of Education, University of Adelaide. The data will only be accessed by the Researchers. The data collected will be deleted five years after the publication of the thesis.

**Publishing:** The key project outcome will be a research report for the purposes of the PhD in Education. The researcher intends to publish journal articles that will be freely accessible. Pseudonyms and codes will be used in all publications.

**Sharing:** A link to published journal articles will be provided to your school at the end of the project.

Your information will only be used as described in this participant information sheet and it will only be disclosed according to the consent provided, except as may be required by law.

**Who do I contact if I have questions about the project?**

Should you have any questions relating to the study, please do not hesitate to contact one of the undersigned researchers.

**What if I have a complaint or any concerns?**

The study has been approved by the Human Research Ethics Committee at the University of Adelaide (approval number H-2020-067). This research project will be conducted according to the NHMRC National Statement on Ethical Conduct in Human Research 2007 (Updated 2018). If you have questions or problems associated with the practical aspects of your participation in the project, or wish to raise a concern or complaint about the project, then you should consult the Principal Investigator. If you wish to speak with an independent person regarding concerns or a complaint, the University's policy on research involving human participants, or your rights as a participant, please contact the Human Research Ethics Committee's Secretariat on:

Phone: +61 8 8313 6028

Email: [hrec@adelaide.edu.au](mailto:hrec@adelaide.edu.au)

Post: Level 4, Rundle Mall Plaza, 50 Rundle Mall, ADELAIDE SA 5000

Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

You can also contact the South Australia Department of Education through email: [education.ResearchUnit@sa.gov.au](mailto:education.ResearchUnit@sa.gov.au)

**If I want to participate, what do I do?**

If you would like to participate in this study, please sign the consent form and hand it back to the Researcher. You can keep this information sheet.

Yours sincerely,

**Principal Investigator**

Dr. John Willison  
Senior Lecturer  
School of Education  
Phone Number: 83133219  
Email ID: [john.willison@adelaide.edu.au](mailto:john.willison@adelaide.edu.au)

**Co-Investigator**

Dr. Brendan Bentley  
Senior Lecturer  
School of Education  
Phone Number: 831-36824  
[brendan.bentley@adelaide.edu.au](mailto:brendan.bentley@adelaide.edu.au)

**Student Investigator**

Mr. Nemwel Aming'a  
PhD Candidate  
School of Education  
0410887061  
[nemwel.aminga@adelaide.edu.au](mailto:nemwel.aminga@adelaide.edu.au)

## Appendix F: Teacher interview-classroom observation consent form

1. I have read the attached Information Sheet and agree to take part in the following research project:

<b>Title:</b>	<b>Kenyan and Australian Science Teachers' Knowledge of</b>
<b>Ethics Approval</b>	<b>H-2020-067</b>

2. I have had the project, so far as it affects me, and the potential risks and burdens fully explained to my satisfaction by the research worker. I have had the opportunity to ask any questions I may have about the project and my participation. My consent is given freely.
3. Although I understand the purpose of the research project, it has also been explained that my involvement may not be of any benefit to me.
4. I agree to participate in the activities outlined in the participant information sheet. The activities I will participate in are:
- *A series of Lesson observations*
  - *Two interviews*
  - *Completing the VASI questionnaire*
  - *Distributing parent and student information sheets and consent forms*
5. I agree to be:
- Audio recorded  Yes  No
- Photographed  Yes  No
6. I understand that I am free to withdraw from the project at any time.
7. I have been informed that the information gained in the project may be published in a journal article/thesis/conference presentations etc.
8. I have been informed that in the published materials I will not be identified and my personal results will not be divulged.
9. I agree to my information being used for future research purposes as follows:  
 Research undertaken by these same researcher(s) Yes  No
10. I hereby provide 'extended' consent for the use of my data in future research projects that are:
- (i) an extension of, or closely related to, the original project: Yes  No
  - (ii) in the same general area of research (for example, genealogical, ethnographical educational research): Yes  No
11. I understand my information will only be disclosed according to the consent provided, except where disclosure is required by law.

12. I am aware that I should keep a copy of this Consent Form, when completed, and the attached Information Sheet.

**Participant to complete:**

Name: \_\_\_\_\_ Signature: \_\_\_\_\_ Date: \_\_\_\_\_

**Researcher/Witness to complete:**

I have described the nature of the research to

\_\_\_\_\_

*(print name of participant)*

and in my opinion she/he understood the explanation.

Signature: \_\_\_\_\_ Position: \_\_\_\_\_ Date: \_\_\_\_\_

## **Appendix G: Parent/guardian-student participant information sheet**

**PROJECT TITLE: Kenyan and Australian Science Teachers' Knowledge of Inquiry Based Learning and Learner Autonomy**

**HUMAN RESEARCH ETHICS COMMITTEE APPROVAL NUMBER: H-2020-067**

**PRINCIPAL INVESTIGATOR: Dr. John Willison**

**STUDENT RESEARCHER: Mr. Nemwel Aming'a**

**STUDENT'S DEGREE: PhD in Education**

Dear Participant,

Your child is invited to participate in the research project described below. Please read this participant information sheet together with your child before you both sign the consent form.

### **What is the project about?**

This research project is about Kenyan and Australian Science Teachers' knowledge of Inquiry Based Learning and learner autonomy. Additionally, the study will seek to determine the factors influencing adoption of inquiry based learning in science classrooms in Kenya and Australia.

### **Who is undertaking the project?**

This project is being conducted by Mr. Nemwel Aming'a as part of the PhD Degree in Education at the University of Adelaide under the supervision of Dr. John Willison and Dr. Brendan Bentley.

### **Why has your child been invited to participate?**

Your child has been invited to participate in this study because he/she is studying in Year 4 and his/her science teacher has accepted to participate in the study.

### **What will your child be involved in?**

If you and your child consent to your child's participation in the study, your child will be invited to be part of the class that will be observed and audio recorded in a series of science lessons.

### **How much time will my child's involvement in the project take?**

Your child will participate in a series of science lesson observations.

### **Are there any risks associated with participating in this project?**

The burden on your child will be having an observer in his/her science classrooms and having his/her classroom participation including discussions audio recorded. As a result, your child may feel pressure to perform and behave differently in the presence of the researcher in their class.

Your child is advised that participation in this study is voluntary, should they feel that they do not want to participate in the study, they are free to withdraw at any time without giving any explanation or consequence.

If they experience discomfort as a result of any aspects of this study, they can contact you, their science teacher or School Headteacher.

**What are the potential benefits of the research project?**

Since this study will involve your Child's science teacher, your child may benefit in the long term through improved teacher skills in teaching through inquiry based learning and better facilitation of learner autonomy. However, in the short-term, there are no benefits associated with participation in this study.

**Can your child withdraw from the project?**

Participation in this project is voluntary. Even if you and your child have consented to your child's participation in the study, your child can withdraw from the study at any time.

**What will happen to my child's information?**

Confidentiality and anonymity: Pseudonyms will be used to identify research participants in lesson observation. Additionally, observation field notes will utilise pseudonyms and codes, hence there will be no information that will be used to identify your child.

Storage: All data collected in this study will be stored on a password protected computer at the University of Adelaide, North Terrace Campus. The data will only be accessed by the Researchers. The data collected will be deleted five years after the publication of the thesis.

Publishing: The key project outcome will be a research report for the purposes of the PhD in Education. The Researcher intends to publish journal articles that will be freely accessible. Pseudonyms and codes will be used in all publications.

Sharing: A link to published journal articles will be provided to your child's school at the end of the project.

Your child's information will only be used as described in this participant information sheet and it will only be disclosed according to the consent provided, except as may be required by law.

**Who do I contact if I have questions about the project?**

Should you have any questions relating to the study, please do not hesitate to contact one of the undersigned researchers.

**What if I have a complaint or any concerns?**

The study has been approved by the Human Research Ethics Committee at the University of Adelaide (approval number H-2020-067). This research project will be conducted according to the NHMRC National Statement on Ethical Conduct in Human Research 2007 (Updated 2018). If you have questions or problems associated with the practical aspects of your child's participation in the project, or wish to raise a concern or complaint about the project, then you should consult the Principal Investigator. If you wish to speak with an independent person regarding concerns or a complaint, the University's policy on research involving human participants, or your rights as a participant, please contact the Human Research Ethics Committee's Secretariat on:

Phone: +61 8 8313 6028

Email: hrec@adelaide.edu.au

Post: Level 4, Rundle Mall Plaza, 50 Rundle Mall, ADELAIDE SA 5000

Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

You can also contact the South Australia Department of Education through email:

[education.ResearchUnit@sa.gov.au](mailto:education.ResearchUnit@sa.gov.au)

**If I want to consent my child to participate, what do I do?**

If you would like to consent to your child's participation in this study, you and your child should sign the consent forms, place them in the envelope provided and hand it to your Child's school secretary or let your Child give the envelope to their science teacher. You can keep this information sheet.

Yours sincerely,

**Principal Investigator**

Dr. John Willison  
Senior Lecturer  
School of Education  
Phone Number: 83133219  
Email ID: john.willison@adelaide.edu.au

**Co-Investigator**

Dr. Brendan Bentley  
Senior Lecturer  
School of Education  
Phone Number: 831-36824  
brendan.bentley@adelaide.edu.au

**Student Investigator**

Mr. Nemwel Aming'a  
PhD Candidate  
School of Education  
0410887061  
nemwel.aminga@adelaide.edu.au

## Appendix H: Student consent form

1. I have read the attached Information Sheet and agree to take part in the following research project:

<b>Title:</b>	<b>Kenyan and Australian Science Teachers' Knowledge of Inquiry Based Learning and Learner Autonomy</b>
<b>Ethics Approval</b>	<b>H-2020-067</b>

2. I have had the project, so far as it affects me, and the potential risks and burdens fully explained to my satisfaction by the research worker. I have had the opportunity to ask any questions I may have about the project and my participation. My consent is given freely.
3. I have been given the opportunity to have a member of my family or a friend present while the project was explained to me. The project has been explained to me in the presence of the science teacher.
4. Although I understand the purpose of the research project, it has also been explained that my involvement may not be of any benefit to me.
5. I agree to participate in the activities outlined in the participant information sheet. The activities I will participate in are:
- *Having my involvement in a series of lesson observations observed by the Researcher*
6. I agree to be:
- Audio recorded  Yes  No
7. I understand that I am free to withdraw from the project at any time.
8. I have been informed that the information gained in the project may be published in a journal article/thesis/conference presentations etc.
9. I have been informed that in the published materials I will not be identified and my personal results will not be divulged. `
10. I agree to my information being used for future research purposes as follows:
- Research undertaken by these same researcher(s) Yes  No
11. I hereby provide 'extended' consent for the use of my data in future research projects that are:
- (i) an extension of, or closely related to, the original project: Yes  No
  - (ii) in the same general area of research (for example, genealogical, ethnographical educational research): Yes  No
12. I understand my information will only be disclosed according to the consent provided, except where disclosure is required by law.
13. I am aware that I should keep a copy of this Consent Form, when completed, and the attached Information Sheet.

**Participant to complete:**

Name: \_\_\_\_\_ Signature: \_\_\_\_\_ Date: \_\_\_\_\_

**Researcher/Witness to complete:**

I have described the nature of the research to

\_\_\_\_\_

*(print name of participant)*

and in my opinion she/he understood the explanation.

Signature: \_\_\_\_\_ Position: \_\_\_\_\_ Date: \_\_\_\_\_

## Appendix I: Parent/guardian consent form

1. I give consent to \_\_\_\_\_'s involvement in the following research project:

<b>Title:</b>	<b>Kenyan and Australian Science Teachers' Knowledge of Inquiry Based Learning and Learner Autonomy</b>
<b>Ethics Approval</b>	<b>H-2020-067</b>

2. I have read the attached Information Sheet and had the project, so far as it affects my child, and the potential risks and burdens fully explained to my satisfaction by the research worker. I have had the opportunity to ask any questions I may have about the project and my child's participation. My consent is given freely.
3. I have been given the opportunity to have a member of my family or a friend present while the project was explained to me.
4. Although I understand the purpose of the research project, it has also been explained that involvement may not be of any benefit to my child.
5. I agree for my child to participate in the activities as outlined in the participant information sheet.
6. I agree for my child to be:  
     Audio recorded  Yes  No
7. I understand that my child is free to withdraw from the project at any time.
8. I have been informed that the information gained in the project may be published in a journal article/thesis/conference presentations etc.
9. I have been informed that in the published materials he/she will not be identified and his/her personal results will not be divulged.
10. I agree to my child's information being used for future research purposes as follows:  
 Research undertaken by these same researcher(s) Yes  No
11. I hereby provide 'extended' consent for the use of my child's data in future research projects that are:
- (i) an extension of, or closely related to, the original project: Yes  No
- (ii) in the same general area of research (for example, genealogical, ethnographical, epidemiological educational research): Yes  No
12. I understand my child's information will only be disclosed according to the consent provided, except where disclosure is required by law.
13. I am aware that I should keep a copy of this Consent Form, when completed, and the attached Information Sheet.

**Third Party to Participant to complete:**

Name: \_\_\_\_\_ Signature: \_\_\_\_\_ Date: \_\_\_\_\_

Relationship to participant: \_\_\_\_\_

Name and age of participant: \_\_\_\_\_

**Researcher/Witness to complete:**

I have described the nature of the research to

\_\_\_\_\_

*(print name of participant)*

and in my opinion she/he understood the explanation.

Signature: \_\_\_\_\_ Position: \_\_\_\_\_ Date: \_\_\_\_\_