Student and teacher perspectives of Construction Zone Activity in the Thinking Science Australia Program

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ABSTRACT

Research into cognitive acceleration programs, such as the Cognitive Acceleration through Science Education (CASE) program, has shown the program to be effective in developing student cognition with effects that are considered long-term and far-transfer. Available in Australia as the Thinking Science Australia (TSA) program, based on Thinking Science (Adey, Shayer & Yates, 2001), empirical evidence has shown similar results in this context. Like all similar cognitive acceleration programs, TSA pedagogy has three pillars, cognitive conflict, social construction and metacognition, that through interaction form a Construction Zone that is purported to be responsible for student cognitive gains. This research was built upon the premise that the small-group discourse, experimentation and activities collectively referred to as Construction Zone Activity (CZA), is described in the literature but has little empirical research about what teachers and students perceive happens during CZA episodes. The aim of the research presented in this thesis was to examine student and teacher perspectives of CZA in TSA lessons. The study forms an embedded case study to explore these perspectives in the context of a Western Australian school that had been implementing the program for a number of years. Qualitative data were collected through semi-structured interviews with teacher participants who delivered the program as part of the school's curriculum and focus group interviews with some of their students.

The findings indicate that teachers and students in this case study hold many similar perspectives about CZA in TSA lessons with respect to their stated aims, intentions and significance for CZA, their expectations of how different students respond to CZA episodes in these lessons and the expected outcomes that result. Findings from student and teacher data suggest that these episodes allow for social construction and improved or different student thinking, with the capacity to develop skills described by both parties. Further, it appears that not all students respond in the same way to CZA episodes, with students engaging in both productive and unproductive, or off-task, behaviours that may be informed by the attributes of different learners and social factors. Students and teachers indicated they expected outcomes for students that aligned with their stated aims, intentions and perceived significance of CZA, although students also reported improved teamwork, confidence and ability to work with other perspectives in addition to improved thinking and skill development. Teachers were also able to describe their strategic approaches to CZA and their reasoning, implying that these strategies inform and are informed by what happens during CZA episodes in these lessons. The findings also indicate that students not only engage in productive discourse as described in the

theoretical framework of cognitive acceleration, but also cycle in and out of this discourse within CZA, why this might be and how students perceive themselves to be effective self-regulators of their social construction.

To communicate the study findings about CZA, a model was constructed. This model proposes that teacher involvement in CZA extends beyond teacher mediation of cognitive conflict to the ways in which teachers group students, manage their classes and facilitate group work during CZA episodes. It also seeks to show the ways in which students engage in discourse and behaviour that is not related to solving the specific problem, but attempt to manage their own behaviour. This study highlights the importance of understanding such pedagogy through the perspectives of its participants and the potential for ongoing research to develop our understanding of this pedagogy further.

LIST OF TABLES AND FIGURES

TABLES

FIGURES

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

> "I guess I was wrong when I said I never promised anyone. I promised me."
>
> - Kermit the Frog, The Muppet Movie (1979).

Writing this Masters Thesis has been at times, a Herculean task. There have been many moments where I have actively questioned my sanity and why I even chose to do this. Not because it has not been rewarding, but because when seeking a challenge to shake myself loose from my moorings, I took on a challenge that was far bigger than I had anticipated at the time. But in the end, I made a promise to myself. And that promise kept me coming back, even when I did not think I could possibly handle anything more than everything that was already happening at that particular moment in time in my life.

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CHAPTER ONE
INTRODUCTION AND BACKGROUND

1.1 Introduction and Research Purpose

Thinking and thinking skills (sometimes referred to as cognition) are critical to effective development of students in science. Programs such as the Cognitive Acceleration through Science Education (CASE), and Thinking Science Australia (TSA), aim to improve student cognition, and thereby, improve student learning. These programs have demonstrated impacts on student cognitive development and school achievement (e.g Oliver & Venville, 2016). As such, Australian science educators may adopt them to help develop higher order thinking in their students. This is especially pertinent in the context of recent curriculum reform and declining participation and retention in science.

Despite showing positive impacts that are considered both long-term and far transfer, little research has been conducted into how or why these programs are effective. This is particularly true with respect to the episodes of group work, talk and experimentation in these lessons collectively known as 'Construction Zone Activity' (CZA). The activities encompassed in CZA are considered to be the mechanism through which the program is most impactful. The purpose of this study was to explore student and teacher perspectives of CZA and establish the degree to which their perceptions aligned. This chapter outlines the background and context of the research, the significance of the research, the research questions and the locality and subjectivity of the researcher.

1.2 Background and Context

Australia has experienced major curriculum reform in recent years. For example, the new Australian Curriculum aims to provide Australian students with the necessary foundation for sustained and effective life-long learning and participation in the Australian community, even as the ways in which young people learn and the challenges they face as learners evolve in the context of the twenty-first century (ACARA, 2017a). Cutting across the content of the learning areas in the Australian Curriculum are seven general capabilities. These capabilities encompass knowledge, skills, behaviours and dispositions considered important for young people to successfully navigate the demands of the twenty-first century (ACARA, 2017a). They include: *literacy; numeracy; information and communication technology (ICT) capability*; *critical and creative thinking*; *personal and social capability*; *ethical understanding* and *intercultural* *understanding* (ACARA, 2017a). Every teacher is expected, regardless of subject area, to facilitate and develop these capabilities in their students.

Facilitation and development of student ability to engage in critical and creative thinking should be an important, well-developed aspect of science teacher pedagogy (Oliver & Venville, 2012). This type of thinking is embedded throughout the Australian Curriculum: Science in a variety of skills including: the ability to pose questions, make predictions, speculate, solve problems through investigation, make evidence-based decisions, analyse and evaluate evidence and summarise information (ACARA, 2017b). However, teachers may be left uncertain as to the hierarchy of thinking skills, how to teach the skills successfully, how they can be evaluated and even the impact such skills can have on students' learning (Oliver, Venville & Adey, 2010; 2012). Examples of excellent practice in Australia with respect to teaching and learning thinking appear to exist as 'islands' of practice, with many practitioners rarely engaging in the kinds of stimulating activities that advance student cognition (Venville & Oliver, 2015).

At the same time as the implementation of the new curriculum, science education in Australia, as with other post-industrial societies, was previously said to be in a state of crisis (e.g. Tytler, 2007) or more recently a concerning decline (Kennedy, Lyons & Quinn, 2014). Participation in senior secondary school science has declined over the past four decades, particularly with respect to subjects such as biology, physics and chemistry (Ainley, Kos & Nicholas, 2008), even accounting for increased numbers of students in Year 12 (Kennedy *et al.*, 2014). In some cases, the numbers of students who actually do science subjects may even be somewhat inflated by student perceptions of which courses will boost tertiary entrance scores and/or grades (Venville, 2008). Recent benchmarking of Australian Science, Technology, Engineering and Mathematics (STEM) suggests these issues may not be quite as dire at the level of participation and completion in higher education (see Office of the Chief Scientist, 2014a). Australia, however, still finds itself in the midst of a renewed national focus on STEM, particularly in school education (see Office of the Chief Scientist, 2014b; Education Council, 2015).

Findings from comparative international studies, including the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) also are cause for concern. Results from PISA and TIMSS show that Australia continues to be increasingly outperformed (Thomson, De Bortoli, Nicholas, Hillman & Buckley, 2011; Thomson, De Bortoli & Underwood, 2017; Thomson, Wenert, O'Grady &

Rodrigues, 2017). Australia's performance decreased over recent cycles of the TIMSS testing while other countries (many of which have undergone curriculum reform) recorded significant improvements. Furthermore, Australian students appear to be less interested in learning science and less inclined towards scientific enquiry and its application to environmental issues, despite being more likely to have highly qualified teachers, positive school climates, and comparatively high levels of educational resources at home, including access to computers and the internet (Thomson *et al.,* 2017*;* Thomso*n et al.,* 2017*).*

This stagnation in achievement gains in Australian students contrasts with anecdotal evidence suggesting students may be more intelligent as a result of ready use and access to technology and information (Oliver *et al.*, 2012). Moreover, gains seen in worldwide intelligence tests may be attributable to the Flynn Effect: a steady increase in Intellectual Quotient (IQ) seen since modern IQ tests were developed (Baxendale, 2010). Whilst some studies have questioned the Flynn Effect (Shayer & Ginsburg, 2009; Shayer, Ginsburg & Coe, 2007), a case can be increasingly made for the adoption of new and innovative approaches that improve student science achievement at high school, especially given recent curriculum reform and STEM strategic initiatives.

Modelled on the Cognitive Acceleration through Science Education (CASE) program in the United Kingdom (UK), the Thinking Science Australia program (TSA) aims to directly address Australian students' falling achievement in and attitudes towards science whilst enabling teachers to develop critical and creative thinking in line with the Australian Curriculum (Oliver *et al.*, 2012). It engages students to think critically through well-managed scenarios of cognitive conflict by giving them access to opportunities for social construction of knowledge and metacognition.

Following a pilot study of TSA in a low socio-economic high school in regional Australia in 2009/2010 (Dullard & Oliver, 2010; Oliver *et al.*, 2010; Oliver *et al.*, 2012), there has been an uptake of TSA in schools within Western Australia and Queensland (e.g. Oliver *et al.*, 2010; Kerr, 2013; Gordon, 2016). This uptake included private and public schools and incorporated a diverse range of student demographics with schools adopting the program to support the academically selective (Venville & Oliver, 2015), as a proactive response to issues around participation and retention of girls in the STEM disciplines (Kerr, 2016) and in modified forms to meet the needs of students with verified learning needs (Mobbs, 2016).

1.3 Central Research Question

Despite significant evidence supporting programs designed to impact on student cognition (e.g. Adey, 1999; Higgins, Hall, Baumfield & Mosely, 2005) a search of the literature (further discussed in Chapter 2) revealed that there is little empirical research into teachers' and students' perceptions of these lessons and how they work to affect student cognitive development and school achievement. This has implications for the effective implementation of these programs. For example, the Construction Zone Activity (CZA) (which represents the 'cognitive struggle') is said to be key to the cognitive gains experienced by student participants in these lessons (Adey, 1999); however, it is not clear to teachers how the CZA can best be structured to maximise these benefits. Based on this insight from the literature, the central research question for the study was developed.

*What are the **perspectives** on 'Construction Zone Activity' of teachers and students participating in the Thinking Science Australia (TSA) program?*

1.4 Significance

In the context of declining or stagnant results internationally, and the Australian Curriculum's general capability of critical and creative thinking, a program like TSA is as relevant now as ever for its capacity to facilitate the teaching of thinking. Recent years have seen a surge in focus on effective STEM education which requires teachers to "deliver contemporary science using contemporary pedagogy, with a focus on creativity and inquiry-based learning" (Office of the Chief Scientist, 2014c, p.23). In this context, the teaching of science requires teachers "to promote the development of longlasting skills—including quantitative skills, critical thinking, creativity, and behavioural and social skills— in parallel with disciplinary knowledge" (Office of the Chief Scientist, 2014c, p.23). As Oliver and Venville (2016) argued, it is time for the teaching of thinking to become part of mainstream educational discourse, and time for the principles from evidence-based programs such as *Thinking Science* to be adopted across the board in education.

According to Adey (1999), the theoretical model for CASE (and thus TSA) plays a central role in terms of teacher professional development, introducing teachers to a pedagogy for teaching students to think. As he stated:

> We do not ask teachers to do something on simple empirical grounds, 'because it works', but because that is what theory predicts will work, and because with a better understanding of why they are doing it, teachers are able to make the pedagogy their own and adapt it to their own teaching style. (1999, p. 36)

It is through the practice of teachers engaged in cognitive acceleration programs, such as TSA, that it is possible to develop and inform the theoretical foundation of the program (Adey, 1999). Given the lack of empirical evidence for such programs with respect to their central engine, CZA, this study is significant in that it explores how both students and teachers perceive what happens in the heart of these lessons. It adds to a body of literature in which such activities are described but not explored from these perspectives and has implications for the practice of teachers.

1.5 Locality and Subjectivity of the Researcher

When the researcher is the major instrument of data collection, it is important to specify their background as part of establishing credibility (Patton, 2002). In the case of this study, the researcher currently teaches science at the participating school and this includes teaching Thinking Science Australia (TSA) to students. As Associate Head of Science, he is the school-based coordinator of TSA, a role also held at a previous school for three years. The researcher has also delivered some Thinking Science Australia professional development through The University of Western Australia and has observed lessons and provided feedback, support and mentoring for this program in a school context. As such, he brings detailed knowledge and experience of the program, its delivery and of the school and its participants. From his own experience, he has witnessed the behaviours that can occur during the Construction Zone Activity (CZA) and has been privy to expressions of concern and frustration by teachers who believe students are sometimes not getting the full value out of the lessons. The researcher has, therefore, recognised the need to formally examine the alignment between student and teacher perspectives with respect to CZA and this was a motivating factor in the conceptualisation of the research reported in this thesis.

The researcher acknowledges the potential for bias owing to his roles as Associate Head of Science and TSA Coordinator at the school level and commitment to the program over multiple years. This represents a potential position of power over participants and consent in this case could be deference to the researcher's roles and position or an existing professional or personal relationship with peers that may otherwise compromise the study (NHMRC, 2007). This potential bias and power issues are carefully considered in the methodology section, Chapter Three.

1.6 Summary

The first chapter identified the purpose of the research, background and context and established why the research is significant. Further, this chapter listed the central research question and explained the subjectivity of the researcher. Chapter Two will examine the literature around CASE and TSA, the theoretical framework that underpins this program and research into the perspectives of those participating in TSA lessons.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter synthesises the literature related to the Cognitive Acceleration through Science Education (CASE) and Thinking Science Australia (TSA) programs and the research into student and teacher perceptions of these programs. These programs are based around a shared pedagogy that synthesises elements of Piagetian and Vygotskian theories of cognitive development.

2.2 Cognitive Acceleration through Science Education (CASE) or Thinking Science

Thinking Science (Adey, Shayer & Yates, 2001) is a cognitive acceleration program based on the Cognitive Acceleration through Science Education (CASE) program developed at King's College, London, UK. It consists of a series of 30 lessons carried out over two years in schools (ideally in Years 7 and 8) and serves to accelerate students' thinking to help them more ably cope with curriculum demands (Oliver *et al.,* 2010). The lessons do not subsume normal science lessons (which expose students to the curriculum content), but instead run parallel to them and are sequenced so as to spiral through increasingly more complex levels of specific reasoning patterns (Oliver *et al.,* 2010; Oliver *et al.,* 2012).

Like other such acceleration programs, Thinking Science is based on the premise that young people's minds develop through experiences and challenges rather than just maturing with age (Adey, 2011). The aim of cognitive acceleration is to move students towards the type of abstract, logical, multivariate thinking described by Piaget as 'formal operations' and manifest in student cognitive skills including weighing up both sides of an argument, comparing the advantages and disadvantages of an action or identifying both combined and separate effects of independent variables (Adey, 1999). Such programs incorporate cognitive conflict, highlight social construction of knowledge and encourage metacognition as part of the intervention.

2.3 Evidence for CASE or Thinking Science

The original CASE project attempted to accelerate the development of higher order thinking in young adolescents through science education in secondary schools (Adey & Shayer, 1990). Students aged 11 – 13 in a range of co-educational English schools (and a laboratory school for piloting the materials) participated in up to 30 intervention lessons delivered by their science teachers over two years. Whilst performances on science achievement tests during this period appeared to be unaffected (and were potentially attributed to issues with the quantity and quality of teacher in-service training), gains on Piagetian tests of formal operations were shown for some intervention groups. CASE students performed significantly better than the control group in similar tests one year later (Shayer & Adey, 1992) and on the British General Certificate of Secondary Education (GSCE) in science, English and mathematics (Adey & Shayer, 1994). Detailed analysis of the groups involved suggested age, gender and even teacher understanding of CASE theory had the potential to affect students' cognitive gains (Shayer & Adey, 1993).

More recent studies also show support for CASE strategies (Shayer, 1999; Adey & Shayer, 2002 in Oliver et al., 2012; Oliver & Venville, 2016). For example, students participating in the intervention three years earlier achieved higher results than their peers in control schools when they sat the GSCE (Shayer, 1999). Although lessons were delivered in a science context by science teachers the students showed higher comparative achievement in mathematics and English in addition to science (Shayer, 1999). This demonstrated potential for a long-term, far-transfer effect is considered a major strength of the CASE program.

Application of the theoretical and practical approach to CASE has also occurred outside of the original context to involve mathematics (Shayer & Adahmi, 2007), technology (Backwell & Hamaker, 2004), younger students (Adey, Robertson & Venville, 2002) and older students (Mbano, 2003). Cognitive acceleration programs have also been successfully adapted and tested in a range of other countries including Pakistan, the United States and Malawi (Iqbal & Shayer, 2000; Endler & Bond, 2008; Mbano, 2003). Further, the effectiveness of such programs has been supported in the findings of systematic literature reviews (e.g. Higgins et. al, 2005; Saffin, 2012).

In recent years, the CASE program and resources were adapted for use in an Australian context as Thinking Science Australia (TSA). TSA involves a program of professional learning and research involving Australian science teachers teaching the cognitive acceleration curriculum package available commercially as Thinking Science (Adey, Shayer & Yates, 2001). Research into the program has shown it to be effective, with a pilot study in a low socioeconomic high school demonstrating significant cognitive gains and concomitant improvements in state-wide testing for participating students (Oliver, Venville & Adey, 2012).

Further, a recent quasi-experimental study with a pre- and post-intervention cognitive test of those participating in TSA showed significant cognitive gains compared with an age matched control group over the length of the intervention (Oliver & Venville, 2016).

Quantitative research involving an academically select high school and non-academically select schools also showed that whilst all students demonstrated significant improvements in cognition as part their involvement in TSA, the gains for students from an academically selective school were even more significant (Venville & Oliver, 2015). This was reflected more broadly, where schools considered to be 'disadvantaged' with respect to their Index of Community Socio-Educational Advantage (ICSEA), made cognitive gains on average that were consistent with comparison groups, but lower than the gains for more 'advantaged' groups (Oliver & Venville, 2016). It has been suggested that this reflects greater stability in terms of student population, staffing and participation in the professional learning opportunities with respect to more 'advantaged' schools or positive teacher effects by those maintaining high fidelity in program delivery (Oliver & Venville, 2016).

2.4 Critiques of CASE

A small section of the literature has been focused on issues associated with the early CASE research. The success of the CASE intervention has been linked to the starting age of students in the intervention and the effect of gender, but the statistical approach and interpretation has been questioned. For instance, Preece (1993), critcised Shayer and Adey's (1992) statistical treatment of the data, noting that bimodal interpretation of the data and subsequent separate treatment of a sub-group, made gains seen in the post-test scores inevitable.

Jones and Gott (1998) questioned the confidence that could be placed in the data from the original intervention, expressing reservations around the use of Piagetian 'reasoning tasks' and external exam results and citing issues with sample size and 'arcane statistical approaches'. Drawing on research in a real life situation with associated challenges of change management, the authors attributed differences in school results to varied attitudes toward the program and the choice of groups involved. Whilst teachers who had experienced teaching CASE could see and develop explicit links to investigating in science, there was variance in their commitments to CASE, with the most enthusiastic of the schools also receiving higher levels of in-school support. Schools with less in-school support indicated they may continue only with the lessons they perceived as useful or felt worked. Additionally, there was a perception that this program was more suited to more able students.

Leo and Galloway (1995) suggested that Thinking Science appears best suited to ‘mastery-oriented’ students who perceive learning as valuable and are challenged by difficult tasks instead of threatened (Leo & Galloway, 1995). It is argued that students who are ‘learned helpless’ or ‘self-worth motivated’ may not make maximum progress without having this mastery-orientation nurtured in them. This line of critique questions whether CASE may, in fact, prove to be a cognitive deceleration program for those individuals who possess such traits (Jones & Gott, 1998).

A study by McLellan (2006) tried to determine if potential differences experienced in cognitive gain by students during CASE intervention were influenced by different world-views (comprising orientations and related beliefs). The results showed that some link is apparent between world-view and cognitive gain. However, the students achieving the highest cognitive gains at CASE schools seem to show a decline in motivation, whilst students making average and low gains seem to improve in motivation. Given the unexpected inverse relationship between motivational worldview and cognitive acceleration effects, McLellan concluded it is only possible to partially attribute the effects of CASE to students’ motivational world views.

2.5 Theoretical Framework for Thinking Science

Thinking Science Australia (TSA) refers specifically to a program of professional learning and research involving Australian Science teachers teaching a cognitive acceleration curriculum package available commercially as Thinking Science (Adey, Shayer & Yates, 2001). This program was funded between 2010 – 2012 by the Australian Research Council (ARC) with partner organisations, The University of Western Australia and King’s College, London.

Cognitive acceleration programs such as TSA are informed by both Piagetian and Vygotskyian theory in the way they detail stages of cognitive development, specifically target problems and require “thinking” to problem-solve in the “zone of proximal development” so learning as a result of a conflict occurs’ (Oliver *et al.,* 2010, p. 2).

Six pillars (or principles) underpin the theoretical framework:

1 Schema theory
2 Concrete preparation
3 Cognitive conflict
4 Social construction
5 Metacognition
6 Bridging

Figure 2 (Shayer, 2003) summarises the abstract structure of a typical CASE lesson and the involvement of these six principles.

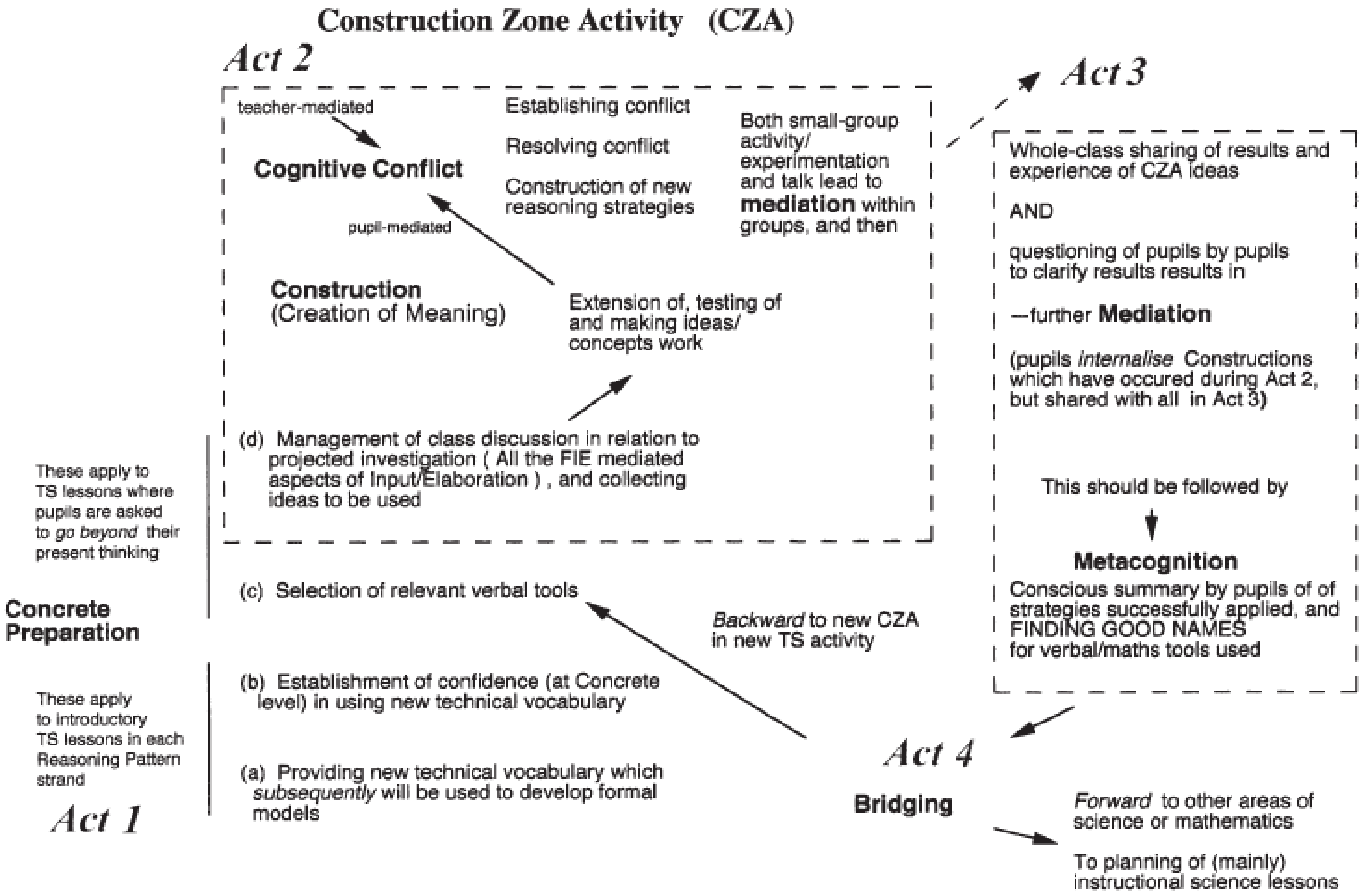

Figure 2 *Summary of the technical terms and features of a cognitive acceleration program such as CASE and its mathematics counterpart, CAME (Shayer, 2003, p. 482)*

Thinking Science lessons occur in the context of a reasoning pattern (schemata) involving multiple levels of understanding (Shayer, 2003). These include: controlling variables; ratio and proportionality; compensation and equilibrium to analyse process; correlation, probability; determining criteria for classification; using formal models of thinking and understanding compound variables. Each of these reasoning patterns is encountered multiple times over the intervention with increasing complexity (Oliver *et al.*, 2012). In the first act of each of these lessons, *concrete preparation* in this reasoning pattern occurs. This involves the teacher engaging students by introducing a problem to be addressed and helping them negotiate any related ideas or terminology (Oliver *et al.,* 2010).

In Act 2, students engage in Construction Zone Activity (CZA), working at the problem in groups of around three to five students in their 'Zone of Proximal Development' (ZPD). CZA specifically refers to the small group activity, experimentation and talk occurring in TSA lessons as students engage with cognitive conflict and social construction of knowledge in the ZPD (Adey & Shayer, 1994; Shayer, 2003). Originally described by Vygotsky, the ZPD is the difference between what a child is developmentally capable of as an individual and what they are potentially developmentally capable of as an individual under the guidance of an adult or in collaboration with more able peers (Vygotsky, 1978).

Cognitive acceleration activities aim to provide students with *cognitive conflict*, an intellectual challenge at an appropriate level of difficulty that can be resolved with guided thought. More specifically it refers to a problem that a child could not solve individually but could solve or gain understanding of with careful help from an adult or more able peer (Adey, 1999).

In this ZPD, *social construction* occurs with students listening to each other, discussing, arguing constructively and contributing to or building on each other's ideas as they try to develop their explanations and understandings of the problem (Adey & Shayer, 2012). Social construction specifically involves students working with their peers to develop shared explanations and understandings of a cognitive conflict and its potential solutions (Oliver *et al.*, 2012). In this sense, students develop their scientific knowledge and understandings through a dialogic process where more skilled peers support and scaffold the meaning making of less skilled peers through conversation in the context of relevant tasks (Driver, Hisako, Leach, Scott & Mortimer, 1994). This helps them to perform tasks, internalise processes and bring these processes under conscious control as they are introduced to communities of knowledge.

During CZA, the teacher actively scans the room to note ideas of interest being discussed and intervenes only to stimulate or facilitate further group conversations (Shayer, 2003). Peer-peer construction and mediation in this stage facilitates student intellectual development; rather than offering solutions, teachers probe with questions and encourage student active participation to maximise this opportunity (Shayer, 2003; Oliver *et al.*, 2012).

Act 3 is the whole class discussion including *metacognition.* The exchange of ideas and reporting of each group's findings happens here and it is this sharing that continues to drive intellectual development (Shayer, 2003). The term metacognition concerns the processes by which we monitor and control our own cognitive processes, which can be described as thinking about one's thinking (Frith, 2012). Students, through questioning by teachers, are prompted to share and reflect on their strategies for problem-solving, articulating the approaches they adopted for problem solving (Oliver *et al.*, 2010). This enables other students to develop awareness about their own cognition (Pintrich, 2002), helps them to access other ways of thinking and evaluating and helps consolidate the learning and how it has occurred (Adey & Shayer, 2012). This gives all participants increased opportunity to complete their own ZPD in respect to a concept (Shayer, 2003). *Bridging* then follows, with developed ideas applied to other real-world problems or contexts, especially those that might be considered in regular science lessons.

The central pillars, or principles, of social construction, metacognition and cognitive conflict are inextricably linked to one another (Adey & Shayer, 2012). This means lessons may be unlike normal lessons as teachers alternate between these pillars, and facilitate small group work, practical activities, direct instruction and whole class questioning and discussion (Oliver *et al.*, 2012).

2.6 Student Small-Group Discourse

When participating in CZA, students are required to work in small groups to complete the activities; in fact, this is considered in the literature as critical to TSA lessons (Adey & Shayer, 2012). As such, students participating in TSA lessons are unlikely to engage in these lessons without some form of social interaction and discourse. There is, however, little in the literature related to the nature of the social interaction and discourse of students in the CZA.

Howe (2014) highlights when discussing her own research and a systematic review of the literature, that science students are likely to come to their discussions holding diverse preconceptions that contrast from each other and diverge from the science. Overwhelmingly, when student groups involved differences in preconceptions during group work, these students showed greater gains than those in groups with similar ideas or unexpressed differences (Howe, 2014). Students can move towards conceptual mastery the more they engage in productive in-group discourse around their contrasting ideas. Importantly, post-group reprocessing based on the discourse seems to be more important than the discourse itself. Moreover, findings showed that growth happened with the same likelihood in groups that converged on poor solutions as good solutions in activities where ideas differed (Howe, 2012).

Kelly (2007) highlighted the social dimensions of student small-group discourse, and how this discourse includes ways of negotiating the nature of scientific knowledge. For students working in small groups, supposed 'scientific explanations' are the product of interaction. These explanations are informed and constructed from a combination of activity goals and purposes, participant structures, the nature of students' intellectual resources and the status of the knowledge being questioned. The discourse itself can involve the posing of questions, offering of interpretations, questioning other inquirers, suggesting alternative approaches and dissention from a group decision (Kelly, Crawford & Green, 2001).

As highlighted in other studies, such as one by Hogan (1999), the intellectual tasks associated with group work can potentially be inhibited by placing demands on students to interact and build consensus. The negotiation of interpersonal relationships and navigation of personal identities can influence the range of discursive practices mediating small-group scientific discourse (Kelly *et al.* 2001), with the inclusion/ exclusion of students being interactively accomplished as students from different communities choose how to participate, involve their peers and guide their actions (e.g. Gomes, Mortimer & Kelly, 2011). Evidence also suggests that teachers have a role to play in developing communal activities and managing or mediating such discursive interactions, especially with respect to framing of activities, focusing of student talk and providing space for the discourse to happen (Kelly, 2007; Gomes, Mortimer & Kelly, 2011).

2.7 Research into Student and Teacher Perceptions of CASE and Thinking Science

As part of ascertaining how the CASE intervention worked, one study included surveys circulated to teachers in a group of five UK schools involved in the program (Jones & Gott, 1998). On the whole, teachers viewed the program favourably; they believed it was beneficial to students (particularly for investigating in a science context), enjoyable to teach and some reported that the pedagogy had bridged into their other lessons. However, preparation time, language in the lessons and resource issues were highlighted as problematic.

Since then, similar perspectives have been reflected in qualitative data collected by Oliver, Venville and Adey (2010, 2012) in Australia. Teachers were found to perceive the TSA program as a purposeful way to engage students in thinking and address the thinking requirement of the Australian Curriculum (Oliver *et al.*, 2010). Similarly, teachers in the pilot study in Western Australia believed there were improvements in student enjoyment, achievement and critical thinking, despite variable interest and enthusiasm and evident intrinsic and extrinsic frustrations with the program (Oliver *et al.*, 2012). Students' perspectives of the TSA program, reflected enjoyment and positive impact of the lessons, although 'thinking' proved the most challenging for over half of them (Oliver *et al.*, 2012).

Qualitative findings from research into TSA in an academically selective school, focused on teacher perceptions of the program in the school's context (Venville & Oliver, 2015). Teachers identified a strong level of commitment from the school, but cited practical challenges related to programme implementation. This included logistical challenges and conventions that could impede group work, like the set-up of spaces in which the lessons were conducted or layout of worksheets students used. They also cited issues with coordinating the programme against the demands of the curriculum.

Teachers did perceive changes in their pedagogy from implementing the program, but also noted that there were specific challenges when implementing TSA with students in the context of the academically selective school. They recognised characteristics of their gifted and high achieving learners that influenced their approaches to program delivery and facilitation of group work in CZA. This included shifting the focus of the lesson to being on application of knowledge and deeper thinking, away from memorisation and absorption of facts; something some high achieving students were perceived to be good at. It was also conceded that teachers needed to adopt creative approaches to get individuals involved, especially as some high achieving students did not typically like group work. Additionally, teachers had to employ classroom management techniques as facilitators of group work, especially when individuals did not want to engage in group work or held strong positions that contradicted those of other students in the group.

2.8 Summary

The Cognitive Acceleration through Science Education (CASE) and Thinking Science Australia programs have demonstrated impacts on student cognition and achievement that are long-term and far-transfer. Whilst much of the literature concerning CASE and Thinking Science has focussed on the program's impact, some studies have focussed on discussion of the challenges and factors that may affect successful implementation of the program within schools from the perspective of facilitating a potential pedagogical shift in teachers (e.g. Adey & Shayer, 1990; Shayer, 1999; Oliver *et al.,* 2010; Oliver *et al.*, 2012; Venville & Oliver, 2015).

Overall, there appears to be a lack of empirical research into how student and teacher participants perceive the program and their involvement. Studies examining the teacher's role in CASE, and therefore the ways in which to best train and support them, and investigations into how students view CASE are still needed (Saffin, 2012). As Construction Zone Activity is purported to be a central mechanism to the success of this program in changing student cognition, research is needed into the alignment of student and teacher perceptions of such activity. This research and understanding is needed to consolidate knowledge and develop an evidence base for helping teachers to understand and modify their practice when adopting cognitive acceleration programs.

This chapter presented a review of the literature related to the CASE and TSA programs, an overview of the conceptual framework for TSA lessons and a review of the research about student and teacher perceptions. The next chapter, Chapter Three, outlines the methodology used for this research.

CHAPTER THREE
METHOD

3.1 Introduction

This chapter outlines the design and research methods for the investigation of student and teacher perspectives of Construction Zone Activity (CZA) in the Thinking Science Australia program (TSA). Consideration is given to the research questions, research design and context, sample and the ways in which data are collected and analysed. Trustworthiness and ethical considerations of the research are also discussed in this chapter.

3.2 Central Research Question

The central research question for this study was:

*What are the **perspectives** on 'Construction Zone Activity' of teachers and students participating in the Thinking Science Australia (TSA) program?*

3.3 Guiding Research Questions

A number of guiding research questions were developed to guide the methods of data collection.

With respect to teachers teaching TSA, the guiding questions were:

1) What are teachers' **aims and intentions** with regard to CZA? What reasons do they provide for these aims and intentions?

2) How do teachers **perceive the significance** of CZA? What reasons do they cite for this significance?

3) What specific **strategies** do teachers employ and how do they act to make CZA part of their practice? What are their reasons for selecting these strategies?

4) In what ways do teachers **perceive students to respond** to CZA? What reasons do they cite for these responses?

5) What are teachers' **expectations** of the perceived outcomes of CZA? What is their rationale for these expectations?

With respect to the students participating in TSA, the guiding questions were:

6) What are students' **aims and intentions** within CZA? What reasons do they provide for these aims and intentions?

7) How do students perceive the **significance of CZA**? What reasons do they cite for this significance?

8) In what ways do students **perceive they interact during CZA?** What reasons do they provide for these conversations?

9) In what ways do students **perceive other students respond** to CZA? What reasons do they cite for these responses?

10) What are students' **expectations of the perceived outcomes** of CZA? What is their rationale for these expectations?

3.4 Research Design

This study aimed to investigate the perspectives of both teachers and students with respect to Construction Zone Activity (CZA) within the scope of TSA lessons. This research was conceptualised within the interpretivist paradigm and employed a social constructivist epistemology. In this paradigm, social interaction is the basis for knowledge and this knowledge is a mutually negotiated construct specific to the situation (O'Donoghue, 2007). More specifically, social constructivism, as an interpretivist theory, views social interaction as the primary means by which students construct new meanings and places emphasis on teacher-student and student-student collaboration as the means through which this learning and subsequent development occurs (New & Cochran, 2007). As part of social constructivism, learning can be considered a reciprocal and collaborative process; both teachers and students are active agents in the process, constructing new approaches to thinking about and solving problems in response to their interactions within the social context (New & Cochran, 2007). As a consequence, by adopting this theoretical perspective, it was deemed possible to not only uncover student and teacher perspectives of CZA, but also how these perspectives informed and were informed by their actions. This was considered particularly appropriate given the way in which students interact with their peers and teachers within TSA lessons.

The overall aim of this study, conceptualised within social constructivism, was to examine the perspectives of teachers and students who participate in these lessons. More specifically, as these lessons involved episodes of 'Construction Zone Activity' (CZA) said to be part of the driving force for cognitive gains in the program, this study aimed to examine how both students and teachers perceived these episodes and how this impacted their approach to these lessons. Drawing from grounded theory analysis, this research aimed to generate substantive theory that would make a useful contribution to those implementing 'thinking skills' or cognitive acceleration programs.

3.5 Research Context

The research was designed as a case study conducted in one high school. The case study school is located approximately 20 km east of the Western Australian state capital central business district. It is one of a number of co-educational government schools in the metropolitan region with Independent public school status and caters for Year 7 to 12 students (12 to 18 year olds). The school is 95% selective and attracts over 1500 students (nearly two-thirds of whom are female) from across the state, with many students participating in gifted and talented arts programs or as part of a specialist soccer program. Teaching staff at the school have been merit-selected on the basis of their understanding of gifted and talented education, and the school offers academic excellence programs in humanities, mathematics and science in order to cater for highly able students. During the research period, the school had an above average Index of Community Socio-Educational Advantage (ICSEA) value of 1089 (mean, 1000; standard deviation, 100), with 43% of students in the top quartile of parental income. Approximately 12% of the student population has a language background other than English. (MySchool http://www.myschool.edu.au, 2016)

At the time the research was conducted, the school's science department included twelve teaching staff, other than the researcher, including those on part-time and full time employment contracts. Teachers in the department ranged from two years of experience in the classroom to over three decades and a significant number possessed postgraduate qualifications. All staff in the department had taught lessons in the TSA program since its introduction into the school in the first quarter of 2012 and ten of these staff had participated in multiple sessions of TSA professional development offered through the Graduate School of Education at the University of Western Australia (UWA) as part of the University's professional development program.

3.6 Sample

Sampling of consenting teacher participants and students in this study was purposive with a view towards obtaining maximum variation. In doing so, the aim of the researcher was to increase the likelihood that variability inherent within the studied phenomenon would arise (Maykut & Morehouse, 1994). The aim was to select participants reflecting the scope and range of different perspectives within the case study school. Participant Information and Consent Forms are shown in Appendix A, B and C.

The sample consisted of five teacher participants, and student participants drawn from each teacher's nominated class currently engaged in TSA. Teachers ranged in experience from more recent graduates (5 years experience) through to highly experienced individuals (30 years experience). Of this sample, two had not undergone the full formal training offered by UWA and had instead participated in condensed and modified versions of the first two days of initial training, whilst the remainder had participated in the majority of the six days of formalised training. All but one of the teachers had been immersed in teaching the lessons for a minimum of one year prior to the data collection for this study. Data collection took place between May and June of 2015.

Once participant staff were identified, they were given information and participation/consent forms for students in one of their Year 7, Year 8 or Year 9 classes currently engaged with the program. In situations where staff had more than one class that could participate in the research, they were asked to choose the class they felt most appropriate for observation. The research to be conducted and the nature of the project was then introduced to the class by their teacher, with information and participation/consent forms distributed and collected prior to the observation of that class and in a timeframe considered reasonable for students and their parents to respond. Two or three focus groups consisting of three to five consenting students were constructed and interviewed from each class. Teachers were provided with criteria to facilitate the selection and composition of student focus groups from the class with a view to accessing a diverse range of student perspectives. Students selected participated in the program of 30 lessons in Year 7 to 8 or Year 8 to 9 only, meaning that all students were either in their first or second year of the program.

3.7 Data Collection

Data collection occurred in two main stages. In the first stage, teacher perspectives were collected through individual interviews with consenting staff participants following observation of a TSA lesson taught by that teacher. In the second stage, student perspectives were obtained through focus group interviews with up to five students at a time in each group. The researcher used identified groups of consenting students from each participating staff member's nominated Year 7, Year 8 or Year 9 class for the second stage.

Whilst individual interviews were appropriate for consenting staff participants, it was recognised that consenting student participants may be unwilling or uncomfortable with structured individual interviews, and had the potential to make them reticent (Johnston & Toplis, 2012). To minimise some of this reticence and boost the confidence of student participants, facilitated focus group interviews were chosen (Johnston & Toplis, 2012). Students often possess insightful perspectives and observations about their learning (Simons, 2009). When facilitated well, group interviews have the potential to stimulate participants to make their views, perceptions, motives and reasons explicit and may also help draw out aspects of the situation that may otherwise remain unidentified (Fontana & Frey, 2000).

In the first stage of this research prior to interviews, the researcher observed each teacher participant conducting a TSA lesson with their nominated class at a time when a TSA lessons had been scheduled. The aim of this non-participant observation was to provide a common context for both the teacher and interviewer to draw upon during the interview, especially as aspects of the TSA pedagogy may otherwise prove too abstract for participants to discuss in depth, limiting the richness and meaningfulness of the data as a tool to access teacher perspectives.

Observations of each teacher participant's nominated lesson were made using a combination of the Lecky observation schedule (which notes what is happening within the lesson at each 3 minute interval; Appendix D) and field notes. The observation schedule chosen was developed specifically for making observations in Thinking Science lessons in accordance with British Education Research Association (BERA) ethics guidelines to ensure ethical data collection (Lecky, 2012) and as such, was considered a suitable instrument. Teachers participating in the research had previously encountered this schedule in coaching following professional development sessions for TSA with UWA and were also likely familiar with its structure and purpose. The field notes taken to supplement the observation schedule concentrated on the observed behaviour of students within their groups, how the students responded to teacher practice and the actions of the teacher with respect to the lesson and how they approached, developed, maintained and responded to these episodes of CZA. The classroom observations did provide a shared experience that facilitated the interviews. Due to the scope of this Masters research, however, the data collected were not systematically analysed or presented in this thesis.

Each teacher interview and student focus group interview was conducted using a pre-determined interview guide with standardised questions to ensure that the research pursued the same lines of enquiry with each participant and group (Patton, 2002; Appendix E). The guiding questions were provided in advance to allow all participants time to consider their responses, encouraging more meaningful responses and enhancing the richness of collected data. The guiding questions used were modified for students to facilitate their understanding and better contextualise their experiences in the context of TSA lessons in which they had participated. For both teachers and students, guiding questions were used along with clarifying questions as part of a semi-structured interview process that allowed participants to direct interview progress and focus on what was really important to them, rather than being limited to only those permitted by the facilitator. As this opened up new possibilities, the researcher was required to employ good general communication skills, active listening and follow-up questions, without restricting the field of inquiry through overly leading questioning (Simons, 2009).

Each individual interview and focus group interview was kept to 45 minutes or 30 minutes respectively at a location on site with minimal disruption and at a time convenient for participants. Participants consented to the use of an audio recording device prior to the interview beginning and were given an opportunity to listen to themselves after the recording to verify interpretations and limit any concerns they may have of being recorded (Johnston & Toplis, 2012). The researcher also took brief field notes during the interviews. The combination of both note-taking and audio recording was chosen as it was inexpensive, responsive and flexible, whilst yielding rich data (Punch, 2009).

3.8 Data Analysis

Qualitative data, in the form of participant answers, generated from the semi-structured interview process or student focus groups were transcribed directly into a separate word document for each interview or focus group. To capture the exact responses used by participants, recordings were played multiple times to ensure that the words transcribed matched the spoken words as accurately as possible. Once transcribed, audio recordings were replayed against the transcripts to verify their accuracy.

Data analysis for this research drew upon the model of inductive analysis developed by Miles and Huberman (1994 in Simons, 2009). At the centre of this model are three interlinked components: *data reduction*; *data display*; *conclusion drawing and verification*. These activities interacted throughout the analysis process in line with the model presented in Figure 3.

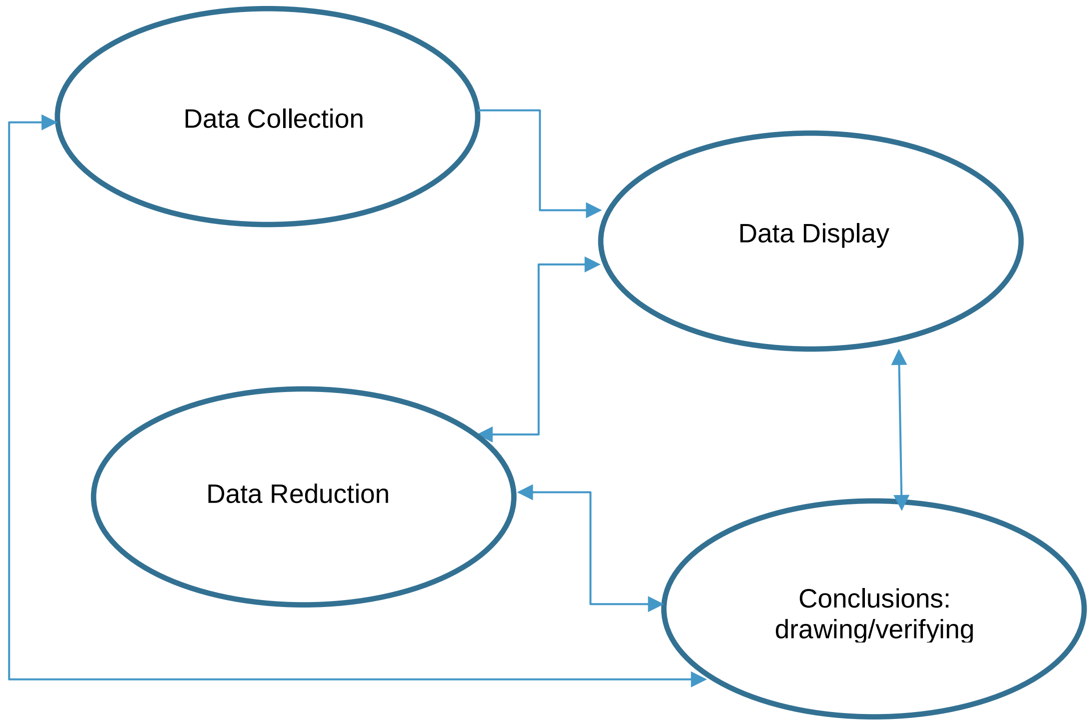

Figure 3 *Interactive Inductive analysis model, Miles and Huberman (1994 in Simons, 2009)*

In the data reduction phase, key data from the interviews were selected. Open codes were generated from the transcripts and also recorded, along with an exemplar, in a separate word document as the first part of the analysis process (see Appendix E). Each code was generated organically from the data in the transcripts and codes evolved and were updated over time to best encapsulate emergent properties of the qualitative data as analysis continued. Codes were subsequently used to generate themes from the transcribed responses with the researcher using the most frequent and significant codes to conceptualise the themes and categorise the data within the themes. When analysing codes, the researcher used the prominence of this code or theme within the transcript (and across transcripts) to determine its significance within the data. Codes which appeared infrequently within or between transcripts or which could not be applied directly to transcribed data were de-emphasised relative to others. Major themes were differentiated by occurrence in 50% of transcripts or greater; 'minor' themes appeared less frequently. Emergent major and minor themes were continually analysed and scrutinised against the research questions to ensure categorisation aligned with the focus of the study.

In the data display phase, major themes and minor themes emerging in the data and their categories were used to produce an organised, reductive summary of the data. This summary is displayed in the next chapter on an open-grid. The specific research questions were used as a continual guide to help cluster themes within relevant categories and this is reflected in the display.

In the drawing and verifying conclusions phase, which occurred concurrently with reduction and display of data, possible conclusions were noted, but sharpened as more data were analysed, reduced and displayed. Following analysis, these conclusions were articulated as propositions which were subsequently verified against the data. The propositions are presented in the subsequent chapter.

Throughout the data analysis process, the researcher maintained reflexivity as a means to preserve truth in the research process and ameliorate possible effects from the researcher's own thoughts and values when generating codes and determining significance. This was achieved by ongoing discussion of emerging codes, themes and categories, the interpretation of key data and potential new lines of enquiry, with critical colleagues to enable the researcher 'handling' the data to combine their insights into the data with wider perspectives related to possible issues in methodology and the research topic. Data from field notes and observations were also used to effectively triangulate findings from transcribed data and ensure that this data aligned with the perspectives shared by participants.

3.9 Trustworthiness

As qualitative studies examine in-depth how people think and feel, they should be high in internal validity. The term 'trustworthiness' is often preferred in place of external validity and reliability for qualitative research (Patton, 2002). As the researcher is the major instrument of data collection, it is important to specify their background as part of establishing credibility (Patton, 2002). As an instrument for data collection, the researcher in this study was a relative novice, however all questions were provided to participants in advance following screening by experienced third parties. This also ensured that participants had adequate opportunity to read and interpret the general questions used as a basis for instrumentation (see Appendix F).

Trustworthiness of qualitative data was maintained through the reflexivity of the researcher. This was achieved by means of personal reflections, audit trails and subsequent discussions with third parties to check that interpretations were accurate.

The following measures were undertaken to contribute to the overall trustworthiness:

- Triangulation - triangulation of data collection and analysis were used to crosscheck the data (Patton, 2002). Individuals unconnected with the data (in this case the supervisors) were used for crosschecking emergent categories and themes in the data as a form of analyst triangulation (Patton, 2002). Observations of teacher and student behaviour and conversation within sampled Thinking Science classes also functioned to triangulate data sources (Patton, 2002). As noted by Yin (2009), case studies present an opportunity for the use of multiple sources of evidence. This is considered a strength of this approach.

- Checking for Contrary Findings - Consistent with Yin (2009), preliminary findings were reported during the data collection phase to critical colleagues to test for tolerance to contrary findings. Where appropriate, these colleagues offered alternative explanations to rebut these findings and help ensure bias was minimised.

- Maintenance of an audit trail – A clear audit trail was maintained during qualitative data analysis to increase the reliability of the information (Yin, 2009) (see Appendix G for an example).

3.10 Ethical Considerations

All research was conducted in a considerate, ethical manner in accordance with the requirements of the *Australian Code for the Responsible Conduct of Research* produced by the National Health & Medical Research Council (NHMRC), the National Statement on Ethical Conduct in Human Research (NHMRC, 2007), the Human Research Ethics Office (HREO) at UWA and the Graduate School of Education at UWA. Ethics approval for this research was granted by both the Human Research Ethics Committee at the University of Western Australia (Approval Number: RA/4/1/7122; see Appendix H) and the Research Ethics Committee of the Western Australian Department of Education (Approval Number: D15/0098794; see Appendix I). All requirements for engaging Department of Education staff and students in research were adhered to. This included maintenance of staff and student confidentiality and secure storage of information provided by participants for use solely for the purpose of research.

All raw data will continue to be stored securely in a locked filing cabinet in a secured office at the University of Western Australia for a period of five years from the thesis' completion, consistent with Ethics Committee requirements and NHMRC regulatory guidelines (2007). At the conclusion of the study the researcher will permanently delete all materials saved on the hard drives of computers used to store and analyse data. Electronic materials will be stored on a compact disc and stored securely with hard copies of research materials consistent with the five year timeframe prescribed by the NHMRC. At the conclusion of this mandatory storage period, the materials will be destroyed.

The ethics application process did identify a potential problem with the primary researcher also being a member of the science department and the TSA Coordinator in the school in which the research was being conducted. The potential problem was that staff members or students may feel obliged or coerced to participate should they be approached by the primary researcher in the process of recruitment. To avoid this potential problem, consent for the research was first sought from the school's principal. Once approval had been received from the principal, the head of the science department at the school was approached and lengthy discussions took place about the research, in particular, how the recruitment process would take place and the role he would need to take so that an ethical process would be ensured. The head also consented to participate in the research and was a willing facilitator of the teacher recruitment process. To minimise the possibility of perceptions of coercion or pressuring of staff or students to participate in the research due to the researcher's roles, the head of the department, was asked to manage the delivery of information to prospective participants and the subsequent seeking of consent and collection of signed consent forms. Participation was entirely voluntary and the right of an individual to refuse was respected, without pressure to provide a reason. Based on expressions of interest, and subsequent completion of information and participation/consent forms the head identified suitable staff in response to specific criteria provided and teachers similarly identified suitable students (Appendix J). These were presented to the researcher before any observations and interviews with staff were scheduled.

In accordance with NHMRC (2007) guidelines, the researcher acknowledges that student participants represent a vulnerable group within the school being studied. Given the age of the participating students and their developing maturity, student consent and parental consent was also essential (NHMRC, 2007). As such, all student participants (and their parents or guardians) were asked to give written consent to participate in the research (NHRMC, 2007). This consent involved information regarding the intent, nature and methods of the research, the risks involved and the possible social and personal consequences as a result of publication. They were also informed of the extent to which the data collected is confidential, and offered the right to withdraw from the study at any time. Opportunities to validate the content of recorded audio and written transcripts were also given. Additionally, the researcher had not previously taught any students in the year groups involved in this research and had no current classes involving any of those students to minimise potential bias.

Students within participating classes who did not consent to be involved were not excluded from the observation as TSA lessons formed a part of the school's normal program and curriculum delivery, however, these students were automatically excluded from participation in the focus groups. Consenting student participants were interviewed in groups of three to five during times following the lesson observation that minimised the impact upon their learning. Additionally, there was no specific limit on the number of student participant focus groups, as this minimised potential harm, such as embarrassment or feelings of not being important, with students who had consented to be involved but would otherwise be unable to participate under a specified cap on numbers of student participants.

3.11 Summary

This study utilised an embedded case study design to examine students' and teachers' perceptions of CZA within lessons of TSA in a single school in Western Australia. Data were collected through semi-structure interviews with teacher participants and focus groups conducted with selected student participants in classes currently participating in the TSA program with that teacher. Participants were asked to respond to open-ended questions about their perceptions of their approaches to construction zone activity and their perceptions and opinions of what occurs when students work together in this specific part TSA lessons and possible reasoning. The next chapter, Chapter Four, presents the findings from this research.

CHAPTER FOUR
FINDINGS

4.1 Introduction

This chapter presents the findings resulting from the data analysis of teacher interviews and student focus group interviews. In the first section, demographic data of teacher and student participants is presented. This is followed by findings from the interviews conducted with teacher participants and subsequently, those from the student focus groups. The major findings are reported in categories derived through the thematic analysis of data and based on the research question and complementary guiding questions. The chapter concludes with a summary of the findings.

4.2 Teacher and Student Participant Demographics

A total of five teachers and their students were involved in this case study. All five of the consenting teacher participants were female. In 2015, at the time of this study, the department at the school where research took place included seven female science teachers (58.3%) and five (41.7%) male teachers, making the participants somewhat unrepresentative of the gender distribution within the department. This was unavoidable due to the ethical and voluntary nature of the recruitment.

The teacher participants varied with respect to their years of experience, time at the school, experience with the Thinking Science Australia (TSA) program and level of formal professional development in TSA. Their demographics are summarised in Table 1.

Table 4.1

Teacher Participant Demographic Data

Teacher	Gender	Subject Area	Years of Experience	Years at School	Thinking Science Training
A	Female	Science	< 5	2 years, 5 months (when first introduction of Thinking Science took place)	Completed more than 50% of training though UWA
B	Female	Science	< 10	5 months (beginning of school year)	Condensed introductory session through UWA
C	Female	Science	> 30	More than 20 years	Completed more than 50% of training through UWA
D	Female	Science	< 10	At school for introduction of program 2 years and 5 months previous. Took 18 months to teach internationally before returning.	Completed more than 50% of training offered through UWA
E	Female	Science	Between 10 to 20	Had previously taught at school; returned 18 months after the program introduction.	Condensed introductory session through UWA

With respect to student participants, in 2015, 902 (62.5%) of the students within the school were female and 540 (37.5%) were male. For this case study, focus groups involved 26 (66.7%) female students and 13 (33.3%) male students in total, making it consistent with the demographics of the school. Of those students interviewed, 14 (35.9%) were in Year 7 at the time of the study, 10 (25.6%) were in Year 8 at this time and 15 (38.5%) were in Year 9. Of those interviewed, 8 (57.1%) Year 7 students and 8 (53.3%) Year 9 students were in the schools' academic enrichment classes for science. This is disproportionate to the numbers of students who participate in these classes within the cohort, with 30 (12.3%) and 64 (24.4%) for Year 7 and Year 9 respectively.

4.3 Teacher Perspectives of Construction Zone Activity (CZA)

Teacher participants were asked questions in their semi-structured interviews that pertained to the research questions outlined in the previous chapter. Major themes (appear in more than 50% of teacher's transcripts) and minor themes (appear in less than 50% of teacher's transcripts) emerged from answers to the questions in each general category and are presented in Table 4.2. Each of the categories is further elaborated where appropriate, into the major themes and minor themes arising from the data collected.

Table 4.2

Data Reduction Matrix for Teacher Participants

Themes	**Teacher**					**Theme: Major or Minor**
	A	**B**	**C**	**D**	**E**	
Category 1: Aims, Intentions and Significance of CZA						
Improved or Diff Thinking		*				minor
Social Construction	*	*	*	*	*	major
Participation	*				*	minor
Knowledge or Conceptual Understanding	*		*			minor
Application				*		minor
Justification		*				minor
Resilience				*		minor
Skill Development	*			*		minor
Category 2: Strategies for CZA						
Grouping	*	*	*		*	major
Classroom Management Strategies	*	*	*	*	*	major
Teacher as Facilitator	*	*	*	*	*	major
Category 3: Teacher Perceptions of Student Involvement in Construction Zone Activity						
Perceptions of How Students Respond to Episodes of Construction Zone Activity						
On-Task Behaviour	*	*	*	*	*	major
Off-Task Behaviour	*	*	*	*	*	major
Learner Differences	*	*	*	*	*	major
Social		*		*		minor
Expected Outcomes for Different Students						
Evidence/Justification		*			*	minor
Think Differently		*				minor
Skill Development	*	*		*		major
Improve Knowledge or Conceptual Understanding	*		*		*	major

4.3.1 Teacher Aims, Intentions and Perceived Significance for CZA

In this section, the major finding related to Research Question 1 and Research Question 2 is that teachers' stated aims, intentions and perceived significance of the construction zone activity (CZA) within Thinking Science Australia (TSA) lessons showed considerable variation with some degree of overlap between individuals. Teachers identified a range of aims and intentions for CZA, such as participation or working with different people, yet the significances they attached to the CZA included discussion between group members, construction of knowledge and the potential links to students' life skills or the real world.

Teacher A emphasised social construction as being important in these lessons, particularly with respect to coming to a correct answer and the many valid ways to arrive at that point. This meant peers speaking together and "using all of their strengths to find a solution to a problem." For her, discussion with other students was a critical component of TSA that allowed students to have a better understanding of the problem and come to a solution they could not otherwise. This emphasis on peer discussion meant that Teacher A wanted everyone to participate in the TSA activities or at least capture "most of the students, most of the time."

Similarly, Teacher B's focus for CZA episodes was on the importance of working with different people in order to help students be exposed to "different people's opinions and ways of thinking." This was critical, as Teacher B stated:

> If they constantly work with their friends, they're not going to branch out and be exposed to new ideas and new things. So, for the construction zone activity, I want them to not only complete the activity, but be involved with new people each lesson if possible. (Teacher B)

Teacher B clearly indicated that, for her, CZA is essential to TSA lessons and the interaction with other students is more important than individual student answers. She stated that:

> It's the interaction and the discussion and the conflict they have within themselves and within their group and the resolution, I feel that's what Thinking Science is about a lot… a large part of it. Not only the science aspect of it, but that human… dealing with humans and dealing with your own thinking. (Teacher B)

Teacher E similarly emphasised the importance of discussion in groups to come up with an answer to the activity. For her, the teacher presenting information, such as "what a solid looks like and what a gas looks like" was de-emphasised in favour of students working in groups to "try and find an answer and do experiments to provoke their thinking." This meant that students enagaged in "constructivism type thinking" where they built upon ideas through their discussion. It was suggested that this made students more likely to take such ideas on. It also increased their participation, as they felt more comfortable, and allowed them to discuss their misconceptions and find out from others. This then allowed Teacher E to be a little more "abstract and bring it to a higher level", going from "specifics to more general ideas."

Teacher D saw CZA episodes as opportunities to provide students with a "conflict." She felt CZA aligned with her pedagogical focus on resilience and determination and the need to build these qualities in students, especially given "the fact that failure can be a motivation rather than a deterrent." She felt that development of skills, through working with other students and being able to come to consensus in a group aligned were needed for the real world. As she noted, this gave her students:

> The opportunity to utilise and develop their social skills and to, at the same time, work on their leadership skills and cooperative skills. (Teacher D)

To Teacher D, the challenge of "pushing them (students) out of their comfort zone, in regards to thinking and working and social constructivism is very important."

The value in being able to problem solve, work in groups and develop other skills was perceived to be a function of needs in the real world and this overlapped with sentiments expressed by other teachers. Teacher B noted the following when asked about what students were doing:

> They're working on problems. Either ones that they recognise or are new to them. And they're also building, I suppose, a network by working with different students. So, they're problem-solving, networking, which are big things in the workforce… They're life skills. They're practising life skills as well. (Teacher B)

Teacher A and C also felt that the group work emphasised and developed life skills. For Teacher A, this was important regardless of whether students liked the people they were working with or there were differences between the learners in the group, such as being introverted or extroverted.

Teacher C, who saw TSA lessons as asking teachers to be "socio-constructivists", also suggested CZA episodes might act as vehicles for developing students' skills such as negotiation. She hoped her students would be building concepts or knowledge that could be drawn upon in future lessons or "serious conversation." Unlike her peers, however, she questioned whether the lessons actually encouraged collaboration and the development of collaborative skills instead of just group work.

Proposition 1: Despite differences in their individual aims and intentions for Construction Zone Activity, participant teachers showed similarities in their perceived significance of CZA episodes especially with respect to the importance of group discussion, the constructive nature of the thinking that occurs and the potential relevance of CZA as a means to develop skills relevant to the 'real world'.

4.3.2 Teacher Strategies for Construction Zone Activity

In this section, the major finding relevant to Research Question 3 was that all teachers, irrespective of their stated aims and intentions, were able to describe strategies that they employed in order to maximise the perceived effectiveness of the CZA. For all teachers, this included the specific ways in which they managed the classroom environment. Teachers also discussed their strategic approach to the grouping of students expressly for CZA episodes. Finally, teachers described how they facilitated the work of groups during CZA episodes**.**

Grouping

With the exception of Teacher D, each teacher specifically described their strategic approach to grouping students with respect to TSA lessons, and more specifically, for episodes of CZA. Despite this, teachers varied considerably in how groups were constructed and their stated reasoning behind this.

Teacher A emphasised the importance of student participation. She then described how she consciously structured groups within her classroom to be diverse yet able to work together, stating:

> When I normally have my groups set up, I try and get a mix of students that… we've only got five or six boys in class, so I try and put one of those in each group to add kind of a different gender aspect. But also when I pick my groups, I try and pick them so that they will be able to work together. (Teacher A)

This approach towards conscious grouping was also reflected by Teacher E who had tried a range of different approaches, before settling on an approach that favoured students forming their own groups, stating:

> I've tried putting them in different groups to see what happens. I've tried putting bright students with lower ability ones. I've tried putting all the bright ones together and the lower ability ones together and I've tried putting them with friendship groups or out of friendship groups. I've actually found that they work better when they choose their own groups. (Teacher E)

For Teacher E, students who formed their own groups were more comfortable in expressing ideas, even when uncertain, which she believed had the most positive impact on students who were weaker. Citing an example of students who were divergent in their mathematical ability, she described observing the following during an activity involving probability:

> I remember going around to different groups a lot and listening to how they talked and questioning them and at the start you should see there was kind of two out of four of them that kind of got it straight away and they spent a lot of time explaining to the others. And when I questioned the weaker ones after, they seemed to have the idea… I think if I had put them in groups that they weren't comfortable with, the lower ability ones might not have been so good. (Teacher E)

For the other two teachers, group composition was intentionally dynamic. Teacher B, who prioritised students working with different people, randomly allotted groups using a card system as this allowed students to be exposed "to different ideas and different people's opinions and ways of thinking." Her reasoning was as follows:

> If they consistently work with their friends, they're not going to branch out and be exposed to new ideas and new things. So for the construction zone activity, I

> want them to not only complete the activity but be involved with new people each lesson if possible. (Teacher B)

However, for Teacher C, the desks in the room and the amount of equipment available for activities dictated a different approach. She chose to set up three pairs in a triad configuration as the room she shared had desks that needed to be returned to their original configuration. This allowed a flexible approach to groups in their classroom, with the teacher noting:

> You can have people facing the board if you want to, then they can work in pairs or threes which takes into account people who don't have a partner because they can work in twos or threes depending on the equipment you have as well… Instead of doing three trials each, each pair does a trial and that teaches collaboration and sharing. (Teacher C)

Teacher C also noted that not only was this approach time effective for her, but it addressed a problem presented by only having limited sets of equipment to support numerous groups. This prompted decisions around the number of students using one set of equipment and in turn, was suggested as the reason for not setting up specific groups.

> My groups are mobile and they can change from pairs, to threes of fours within that structure. If there was six of them sharing something, that can work as well because that's part of group positive reinforcement. (Teacher C)

One additional aspect of grouping that multiple teachers described, regardless of their approach to group composition, was that of having specific roles. For teachers that used specific roles within groups, students were randomly assigned to their roles or rotated through them in a teacher determined order. As Teacher A noted, this allowed her to:

> … make sure that every person in the group is responsible for something and to try and get students that are perhaps shy or work avoiders… involved because they know there are responsibilities and that changes every week. (Teacher A).

For Teacher C, however, roles were viewed differently. She consciously did not allocate roles, saying:

> I find that if I do that I spend my time answering low order questions or asking low order questions like 'Are you the reporter? Are you supposed to be talking to me? Are you the person who's supposed to be collecting equipment?' (Teacher C)

For Teacher C, it was preferable for students to have the equipment on their desk and have them "negotiate who does what with it." By having to sort it out amongst themselves and share their resources, she hoped it helped the students to develop their negotiating skills.

Strategies to Manage the Classroom Environment

All teacher participants were explicitly aware of the classroom environment and the management strategies they employed during the CZA. This included preparation in advance of the lesson and the ways in which they managed student behaviour throughout CZA episodes.

In order to facilitate episodes of CZA, teachers reported planning relevant aspects of the lesson's implementation ahead of time. For some teachers, this meant looking at the lesson ahead of time to determine the mechanics of the lesson and how resources were to be used. As Teacher C described:

> The main thing I am worried about is the number of pieces of equipment for activities we've got. Yesterday I only had 8 bags of materials for groups but I effectively had 10 groups, so you have to think, am I going to have four students on one bag, or two bags for three? That kind of thing. (Teacher C)

For Teacher A, planning also meant looking to see that they had the necessary materials for the lesson and understood when they were to be used and planning accordingly. For instance:

> … Look at the mechanics and work out, okay, the students only need the dice for the first activity and quite subtly just go and take it off them for the rest of it to lessen the distractions. (Teacher A)

Such decisions were also consciously made regarding scaffolded worksheets or workbooks that supplemented the lessons. Teacher A chose to only use one workbook per group in order to maximise "social construction."

Recognising that timing could be an issue, teachers also adapted their instructions and organisation for the lesson. In some cases, this meant structuring or altering the activities to complete the lesson. For Teacher D, this meant being “a bit more explicit with instructions” and changing how she scaffolded the class or activity based on the complexity of the activity. She noted she might:

> … give them two minutes to read the activity first and then one minute for one person or all of them to discuss what the activity is trying to say. That way it reduces the confusion and the time frame that’s spent on irrelevant parts. (Teacher D)

When referring to a classification activity in a TSA lesson that Teacher A had found to be very time consuming, she described relating organisational suggestions to other teachers. Rather than assort items onto limited shelves in a cupboard as described, she instead chose to get students to discuss how they had their shelves arranged at home. Such strategic choices were also described by this teacher as a function of “what the lesson was about.”

In addition to their preparation beforehand, all teachers described their own behaviours associated with behaviour management whilst students were working in episodes of CZA. Teachers described themselves as showing vigilance and moving through the classrooms during these times, often stopping to interact with groups at various points. This was often to ensure groups remained focused on their task. Teacher D explained that:

> It’s just making sure students are on task because there are opportunities for students to go off-track, so that’s why you try and make sure. Because there’s no such thing as free time. If you give free time to kids they will obviously make the most of it. (Teacher D)

This was further supported by Teacher B, who saw her use of proximity as allowing her to gauge the extent to which students understood the activity or were “on the right track.”

According to Teacher A, a lot of the monitoring could not be done just from the front of the room. She would spend most of the lesson walking around and visiting groups, with an ear for when the conversation changed. She suggested that:

> As a teacher you know it they are talking about other things. Your ‘spidey senses’ are tingling because there are words that perhaps aren’t in that and then you can go over and say, ‘Guys, what are you doing?’ to try and get them back on task. (Teacher A)

For Teacher A, sometimes the challenge was even just to get students to focus on what was happening within their groups as they were likely to “muck around with equipment” or “call out to other groups” which became highly disruptive. The frequency of the misbehaviour she perceived was also important, necessitating different levels of response. Teacher A, who described herself as having consistent rules for misbehaviour, explained it as follows:

> I suppose it’s how often they do it. I suppose it all goes back to the… bumps…There’s not threats, but my class knows there are consequences. If they get three warnings then it’s a duty. So that’s to fall back on if it’s really huge. Yesterday there was a bit of it so I just call out their name, get them to stop, maybe quieten the class so it’s silent and go back on again to try to refocus in their groups. (Teacher A)

Being aware of the dynamics of the class or individuals within group environments was also stated as an important consideration for some (Refer to Table 4.2). When discussing how groups were randomised and its effectiveness, Teacher B noted:

> I know there is one in that class, there is one social aspect I need to be aware of that… a negative interaction that’s been occurring. But I obviously manage that without the students being aware of it. (Teacher B)

For Teacher E, being aware of the dynamics meant a “bit of nudging” to get students back on task, particularly with a group of boys she described as very bright who needed the stimulus to refocus. As Teacher E allowed students to choose their own groups, she recognised this as a consequence of that choice. This did not mean, however, that all misbehaviour in groups necessitated the same extent of response. For Teacher E, sometimes the choice was not to intervene. As she described:

> Sometimes there’s that equipment we haven’t used before or used in that way. So with the Year 7s, we had the gears and they had never used gears before. Some groups were quite off-task, but I actually think they can learn a lot by mucking around with gears. So I wouldn’t say I encourage them to be off-task but I’m probably less on top of

> someone who's off-task but potentially learning than someone who's just sitting and having a chat. (Teacher E)

Teacher as Facilitator

All teachers described situations during which they facilitated student group work in the CZA; something that often coupled with their self-described behaviour management strategies. This included specific reference to the nature of their interactions with groups beyond simple management of perceived misbehaviour. Rather, it focused on aspects of their interaction such as clarification of the task and targeted questioning.

Multiple teachers reported that at times students were quick to seek teacher support for solving problems which Teacher A attributed to the nature of schooling. Teacher A noted that it was then her responsibility as a facilitator to:

> Come back, find out who the reader is for the day, get them to read it out, get other group members to ask those questions… Try and get the students to work it out themselves rather than relying on someone to tell them (Teacher A).

Teacher D also noted that sometimes, she was required to explain the task further to one or more groups as they did not understand, and this in turn, affected whether or not they were able to engage in the work.

For Teacher E, the first hurdle in CZA was getting students on-task. Often, she initially set them on task and then prioritised time with groups who were not working at the same level. This could mean choosing to "spend a little more time with that group or start them off and come back again," where other groups who did not have any major misconception were largely left alone.

Teachers also gave examples of their role as a facilitator in shaping group discourse and resolving dispute or conflict that could not be accommodated by the groups. Teacher B, for example, reported that she was sometimes drawn into conflict resolution as students worked. This could range from helping to negotiate the anxiety and uncertainty expressed by group members (such as when one group required a simple definition of flight to resolve anxiety and debate as to whether flight/flightless meant the same thing for their activity) through to managing discourse in groups containing students that had "all the answers and aren't willing to listen to others". As she stated:

> I have to remind them this is an activity that involves everyone being part of the discussion and being part of the thinking process. And it has to be a group agreement. It's not one person saying 'Well, I'm right. This is the decision that we're making.' (Teacher B)

As Teacher B discussed, this could mean standing there and allowing other students to share their ideas or views, help them listen to each other and have a group discussion.

Teacher D often used these opportunities to reinforce that students needed to work together and convince each other of their answers, so often prompted the students with targeted questions, asking them why they had done certain things, what evidence they had to support their claims, or what reasoning lay behind their argument. Similarly, Teacher B, who valued the justification of students' responses, noted:

> I will be aware of what questions they need to answer… 'Why did your group decide on that answer? Did anyone disagree with that answer? And how did you come to an agreement?' (Teacher B)

When asked such questions, Teacher B noted that some students often concentrated on having a "right answer" which was not the focus of activities designed to stimulate the students' thinking. This small cohort of students needed "constant justification" and to be reminded that there was no right or wrong answers in the discussions. She also noted that as a facilitator it was important to be non-judgmental, as this could impact the future likelihood of students sharing. This made the scale of questioning important as questioning within the small group structure maintained a safe environment and promoted accountability for answers.

Teacher C, who worked with an academic enrichment program group, reflected that she focused more on constructivism rather than individual accountability and the social part of the groups. Whilst she tried to help groups resolve their issues, it was a "difficult balancing act" with more than 30 students. Unlike the other teachers, Teacher C also made a distinction between the perceived nature of group work and collaboration in these lessons.

> It just says groups which is not collaborative because collaborative structures are there to teach people how to collaborate. So do you assume the students have that? Or do you teach them? (Teacher C)

For Teacher C, she felt, as a facilitator, that Year 7 students needed more instruction in how to collaborate, which was different to having roles within groups such as a leader or equipment manager. She reasoned that whilst teachers were good at facilitating aspects like use of equipment, she was not sure about engaging in low order questions and answers with students. Rather, she felt that prescribed skills or suggested collaborative skills that could be used would be more beneficial in these lessons.

Proposition 2: Teachers described and provided reasoning for strategies that they used to manage episodes of CZA within these lessons, including strategies for structuring their groups, strategies for managing their classroom environment and the strategies they employed as facilitators of group work.

4.3.3 Teacher Perspectives of Student Involvement in Construction Zone Activity

Teachers were asked in relation to Research Question 4 and Research Question 5 to articulate what they perceived to happen during episodes of CZA and the expected outcomes of involvement for students. This included behaviours that students were engaged in when they were supposed to be engaged in episodes of CZA and how the expected outcomes may or may not differ depending on each students' involvement.

How Students Respond to Episodes of CZA

Teachers recognised that students responded in different ways to the challenge of CZA including productive problem solving, as well as unproductive and disengaged behaviours. For example, when asked what students were actually doing during CZA, Teacher B noted that students were 'normally problem solving'. Teacher A echoed this sentiment, noting that students:

> …Should be working cooperatively… they should be able to work cooperatively and work out a balance. They should be trying to go through the task and again they should be trying to do that in a cooperative way… They need to be actively engaged in the

> task that we are doing… What should be happening is they should be doing it themselves and there should be all this working through it. (Teacher A)

According to Teacher C, who had taught one of the TSA lessons on classification:

> When I went around they were always trying to do something with the birds or they were arguing about different aspects of that picture which is surprising because sometimes you think they're talking about other things, but I think they're about 80% on task. (Teacher C)

Like her peers, Teacher E at least hoped that students were doing the right thing. To her, the majority of the class were doing the activity, even if they had not all done things like writing down their observations. These students had at least "all seen the activity and are able to complete the worksheet that asks them to write it down." Even the students who did not like to write stuff down had the chance to get in and do the "hands on" stuff she considered valuable.

Both Teacher A and Teacher B noted that it was also possible for there to be unproductive conflict during CZA with respect to student discourse. Teacher B noted that amongst her students there were "three or four that think that they are always right" and as a result got "very argumentative." For Teacher A, this conflict arose where "one student believes one thing and another student believes another thing." From her perspective, it was possible that one student was "unmovable on a point." Teacher E also acknowledged that some group members were likely to get "frustrated with others." However, from Teacher A's perspective, student discourse, particularly when they were trying to change each other's minds, could be a positive learning experience when it included "lots of different point of views in an argument" and "lots of evidence and working through it logically in a group".

Whilst most teachers felt that students were often engaged in a productive manner, it was quite possible for students to be distracted or engage in behaviours they deemed to be off-task with respect to what should be happening during CZA (see Table 4.2). As Teacher A put it:

> Certainly kids are doing the right thing. I think if you want all of them to be doing the right thing all the time, then I think you are going to be really disappointed at the end of the day. (Teacher A)

This could be attributed to a range of factors, often related to differences between individual learners. For example:

> We have students that are shy, students that are introverts and certainly trying to make them part of it is problematic and hard. Then there's the question, should we make introverts do group work? … Lots of studies have shown that introverts are very happy working by themselves and they get the most out of that. I'm also conscious of not pushing students that might feel awkward or not wanting to get involved… But other students who are work avoiders… these are the guys that respond differently. They think, 'I've got an hour to get out of doing work and I'm going to sit here and chat with my mates.' (Teacher A)

For Teacher A, those students perceived as trying to avoid work would "sit and stare into space, play with equipment and call out to other groups" which was considered quite disruptive. These interruptions also had the capacity to "get other students off-task" and given the highly talkative nature of the students, she felt it was a bit of struggle to "try and stop them talking." When asked what students might be talking about when they were off task, Teacher B summarised student discussion unrelated to the activities as follows:

> Have a chat. Talk about the weekend. Talk about celebrities… they will tell another person that they're wrong because they think it's funny. They don't realise that it's not the purpose of it. (Teacher B)

Observations about the effects of differences in the nature of the learners were made by all teachers although different reasons were given to explain the variable engagement. For Teacher B, some of the students she was working with seemed to participate less simply because they were highly observational students who would "sit back and just watch," choosing to involve themselves when they thought they should. Yet in the case of Teacher C's class, a failure to stay on-task may have been a product of boredom from one of her gifted students 'who thought she knew what she was doing'. In Teacher D's case, some groups were side tracked during CZA because they finished the task before the end of the time allotted, failed to see the next part of the activity, or did not take initiative.

Teacher E thought most students were happy with being engaged in a 'group experiment' and responded to the opportunity to use 'cool' equipment. This was not without its problems however, as this 'cool' equipment, which was sometimes new to students, could distract as much as engage from CZA.

> I think often when you have equipment they are interested in what the equipment is and you know if we have slaters they are doing slater races instead of what the experiment says to do. (Teacher E)

Social factors were also cited as a consideration during the CZA (see Table 4.2). For Teacher B, who used random groups to avoid letting students work with their friends, social pressures and peer identity were perceived to impact how her Year 9 students responded. The need to "look cool" and the pressure on students to be "seen as not enjoying something" prevented students from enjoying or expressing interest in some of the activities. Despite sometimes expressing negative attitudes toward the lessons, this could change as students became involved in the lesson, or with the passage of time as students started to perceive the TSA lessons as "not too bad now."

Conversely Teacher D, who worked with Year 7 students, perceived that social factors could impact participation in a different way with her younger students. She described her students as enjoying group activities and working outside friendship groups because the students were all very social and enjoyed "the chance to talk to students and question and try and understand and work with different people." It was possible that "132 students could come from 132 primary schools at this school" creating a massive range of attributes that differed between students. Whilst this initially posed a problem for the students who did not know their peers at the beginning, she noted it presented an opportunity to meet new students that led to the development of group work skills.

Teacher D also noted that student engagement or enjoyment of the activities could vary with other factors outside the lesson. As she suggested:

> Some days they might enjoy it or it might just have been that they didn't have breakfast this morning and they're really grumpy about it. (Teacher D)

Expected Impact of CZA on different students

When asked about how involvement in CZA was expected to impact different students, teachers gave a range of responses that aligned with their stated aims and intentions. In particular, teachers expected work in CZA to enable students to develop or improve their understanding, provide more evidence or reasoning behind their thinking and support the development of transferrable skills in the real world.

Teacher A expected that students would get a "greater understanding of concepts" that ran through the science curriculum. For more able students, these lessons were an opportunity to "strengthen their concepts by explaining them to other students" and a chance for students to "work out how they think and actually think about thinking for probably the first time in their lives."

Teacher E also hoped that students would see improved understanding from their involvement, especially due to the practical component. Whilst she perceived that not every student had a learning style that aligned with a "hands-on type of learning," she hoped that it supported at least some of the students. Often, she hoped it gave students greater evidence and more examples of ideas she was trying to build and helped them to stretch their thinking.

Opening students up to new ideas and concepts was also at the forefront of Teacher B's expected outcomes for students. Like Teacher A and E, she expected that being involved in CZA could enable students to:

> ...just to be aware of why they thought what they did. To be metacognitive. And I want them to be able to justify why they made a decision, I guess. And even if they say, 'Well, I was wrong.'… if they can describe why they were wrong or why they felt that they were right… if they can talk about why they're thinking something, I think we've achieved what we want to in Thinking Science. (Teacher B)

Teacher B did acknowledge that such metacognition may not be the same for all students. When asked if students who participated to different degrees benefitted in different ways, Teacher B stated the following:

> They do need to take part in it. They need to discuss things, they need to be an active group member and we have talked about being active group members and active listening in the past. (Teacher B)

Whilst she perceived that all students were working towards the same end point, often without realising it, it was Teacher B's perception that there were definitely different developmental levels with respect to the benefits of involvement in CZA.

Most of the teachers articulated that involvement in CZA episodes was linked to the expected development of problem solving skills that were referenced in the context of the students' future, or the real world (see Table 4.2). Students were expected to develop these skills that could be used elsewhere, whether in the context of future lessons or beyond. According to Teacher D, students did not:

> … necessarily see the value in being able to problem solve until they leave school and they are out in the real world and it is a skill that needs to be developed for your survival and it needs to be developed on. So it should be across all subject areas, this concept of problem solving. (Teacher D)

For Teacher D, students ended up taking from these lessons an ability to work with, and draw contributions from others, regardless of differences in the engagement or motivation or distraction or work avoidance of those others. Students could experience conflict in a group and still come to consensus in a considerate way. To her, this was a skill transferrable to the real world especially given that she identified that "being able to work with people is a necessity."

Skill transferability was echoed by Teacher B who expected that problem-solving and networking were life skills with workforce relevance. Whilst Teacher A perceived these as "skills for dealing with other people" and noted that students "may have to change their minds on something" including something "they may have held for a really long time."

Proposition 3: Teachers generally perceived students as engaging in purposeful, on-task behaviour during Construction Zone Activity but also recognised that not all students would engage in this way all of the time. Student engagement was influenced by differences in individual attributes as well as social factors.

Proposition 4: As a result of their involvement in Construction Zone Activity, teachers expected students to improve their conceptual understanding, provide more evidence or reasoning for their thinking and further develop transferrable skills applicable to their perceived future. These outcomes could be influenced by the extent to which students participated.

4.4 Student Perspectives of CZA

Student participants were asked questions in their focus groups that pertained to the research questions outlined in the previous chapter. Themes and sub-themes in the data collected emerged from answers to the questions in each general category and are presented in Table 4.3. Each of the categories is further elaborated where appropriate, into the major themes and minor themes arising from the data collected with propositions coming directly from the themes in each category.

Table 4.3

Data Reduction Matrix for Student Participants

Themes	Teacher (Class)											Theme: Major or Minor
	A (Yr 9)		B (Yr 8)			C (Yr 7 Academic Enrichment)		D (Yr 7)		E (Yr 9 Academic Enrichment)		
	FG 1	FG 2	FG 3	FG 4	FG 5	FG 6	FG 7	FG 8	FG 9	FG 10	FG 11	
Category 4: Aims, Intentions and Significance of CZA												
Improve or Think Differently	*	*	*	*	*	*	*	*		*	*	**major**
Work in Groups/Teams	*	*	*	*	*	*	*	*	*	*	*	**major**
Other Perspectives	*		*	*	*	*		*	*	*	*	**major**
Efficiency		*			*	*				*	*	**minor**
Better Learning/Idea/Answer	*			*	*	*	*		*		*	**major**
Skill Development			*			*			*	*	*	**minor**
Category 5: Student Perceptions of Small Group Discourse												
Procedural	*	*			*	*						**minor**
Discussion		*	*	*	*	*	*	*	*	*		**major**
Justification		*	*							*		**minor**
Regulation	*		*	*			*	*		*		**major**
Consensus			*	*	*				*			**minor**
No Right or Wrong					*				*	*		**minor**
Dynamics	*		*		*			*	*		*	**major**
Off-topic	*		*		*	*		*		*	*	**major**
Category 6: Student Perceptions of Student Involvement in Construction Zone Activity												
Perceptions of How Other Students Respond to Episodes of Construction Zone Activity												
Off-Task	*		*			*		*	*			**minor**
Learner Diff	*	*	*	*	*	*	*	*	*	*	*	**major**
Social	*		*		*				*	*	*	**major**
Expected Outcomes for Different Students												
Other Perspectives			*		*	*	*	*		*	*	**major**
Skill Development	*			*	*	*			*		*	**major**
Improve Knowledge or Conceptual Understanding					*		*	*		*		**minor**
Vary with Learner	*		*		*	*	*			*	*	**major**
Confidence	*			*	*			*	*	*	*	**major**

4.4.1 Student Aims, Intentions and Perceived Significance of CZA

In this section, the major finding, addressing Research Question 6 and 7 was that students' stated aims, intentions and perceived significance of CZA within TSA lessons, was concentrated around how students improved their understandings and their thinking, especially with respect to hearing other people's opinions, and the importance or value students placed on group or team work.

When asked about what happens in their groups in TSA lessons, students presented recollections of what they had been doing in lessons. For some, their aims and intentions in CZA were related to the conducting of the specific activities. For example in Focus Group 7, Student 7A stated:

> When we were categorising things we worked as a group because we all liked to think of something that we could categorise them on and why that would be useful to categorise them like that. (Student 7A, Focus Group 7)

Often, students were able to align their aims or intentions with a broader perspective than student 7A (see Table 4.3) suggesting that it was about thinking differently and doing the science in a "different way so that we sort of understood it more" (Student 1D, Focus Group 1), often by challenging them to think about the problems or concepts collectively, and for some, more deeply. As one Year 9 student described:

> So Thinking Science…it brings all these every day simple science ideas that we all accept but it really makes us question like… 'Why is it like that? Why do we think that way? Why is that being taught to us instead of something else?' (Student 10D, Focus Group 10).

Almost universally, students in this study reported that they perceived TSA lessons as "feeling different" to their normal science lessons (see Table 4.3). Students noted that what made the TSA lessons feel different had components related to the nature of their work in small groups, the importance of discussion in these groups and the way in which they worked together and learnt from each other. TSA lessons involved getting different people's points of view and allowed them to hear how other people in their groups and the class think. This was reported by many groups as improving their thinking (see Table 4.3). This idea was exemplified in Focus Group 7, where the following exchange occurred:

Student 7E: I think it’s very important, case when we get different people’s opinions and we mix it with our own, it can be a really great thing.

Student 7A: It can really help us think about the science we’re doing.

Student 7B: Yeah, because often if you’re working on your own, you wouldn’t be able to think of…about… things, except when they give you an idea you can expand on their ideas which makes your knowledge better and helps your thinking become better. (Focus Group 7)

Students felt that they did not just learn theories relating scientific concepts or variables that could be applicable elsewhere, but that they were given the opportunity to think outside the box. As such, they could develop something that moved beyond a “basic foundation” with “other people adding your building blocks to build up this creation and have a really massive and also stable idea” (Focus Group 10). It was suggested that individuals working alone could miss developing or hearing these better ideas or answers. For some students, the value of these lessons was linked to these collaborative opportunites, with one student stating:

> I like them because I like to hear other people’s opinions. Like I think I do better hearing other people’s opinions than working by myself. (Student 10C, Focus Group 10)

Students also emphasised how they worked in small groups (see Table 4.3). They reasoned that these lessons were “a lot about team work, in a group,” (Focus Group 4) and that the aim was to work out the problem together. In one group that emphasised the importance of team work, a student noted that there “are lots of activities that you do that need multiple things happening at the same time” (Student 1B, Focus Group 1), whilst others emphasised that team work enabled greater efficiency and ease in problem solving for a better outcome. Additionally, one Year 9 student saw CZA in TSA lessons as a chance to evaluate their group’s developing teamwork skills:

> We work on our grouping like, we get to see how our teamwork goes and how its building up like teamwork in our class, I reckon. And becoming more comfortable with each other. (Student 1C, Focus Group 1)

This idea of social development was also reflected through multiple focus group interviews, and occasionally related by the students to their perception of skills they would need in other contexts such as high school or their future careers or workplaces (see Table 4.3). As one student noted:

> Being in group work, especially in Thinking Science, is important because even all throughout life, if you get older and you decide to like going into a career that has something to do with science, everything is in group work. Like it's lots of scientists or doctors or whoever it may be, but it's always in group work. It's not just one person does everything. (Student 3B, Focus Group 3)

A number of students suggested that the work in groups enabled them to not only hear from each other, but gave them skills to help their future teamwork. TSA lessons were seen as an opportunity to learn to "cooperate with different minds" (Student 8C, Focus Group 8), something that was needed when working with people who did not necessarily all agree with you.

Additionally, some students reflected that, in coming to an answer as a team, their focus was on making a decision as a group. For some, it was more important to agree in their group, rather than be correct. Acknowledging that there could be multiple perspectives or ways to reach an answer, one student suggested: "Even if we get it wrong, we've worked together and we got an answer that we all think is right" (Student 4C, Focus Group 4). This was considered a measure of success for CZA.

Proposition 5: Students shared broad collective perceptions of TSA lessons as being different to their normal science lessons. Students perceived the CZA as an opportunity to develop or improve their thinking and teamwork skills and hear other people's perspectives.

4.4.2 Student Perspectives of Small Group Discourse

In this category, the major finding that addresses Research Question 8 is that students could describe the nature of discussions that happen when working together in CZA. Students noted the ways in which they worked as a team to attempt the activities, solve problems and used contributions from multiple individuals to produce consensus, regardless of whether it is ultimately the wrong or right answer. Students also acknowledged that there is a proportion of off-topic chatter that can be stimulated by a range of different factors such as the composition of their groups, or in the case of some of the more able students, potential boredom.

Additionally, students described ways in which they regulate their group talk to account for the different efforts of individual learners.

For most student focus groups, there was a clear acknowledgement of the way in which students used their episodes of CZA to engage in discussion related to the activities or the problem they were trying to solve. When conducting experiments in CZA students reported that they would talk about "how we could do this" and "what we've observed about the experiment" (Focus Group 6). This could include how they would actually complete their task, such as counting or using items or how to interpret the activity. In some cases, students reported experiences in their small groups such as the following:

> I remember there was like a dispute if there was an animal… if something was an animal because it looked like a little piece of string, so we weren't sure if it was an animal. And then someone didn't know what a duck was… if a duck was a bird. (Student 8B, Focus Group 8)

In such instances, students would draw upon their group mates to help better understand the task or question, or help those in their group who were struggling or needed support. Students also reported that on occasion, they would use the work other groups were doing and the different way they were doing something to assess whether their answer or approach was the best approach, which stimulated further conversation.

Some focus groups reported how they used their discourse to "try and figure out why and how it relates to the experiment" (Focus Group 10) or "what we have to do to solve this problem" (Focus Group 4). As such, discussion in small groups could involve proposing different ideas for the group to consider and evaluate in trying to come up with the best answer or a consensus answer. Students reported discussions in which they agreed, disagreed and then justified answers in order to come to some form of consensus. They often asked each other questions such as "What's your opinion on this? How could we work our opinions together to form the one solution?" (Focus Group 8) or "Oh, I have a different opinion," or "I think differently" (Focus Group 7). When working, students acknowledged that they would ask each other for better ideas and then use the one they felt best.

One group engaged in a TSA activity related to classification of birds described an example of this process in the following manner:

Student 9A: You got confused about the whole ostrich… it was like which category does it go into and it goes into this one because you look at its tail, it's tiny. It's like 'No, because it's wide, but that doesn't really mean that it's really long as in length.'

Student 9B: It's width. It's different to length.

Student 9A: Are we going to consider the width or are we going in the length part?

Student 9C: It just gets confusing.

Student 9A: Eventually we just settled for… the length of the tail… You'd think that it's just an ostrich's tail for crying out loud! You'd think, just put it into a category, but it's actually a lot harder. (Focus Group 9)

Disagreement was a natural part of coming to consensus within the groups. Some students reported that their peers would present dissenting opinions or perspectives to their own during discourse, but students would debate these ideas before reaching a compromise. For example:

> Well you do eventually even argue about… 'No I don't agree with this.' But then you eventually solve it by maybe going in between your answers, like maybe someone was on 40 and someone else was on 50. You would go 45 or something like that. (Focus Group 5)

Occasionally, it was also possible for the process of reaching consensus to be considered difficult as some group members held strong or forceful opinions and dominated group discussions. Whilst one group suggested it was "healthy to have a leader in a group" (Focus Group 3), they noted that it was important for individuals who were "particularly strong in the way of directing people" to ensure that group members still had the opportunity to feel like they had contributed.

In addition to discussing different ideas, students described using justification to lead individuals or groups to come to different outcomes from their collective discussion. This meant explaining why they thought their answers were right to other people or hearing people provide reasoning for the perspectives given by others in their group. For some focus groups (see Table 4.3), it did not matter if the answer decided on in the groups was wrong or right. As one group noted, when asked about their work as a group:

> Student 4B: If we all agree on one thing, I guess that's the main answer. And instead of one person agreeing on one thing and two others agreeing on one thing… it's one big group decision.
>
> Interviewer: So when everybody is on the same page, then your group work has been successful?
>
> Student 4A: Yeah. So even if we get it wrong, we've worked together and we've got an answer that we all think is right. Because they never say that we've gotten it wrong… or because every answer's right no matter how… if it actually is wrong we won't know because we're not told that it's wrong.
>
> Student 4C: We get to decide for ourself, what we think. (Focus Group 4)

Questions to be answered as part of group discussion in CZA were also sometimes described as stimulating thinking and prompting students to think and discuss simple or observed phenomena at a deeper level. For instance, when talking about density and salt solutions, a topic students in Focus Group 10 considered to be 'such a common thing' and an 'everyday simple science idea', with students recounting what they had been discussing in their small group:

> We were questioning… In our minds we knew the salt would dissolve but we were thinking, "How could it have dissolved? Where has it gone? Like, why has it dissolved? How has it dissolved?" (Focus Group 10).

Even so, most student groups acknowledged that it was likely that groups went 'off-topic' during some parts of their discussions. These discussions could include talk about students' daily lives, gossip, popular culture and social media, amongst other topics. This was attributed by some to group composition, such as whether friends were in the group or not, interest levels within group members or situations in which activities were finished earlier by some groups than others leaving time between perceived completion of a task and the start of the next activity.

Some of the Year 9 students in the academic enrichment programs also reported other factors that they believed shaped off-topic discussions. It was suggested that some students saw the lessons and activities in CZA as not counting towards much and being de-emphasised by individual students as a result. Further, there was “only so much thinking you can do about salt dissolving in water” (Focus Group 10), which students described as being potentially quite tedious. Acknowledging that they knew what was going to happen, such activities could prompt a shift to other topics. As one student put it:

> You’ve done it before or you know what’s going to happen because it’s like mixing salt in water. ‘What’s going to happen?’ And then, it’s like, ‘Well, that happened.’ (Student 11B, Focus Group 11).

If students also had to wait for this something to happen, but it required little monitoring or changing, it was seen as possible for students to get distracted.

Year 7 students in the academic enrichment program, described another reason students may end up off-topic:

> Yeah, we’re like a really vocal class. We always talk a lot. Sometimes we get off track because (Teacher C) will be telling us something and then we’ll go, “Oh, but I’m pretty sure this happens.” And then we’ll just go way off-topic and be talking about something, a totally different aspect of science. (Focus Group 6)

As much as they might get off topic, students did acknowledge ways in which they regulated their own group discussions and eventually returned to working on the task. Additionally, as not everyone was always perceived to contribute in the same way or to the same extent, students would note how they might ignore the non-contributors or try to get them involved by drawing them into conversation.

> You go, ‘Oh, what do you think of this? What’s your opinion? How would you do it differently? Or would you do it differently?’ Or something to try and get them involved more. (Focus Group 1)

In the case of shy students, this could also involve trying to coax answers out of the student more covertly or speaking on their behalf, especially if they were not confident to share their answers. Where students were distracted, groups also acknowledged that eventually one or two of them would bring the group back to focus. As much as they might be distracted, groups still felt they got their work done. As one group of boys explained:

> We get distracted. And like we go off and have a joke and a laugh and then we get back, mind set on what we're doing. We've had our laugh, that's over now. Now we're getting back to work. (Focus Group 8)

Proposition 6: Students perceived and gave examples of the ways in which they work together through small group discourse in order to solve problems and understand experiments or activities during episodes of Construction Zone Activity. Students also recognised that though they can regulate their small group discourse internally, they do engage in off-topic discussions for a range of reasons.

4.4.3 Student Perspectives of Student Involvement in CZA

Students were asked in relation to Research Questions 9 and 10 to articulate how they perceived other students behaved during CZA in TSA lessons and the expected outcomes of involvement for these students. This included behaviours that students were engaged in when they were supposed to be engaged in CZA and how the expected outcomes may or may not differ depending on each students' involvement.

How Students Respond to Episodes of CZA

When asked about how other students responded to CZA, students provided a range of possible responses drawn from their observations. This included engagement or enjoyment, social dynamics within groups and the tendency to get distracted.

Students acknowledged across multiple focus groups that individuals saw and approached group work in different ways. Enjoyment and engagement in TSA or science more broadly were cited as one of the factors that could influence how other students responded and participated in CZA. For instance, students often recognised that peers may not be as motivated to contribute if they did not enjoy TSA lessons, or that individuals sometimes preferred to work alone (see Table 4.3). Rather than argue with their peers to get their point across, or deal with the assertiveness or delegation of others, working alone meant an individual's ideas went unchallenged. One student in Focus Group 6 described it as follows:

> … I used to prefer to do everything individually, because sometimes, people don't agree with your ideas and you want to change that and the other people don't agree with you. So I prefer to work individually, so I can just do it all on my own. (Student 6B, Focus Group 6).

Additionally, it was suggested that perhaps students were just shy or lacking in confidence in these situations. By working alone, or trying to keep to themselves, students did not have to worry if their answers were right or if others thought they were wrong.

As not all students knew each other within a class, especially in the case of Year 7 students, it was possible they could be with people they were less socially comfortable with, or who were from different social groups. As such, they perceived that they had less in common with each other and this could limit whether students asked each other questions. Existing friendships within these groups could also be problematic. For student 3C, for instance:

> … you would be more comfortable with your friends, but then when you do get in a group and there's two best friends, there is like… they're not contributing to the group because they don't really care. They just want to talk and talk and talk... not a lot of work gets done. (Student 3C, Focus Group 3).

Alternatively, it was suggested that some peers may be more interested in being in different groups and as such, they could be distracted during CZA. As students in Focus Group 1 explained:

> Student 1C: They don't leave the group physically, but they leave you. They'll go and talk. They'll just go across the classroom or become involved in something.
>
> Student 1D: Or they'll turn around and talk to the person behind them. Or they'll just sit there and do nothing.
>
> Student 1B: Just stare into space. (Focus Group 1).

On the more positive side, not knowing students in the group also limited the likelihood of going off task. Non-friendship groups could also make it easier for students to settle down to work in CZA. At the same time, moreover, students noted that such groupings meant that they did get chances to make friends and develop bonds with people they previously had not known. Having friends in a group made it easier in the minds of some students to know what others were trying to say, as much as it made their peers feel more safe and willing to contribute.

Across multiple focus groups, regardless of rationale put forward by students, it was expressed that variable investment into the group work happening in the lesson did make it more challenging to engage fully with the activity.

Expected Impact of CZA on different students

When asked about how involvement in CZA was expected to impact different students, students gave a range of responses that aligned with their stated aims and intentions. In particular, students emphasised that different learners could get different outcomes based on their involvement, effort or learning styles and that these lessons helped students develop skills and confidence to work together and be open to new ideas, which were also important in the future.

For students, there was some general consensus that participation in TSA lessons could improve conceptual understanding (see Table 4.3). However, amongst students there was no expectation that everyone would get the same outcome as a result of having participated. For some students, it was perceived that “not everyone’s going to get the same thing out of it because everyone’s mind works differently” (Focus Group 3). As expressed by one student:

> Well, some people might think deeper into the subject. And then, so some people could get just a simple idea. And then those people who maybe think deeper could understand a bit more and maybe figure out a couple of things might be a bit wrong.
> (Student 7A, Focus Group 7)

For those who learnt differently, for example benefitting from discussion and practical work, students felt the lesson may have more of an impact than for other types of learners. Individuals across some focus groups expressed that even though they could see benefits from TSA lessons, they weren’t always of benefit to them personally. As Student 1D expressed:

> I think it also depends what lesson it is, like what we're doing. Some lessons I know I've gotten a lot out of but other lessons… I don't see any reason to be doing it like this. I can't see how this has impacted me. (Student 1D, Focus Group 1)

The varied involvement of their peers in CZA was also generally expected to impact the extent to which said peers benefitted. Students felt that those who "don't really want to put in the effort" were unlikely to "get as much out of the lesson as what they could have" (Focus Group 1). Students who were quiet, introverted or communicated less could still be getting information and learning how to solve problems, but "if people are talking about celebrities and all that, they're not getting much out of it" (Focus Group 5).

Students also believed that involvement in episodes of CZA within these lessons had helped to develop their communication skills and other skills that they labelled as having applications to the real world or the future as they perceived it. The work in small groups was described as aligning to students' futures with students referencing potential benefits to skills around organisation and teamwork. This came in the form of comments students made such as:

> …All throughout our life we're going to be working with other people so I guess it's good to have some group work to have now and like learn how to express your ideas and stuff. (Focus Group 4).

In addition to perceived benefits to skills, students described feeling more confident from their involvement in their work in small groups and felt more open to new ideas. Students across multiple focus groups noted that episodes of CZA provided opportunities for them to bond with each other and allowed for "strengthening your ability to make friends with people you've just interacted with" (Focus Group 8). It not only made them feel more confident, but reinforced ideas of team work, cooperation and an openness to the ideas of others. This also meant, especially when working with people other than friends, that students were better able to "get a different perspective" and "different ways to look at a situation" (Focus Group 11).

As not all students participated in the same way, or got to be in groups with people they liked, students did express that skills and confidence were important since "you've still got to work with them which does happen in real life" (Focus Group 11). As one student noted:

> ... if you're working with people who don't really want to do that then you kind of have to take a bit more charge whereas if you are the people who don't really want to do it then you see that they want to take more charge and that you should probably put in more effort. (Focus Group 11)

Proposition 7: Students generally perceived that not all of their peers engaged in purposeful, on-task behaviour during Construction Zone Activity. Students felt this was influenced by individual differences between learners as well as social factors.

Proposition 8: As a result of their involvement in CZA, students generally perceived that they could build confidence, be more open to hearing other perspectives, improve conceptual understanding and also develop transferrable skills applicable to their future. They perceived these outcomes to be influenced by the extent to which students participated in CZA episodes.

4.5 Summary of Findings

This chapter summarised the findings from the semi-structured interviews of teacher participants and the semi-structured focus groups conducted with some of their students at a single high school in Western Australia. The demographics of the teacher cohort were skewed toward female teachers whilst encompassing a diversity in teaching experience and training and practice with the program. Students were drawn from all three years involved in the program during 2015 and were largely representative of the student cohort at the school. The qualitative responses collected from participants gave rise to eight propositions; four from teacher responses and four from student responses. These propositions and their links to the literature and theoretical framework of the Thinking Science Australia program will be discussed and interpreted in the following chapter.

CHAPTER FIVE
THEMES AND DISCUSSION

5.1 Introduction

The purpose of this study was to determine teacher and student perspectives of Construction Zone Activity (CZA) within Thinking Science Australia (TSA) lessons. The main objective in gathering the qualitative data was to ascertain what perspectives each group held and how these perspectives might align and diverge from one another. A range of themes and sub-themes emerged from the data, leading to propositions detailed in the previous chapter. This chapter discusses the study findings, and represents the researcher's interpretations of patterns and major trends emerging from the qualitative data. Major themes that emerged from the data for both groups included themes related to the aims, intention and significance of CZA, student responses to CZA and expected outcomes for different students. Additionally, themes emerged regarding teachers' strategies to manage CZA and students' perspectives of their small-group discourse within CZA that were unique to specific groups of participants. The Chapter explores the convergence and divergence of major and minor themes.

5.2 Convergence and Divergence of Themes

Given the mutually negotiated, reciprocal and collaborative nature of learning, it seems appropriate to consider the emergent themes from the data in context of both groups, rather than in isolation. Figure 5 was constructed to show the convergence and divergence of the emergent themes and sub-themes within categories common to both student and teacher participants. Teacher and student categories are in the large blue box to the left and right respectively. Divergent themes from teacher data are to the left, whilst divergent themes from student data are to the right. Between the two boxes are convergent themes. In the case of all themes displayed, the strength of the emergent theme (major or minor) is emphasised by arrow thickness. Two of the emergent categories, *Category 2: Teacher Strategies for CZA* and *Category 5: Student Perceptions of Small-Group Discourse*, were not included in the construction of this diagram due to their uniqueness to the teacher and student groups respectively. In the case of teacher and student groups, many themes converged from the data including themes around skill development, on and off-topic discourse and individual learner differences, whilst students and teacher participants had divergent themes with respect to their aims, intentions and perceived significance of CZA and the expected outcomes of CZA in these lessons.

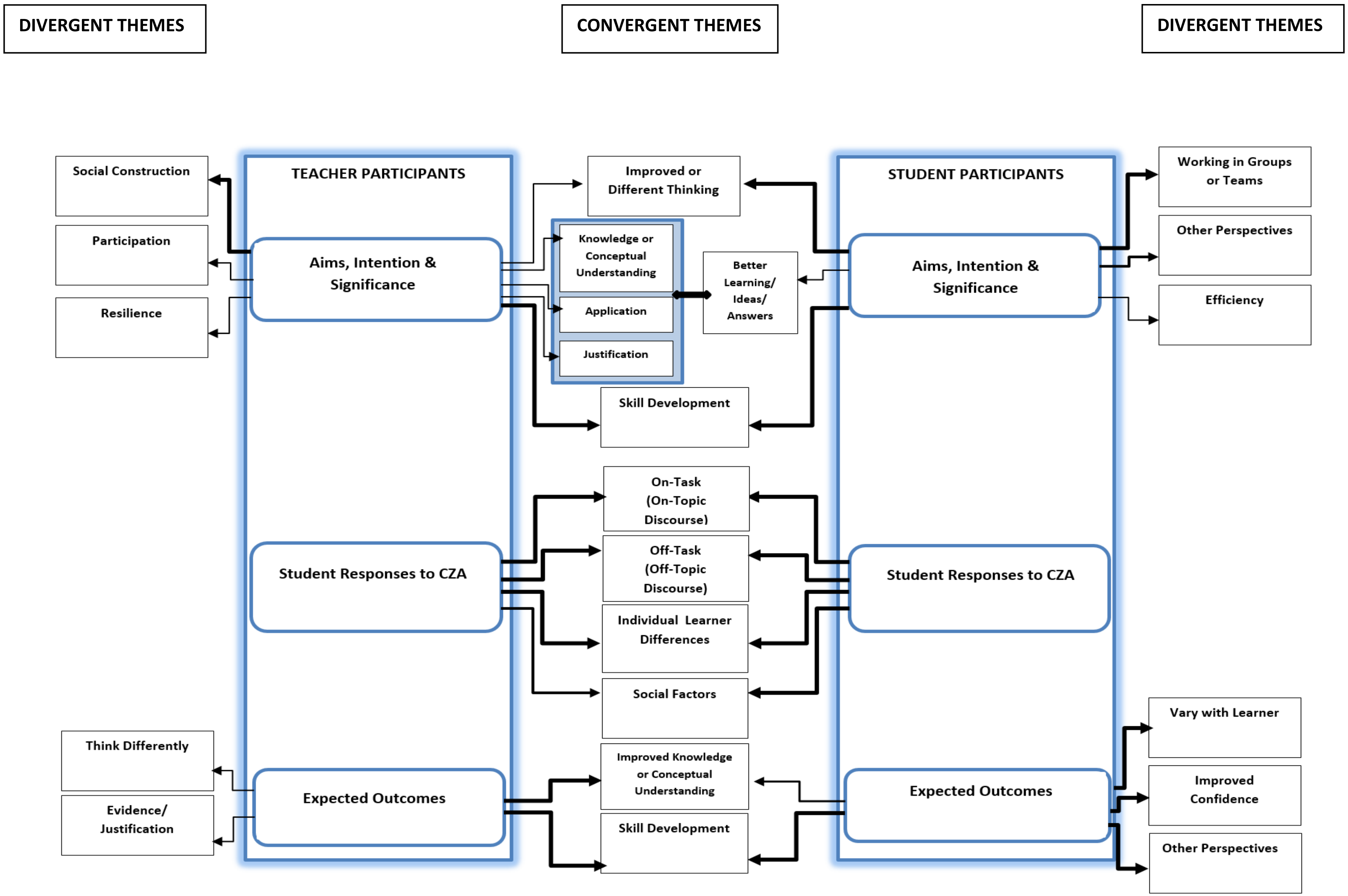

Figure 5 *Diagrammatic representation of the convergence and divergence of major and minor themes from the data.*

5.2.1 Aims, Intentions and Perceived Significance of CZA

Cognitive acceleration programs such as TSA are demonstrated to have a positive outcome for student cognition as measured by pre- and post-test cognitive reasoning tasks. Studies (e.g. Oliver & Venville, 2016) demonstrate continued currency, at least in Australian schools, for the impact of this intervention program some three decades following the original intervention. The weight of evidence for the program as an intervention to develop students' thinking and reasoning (e.g. critical and creative thinking skills) has been used to encourage its adoption by schools. Whilst many of the themes emerging from teacher data can be aligned broadly under the umbrella of thinking, teachers in this study discussed a wider range of themes than their students, especially those related to 'thinking'.

Teacher participants held perspectives of Construction Zone Activity as being important for the social construction of knowledge and skills, consistent with program pedagogy (Adey, 1999). It was clear across all teacher respondents that they understood that CZA involved students working together to co-construct their knowledge, even if not all teachers consistently used the specific terminology associated with cognitive acceleration. For most of these teachers, this social construction was not just about working together, but allowing students to be extended, which was expressed in different minor themes such as: *improved or different thinking*; *knowledge or conceptual understanding*; *application of knowledge*; and *justification of answers*. Only Teacher C, seemed hesitant as to whether this actually happened when students worked together in CZA and this appeared to be related more to a perceived disconnect between group work and collaboration in the lessons themselves.

Whilst teachers tended to focus on different aspects of thinking, only Teacher A seemed to directly acknowledge the idea of the product of co-constructed thinking in CZA as something beyond the scope of the students individually. This is consistent with the theoretical framework (Shayer, 2003) which positions CZA as the means for students to access Vygotsky's Zone of Proximal Development (ZPD). Teachers did imply that CZA was beneficial to some aspect of students' thinking (such as moving to more abstract thought), but did not appear to explicitly link CZA and ZPD in their responses. Whilst this might suggest a lack of understanding of the pedagogy or ZPD, across all teachers, there was articulated awareness of different program pillars, which suggests some underlying pedagogical awareness, if not understanding. It is quite likely that the focus on CZA has left the teachers' pedagogical understandings latent, or may reflect evolving understanding of pedagogy in some teachers who have not trained fully in the program. It is also not surprising that teachers do not make explicit links between CZA and ZPD, especially as CZA, or Act 2 of the theoretical framework, is explored in a more general and practical way for teachers undertaking training.

Interestingly, a theme to emerge from student focus groups was the importance of other student perspectives. In some ways, this aligned with the theme of social construction from teachers, with students emphasising that the value of these lessons was in hearing other people's ideas and ways of thinking. These lessons that 'felt different' to normal science lessons were considered beneficial for the inclusion of the thinking of others. It is quite possible that this theme reflects an inherent student understanding of the value of social construction and the ZPD in these lessons.

There were two themes that emerged strongly from student groups with respect to thinking: *improved or different thinking* and *better learning/ideas/answers* (Figure 5). These themes are consistent with how the program is delivered. Despite having different teachers, the program is introduced to students in the same or similar ways by teachers, using materials provided initially through the training they undertook. The TSA materials emphasise key messages about the program as a way to improve students' thinking and utilise the data showing long-term grade increases for students involved in the intervention. It is worth noting that students do not simply repeat these ideas verbatim; they can provide qualification about how work in CZA allowed them to develop their thinking and the quality of their solutions. In this way, the theme of better learning/ideas/answers to emerge from student focus groups seems to align collectively with the minor themes generated from teachers that describe aspects of thinking such as *knowledge or conceptual understanding*, *application* and *justification* (see Figure 5).

Another area in which both students and teachers aligned was that of skill development, a theme which repeated itself across many of the participants. Both teachers and students approached this theme from the perspective of transferrable skills and the notion of skills that students would need in other contexts or applications. Students seemed to connect this very strongly to their possible future careers or workplaces with some recognising the perceived importance of these skills to multiple contexts including work as a scientist. Whilst it is not apparent from the data, the strong alignment between teacher and student here may be a product of teacher messaging in the classroom or more broadly reflect messaging around group work in the context of the college .

Unlike their teachers, who expressed a theme of social construction which focused more on a cognitive product from group work, students emphasised the importance of CZA as a vehicle for them to not only develop team work, but for a small subsection of students, efficiency (Figure 5). Students recognised the complexity of conducting the activities in the given time frames and saw CZA as a way to get this work done more effectively, whilst also helping them to be better at working together. This aligns with students' perceptions of skill development.

Teachers had two unique minor themes that diverged from student responses in this category related to participation and resilience (Figure 5). In these cases, such themes seem to reflect the individual teacher's underpinning philosophies that shape their pedagogy and thus hold resonance in TSA lessons. Given critiques that suggest the program may demotivate certain students (e.g. Leo & Galloway) or require pedagogical adaptation from teachers to suit the needs of specific student sub-groups (e.g. Venville & Oliver, 2015), such foci may be essential components; it is logical to think students who do not participate or can not handle dissenting opinions may struggle to benefit from CZA. Shayer (2003) does note the role of the teacher in encouraging the active participation of students, but it may be that divergence in teacher themes reflect the complexity of teacher's jobs and the infiltration of necessary foci and requirements placed on teachers more broadly.

5.2.2 Teacher Strategies for Managing CZA

The findings to Research Question 3 illustrate the strategic approaches taken by teachers with respect to maximising the perceived effectiveness of CZA in these lessons (not in Figure 5). In this category, teachers described their strategic approaches to managing CZA in line with their stated intentions. Three themes emerged strongly within this category: *grouping of students*; *classroom management strategies*; and *teacher as facilitator*.

Teachers described a range of different, but conscious, approaches to the grouping of students within TSA lessons and the structuring of groups to have specific roles for students. Teachers' individual grouping choices aligned with their stated aims, intentions and perceived significance of CZA in their lessons. For instance, Teacher A emphasised the importance of participation, structured groups to facilitate collaboration and rotated group roles to ensure every student could be involved. Teacher C was the only teacher who eschewed conscious grouping and roles altogether, citing the importance of focusing on higher order thinking instead of answer low order questions, yet this aligned with her hope that students would develop negotiating skills from CZA.

It is clear from the themes of *classroom management strategies* and *teacher as facilitator*, that teacher approaches to CZA align with Shayer's framework (2003). Teachers described actively and vigilantly monitoring the room, intervening in students' group work to question them and using questioning to further encourage active participation in the activities. Teachers also described how they moved through their classrooms, monitoring group work and discourse and how this informed whether they should intervene or not. Whilst intervention could be relatively minor, teachers moderated their intervention based on a variety of factors in the groups. These could include a sense of whether students were being productive, but also if student discourse was related to solving the specific problem and even whether students understood the nature of the task itself.

The conceptual framework proposed by Shayer (2003) recognises the role of the teacher in mediating cognitive conflict and encouraging active participation; However, teachers, through their responses, provide mechanisms by which this can be achieved. This includes the sorts of questions they asked of students, to the way in which they reframed activities for uncertain or confused students, and created the space and opportunities for students to have their discussions (see Kelly, 2007). Simply placing demands on students to interact and build consensus has been shown to potentially hamper intellectual tasks (e.g. Hogan, 1999) and given their stated aims, it is incumbent on teachers to have proactive and responsive strategies. Rather than simply leaving peer groups to mediate themselves during CZA, teachers described how they can be involved in getting groups started, managing distracting equipment or individuals, and engage themselves in conflict resolution between individuals to help groups better manage their interpersonal relationships and exchange their ideas. Even with skills to make this possible, developed through classroom practice, teachers often came into lessons having thought ahead as to how best to manage these situations as a product of previous experience or through the advice of experienced peers.

5.2.3 Student Small-Group Discourse

The findings to Research Question 8 illustrate the nature of discourse that occurs in small groups within CZA during TSA lessons. In this category, students described how they collaborated within a team during episodes of CZA, built consensus from individual and divergent contributions, irrespective of whether their solution was right. They acknowledged that they could be off-topic during these discussions, but also described the occurrence of self-regulating processes that allowed them to return to the activity at hand (not in Figure 5).

During CZA, students work with their peers to negotiate cognitive conflict and engage in discussions that allowed them to develop shared explanations and understandings in the context of the activities. Consistent with Shayer's theoretical framework (2003), students gave relevant examples in which they used this social construction in CZA to bridge the ZPD. Students described situations in which they relied on each other to establish and resolve cognitive conflict at different points throughout the activities (such as how to decide if ducks were animals or birds, or the optimal feature for classifying items), thereby gaining understanding of the problems posed and solving problems that they potentially could not when working alone (see Adey, 1999). It is purportedly this peer-peer discussion and mediation that facilitates intellectual development (Shayer, 2003; Oliver *et al.,* 2012) and even students acknowledged that they were challenged to take the 'simple' ideas, like those of salt solutions and density, deeper than they might otherwise.

Across focus groups, discussion emerged as a strong theme, with several related minor themes also appearing including: *procedural; justification; regulation; consensus*; and *no right or wrong*. It is evident from the ways in which students described their discussions that they largely align with the existing theoretical framework; students would create meaning in the context of CZA by trying to work out how to conduct the activities, proposing different ideas, testing those ideas against the activity or group, agreeing and disagreeing with each other and trying to resolve the conflict to come to some form of consensus, selecting and evaluating ideas to adopt only those they felt were better, aligning these discussions to descriptions in the literature (e.g. Shayer, 2003; Oliver *et al.*, 2012) and studies of small-group discourse (e.g. Kelly *et al.*, 2001).

Much as Howe (2014) suggested, students acknowledge that their discussions involved dissenting or contradictory positions that needed to be resolved. Students reported that they would present their positions and give reasoning to enable groups to reach a different solution. It is interesting, therefore, that for some students in this study, it did not matter if their answer was right or wrong; consensus was far more important than being correct. Students reported they were also often left to determine whether their answers were right or wrong. Whilst this may reflect the way lessons are structured and delivered by teachers to maintain cognitive conflict, it may also support metacognition and the notion that process is more important than product for social construction. Consistent with Howe (2014), poor answers may be just as likely to produce cognitive gains as good answers if students disagree with one another.

Research studies (e.g. Hogan, 1999; Kelly *et al.* 2001; Gomes, Mortimer & Kelly, 2011) have previously shown that discursive practices in groups are affected by interpersonal factors, which aligned with the emergent theme of *dynamics*. Students were not only contesting ideas to build consensus in these lessons, but navigating relationships with their peers, whether they held strong and forceful opinions, dominated group discussions, got off-topic or even refused to participate.

A theme that emerged consistently from student reports of their discourse was that off-topic behaviour did happen (Figure 5). Students all too readily acknowledged that they would talk about all manner of topics extraneous to the activities, citing factors like group composition, interest levels (especially given there was only "so much thinking you could do about salt dissolving in water"), time between activities or even excitement around science in general as reasons to be distracted.

Even though off-topic behaviour was acknowledged, students did not seem to let being off-topic or interpersonal dynamics stop them from achieving their goals within these lessons. A theme of regulation came through from some groups who described the particular lines of questioning or discourse that they engaged in to promote contributions from their peers and regulate or refocus discussion. Students did not feel this impacted their perceived productivity, however, with these regulatory mechanisms leading students to believe that they still got their work done.

5.2.4 Expectations of Student Responses to CZA

Both teachers and their students were asked about how different students responded to working in CZA in TSA lessons. From the data four common themes emerged. These were: *on-task (on-topic discourse)*; *off-task (off-topic discourse)*; *individual learner differences*; and *social factors* (Figure 5). Overwhelmingly, teachers and students interpreted these questions to be about manifest student behaviour within groups.

Teachers and students could both describe on-task and on-topic discourse and behaviour that they had observed directly during these lessons. On-task behaviour and discourse aligned strongly with the expectations outlined in the theoretical framework for TSA lessons; students were engaged in the activity, would cooperate to solve problems and present divergent perspectives and evidence that they needed to resolve. Sometimes, though it sounded unproductive to their teachers, students appeared to be mostly on task. This is consistent with students' self-reported group discourse.

Teachers were not surprised to see or hear students engaging in behaviour that did not fit with the kinds of productive problem solving that are expected in CZA in these lessons; in fact, Teacher A implied it was inevitable. This was validated in student responses, with both students and teachers providing examples of topics that could come up during discourse that were not related to the activities that students were working on.

As both teachers and students were aware of this off-topic behaviour, it raised questions about why students responded differently to the same activity. In the theme of individual learner differences, students and teachers alike theorised as to what attributes could lead to a varied response within or between groups doing the same activities. For teachers, they recognised that some learners were simply shy or more introverted and therefore appeared to participate less, a description validated by student groups. Teacher B noted that students might simply have been more observational than others which meant their involvement might be more selective, whilst others perceived students to simply want to avoid working. Student groups also suggested that for some students, it might have been simply been an avoidance tactic in order to avoid having their ideas invalidated or losing face in front of peers.

Another reason students might choose to work alone was because they held strong or forceful positions and felt it more efficient to work alone than be exposed to situations in which their ideas and thinking were challenged and tested. Teachers had indicated that these students were part of the environment they needed to manage and reported individuals who displayed these characteristics and who could be unmovable or frustrated in group settings. In this way, the findings support teacher perspectives of TSA lessons with gifted and high-achieving students from an academically selective context (Venville & Oliver, 2015). This aspect of the findings is consistent with Venville and Oliver's finding, given the case study school's high proportion of gifted and talented students.

Students and teachers in this case study also acknowledged that learners experienced different enjoyment or interest in both TSA and the associated activities. Teachers generally perceived that students found the lessons enjoyable, which contributed to on-task behaviour; a perspective validated from student data. For Teacher E though, students' interest might even be elsewhere, such as in the equipment itself, which could cause them to become distracted.

Students also noted that distraction was real, whether through interactions with others outside the group, or simply as a function of how teenagers themselves can be distracted spontaneously despite being on task. One interesting suggestion to emerge from Teacher D's interview was that this lack of enjoyment or engagement may even simply be out of a teacher's control; students come to lessons sometimes with other things affecting them and their moods.

Consistent with studies into student small-group discourse (e.g. Hogan, 1999; Kelly et. al, 2007; Gomes, Mortimer & Kelly, 2011), social factors were also perceived by both groups as impacting how students responded to episodes of CZA. Students suggested that the composition of their group, including the presence of friends, helped or hindered productive activity in CZA depending on circumstance. In some instances students perceived the work was easier with friends whose thinking they understood, or who made them feel safer to contribute, but it was also easy to be drawn off-task or excluded from groups because of friendships between individuals. A lack of friends in the group could also lead students to become disruptive to other groups. At the same time, students who did not know people in their groups could make new friends. Whilst this theme was comparatively for the teachers, some teachers noted their perception that students could be influenced by their peers' opinions of what was acceptable or 'cool'. Interestingly, for younger students, the challenge of working outside friendship groups may not be an issue; Year 7 students coming to the case study from a range of different schools relished the opportunity to make friends and work with other people. It is not clear whether this is unique to the case study school, or whether this is perhaps a product of Year 7 having made a recent transition to high school.

5.2.5 Expected Outcomes for Different Students

In this category, students and teachers showed converging themes related to their aims and intentions including: *improved knowledge or conceptual understanding*; and *skill development*. Much as they diverged in their themes related to the category of aims, intention and significance of CZA, teachers and students also showed divergence with teachers focusing on themes related more to thinking such as: *thinking differently* and *evidence/justification*. The following themes emerged from student data: *vary with learner*, *improved confidence* and *other perspectives (Figure 5)*.

Whilst students did not appear to emphasise the improvement of knowledge or conceptual understanding as strongly as their teachers, data from both groups suggested this to be an expected outcome for students in CZA. Teachers also had minor themes related to thinking differently and provided justification or evidence for their answers, although an analysis of the data revealed these to have emerged primarily from an individual teacher who had identified these in the earlier category.

It seems that students' and teachers' expected outcomes for students seem to largely align with their aims, intentions and the significance they place on CZA in TSA lessons. It is conceivable then to think that the outcomes of interactions in these zones would further reinforce or inform the perspectives groups or individulas hold with respect to CZA, especially within an interpretivist paradigm employing social constructivism. As such, it makes sense that teachers and students repeat some of their themes from earlier categories.

For students, the idea that the outcomes varied between learners was a unique theme that came down to two factors: (1) how much effort did students put in to CZA?; and (2) did this type of learning suit them? It makes sense in the context of the theoretical framework, that if knowledge is co-constructed and mediated through discussion and group work, that students perceived those who participated less as not getting the full benefit. Students did not think this necessarily excluded quieter or less communicative peers, but strongly perceived those who failed to engage fully in group work as not gaining the same things they did. Students did perceive that this type of learning was better suited to some than others, with some individuals saying they personally did not feel like they got anything out of the lesson or noting that the impact on their learning was dynamic over time. This aligned with students' perspectives of differences between individual learners being a factor in these lessons and may be explained by more than just differences between different minds. If students' application to CZA in these lessons are dynamic over time as suggested, they may feel they get less out of those lessons in which they apply themselves less, just as much as they may choose to apply themselves less if they do not enjoy or see value in the particular activity. Of the teachers, only Teacher E made passing mention of the possibility that different learners might develop to different levels as a result of their effort.

Another theme to emerge from the student data was one of improved confidence (Figure 5). Students described their abilities to bond and cooperate with others as being improved from involvement. Given the social nature of work in CZA, this is not surprising. This also opened students up to others' perspectives, a theme that had emerged in the category related to significance of CZA. Again, it seems only logical that being forced to accommodate and negotiate divergent positions within CZA imbues students with skills to open listen to and accommodate divergent perspectives more readily.

Both students and teachers converged on the same theme of skill development (Figure 5), with students and teachers alike contextualising the outcomes of involvement in CZA in the context of skills such as communication, problem-solving and other skills that they linked to perceived future careers and the real world. Teachers and students perceive all manner of transferrable skills that students may develop from being involved and this, along with demonstrated changes in teacher pedagogy (e.g. Venville & Oliver, 2015) may align with the long-term and far-transfer cognitive gains demonstrated for the TSA intervention.

5.3 Summary

Five major categories of major and minor themes emerged from teacher and student data. These included: the aims, intentions and significance of CZA; strategic approaches of teachers to CZA; student perspectives of small-group discourse; expectations of student response to CZA; and expected outcomes of CZA for different students. The emergent major and minor themes have been summarised in this chapter, and a discussion of these themes and the findings presented. The convergencies and divergencies in themes were displayed and summarised in Figure 5.

The final chapter, Chapter Six, outlines the study conclusions and the limitations of the study. The potential implications for those implementing cognitive acceleration programs such as TSA in school contexts is then considered.

CHAPTER SIX
CONCLUSIONS AND IMPLICATIONS

6.1 Introduction

This research aimed to explore student and teacher perspectives on CZA within TSA lessons and whether there were alignments within and between teacher and student perspectives. The data revealed that teachers and students do share a number of common and aligned perspectives regarding what occurs during CZA episodes in TSA lessons. Categories and themes emerging form the data provide a richness to the description of CZA in the theoretical framework of cognitive acceleration lessons such as TSA. This chapter summarises the significance of the research and explores its strengths and the limitations. Recommendations for teachers and schools are also presented and this may help inform the practice of teachers implementing such a program in their contexts.

6.2 Significance and Implications of the Research

The findings of this research are most significant for teachers who implement programs such as TSA in their schools. The findings support the theoretical framework of Thinking Science with respect to those activities occurring in Act 2, the Construction Zone. The findings indicate that students do engage in peer-mediated social construction and therefore access the ZPD through episodes of shared experimentation, activities and group talk that occur in TSA lessons. This is significant for teachers and schools interested in implementing such thinking skills programs in their own schools, especially as the construction zone, and the cycling between social construction, cognitive conflict and metacognition pillars of the program is an 'engine room' for students to make cognitive gains.

The findings also highlighted that, as teachers expect when working with groups of students, it is unlikely that students only contribute 'productively' in CZA, with students and teachers describing off-task behaviours, particularly with respect to discourse and behaviour that occur when students are set to work in groups. Whilst this could present a potential deterrent for those wishing to implement the program, the findings provide evidence that not only can teachers manage these episodes to maximise learner benefit, but students provide evidence of their self-regulation strategies that allow productive discourse to continue, even in the face of distractions or diversions from the task at hand. This has significant implication for teachers in the classroom during TSA lessons, as it can encourage them to explore and refine their own practice and help allay potential concerns that students can not, will not or do not engage productively in such problem-solving endeavours.

These findings have the potential to shape the practice of teachers and their understanding of TSA pedagogy, particularly with respect to CZA. Findings show that teachers drew on their skills as managers of classroom practice, in line with their stated aims, intentions and perceived significance of CZA, to proactively and responsively manage CZA episodes. The way individual students responded to episodes of CZA also served to inform the strategies teachers choose, and insights from both groups may help to explain why students diverge in their behaviours and how teachers can modify their approach to improve engagement. It also provides new avenues to consider in professional development opportunities for teachers, particularly for those who are finding it difficult to manage CZA effectively in their own contexts.

Figure 6 shows how the theoretical framework of cognitive acceleration programs like TSA can potentially accommodate the findings from this study. In this Figure, based on the work of Shayer (2003), the other acts have been de-emphasised to show how findings from this study may interact with the theoretical framework for Act 2, CZA in these lessons. Specifically, this Figure shows the interaction of teacher strategies, which inform and are informed by CZA, and the cycling between productive and unproductive student discourse during CZA.

With national approaches to science and STEM, emphasising the importance of thinking skills, including critical and creative thinking, and skills such as communication and collaboration, these findings may also have implications for teachers involved in developing and implementing programs that involve similar construction zones.

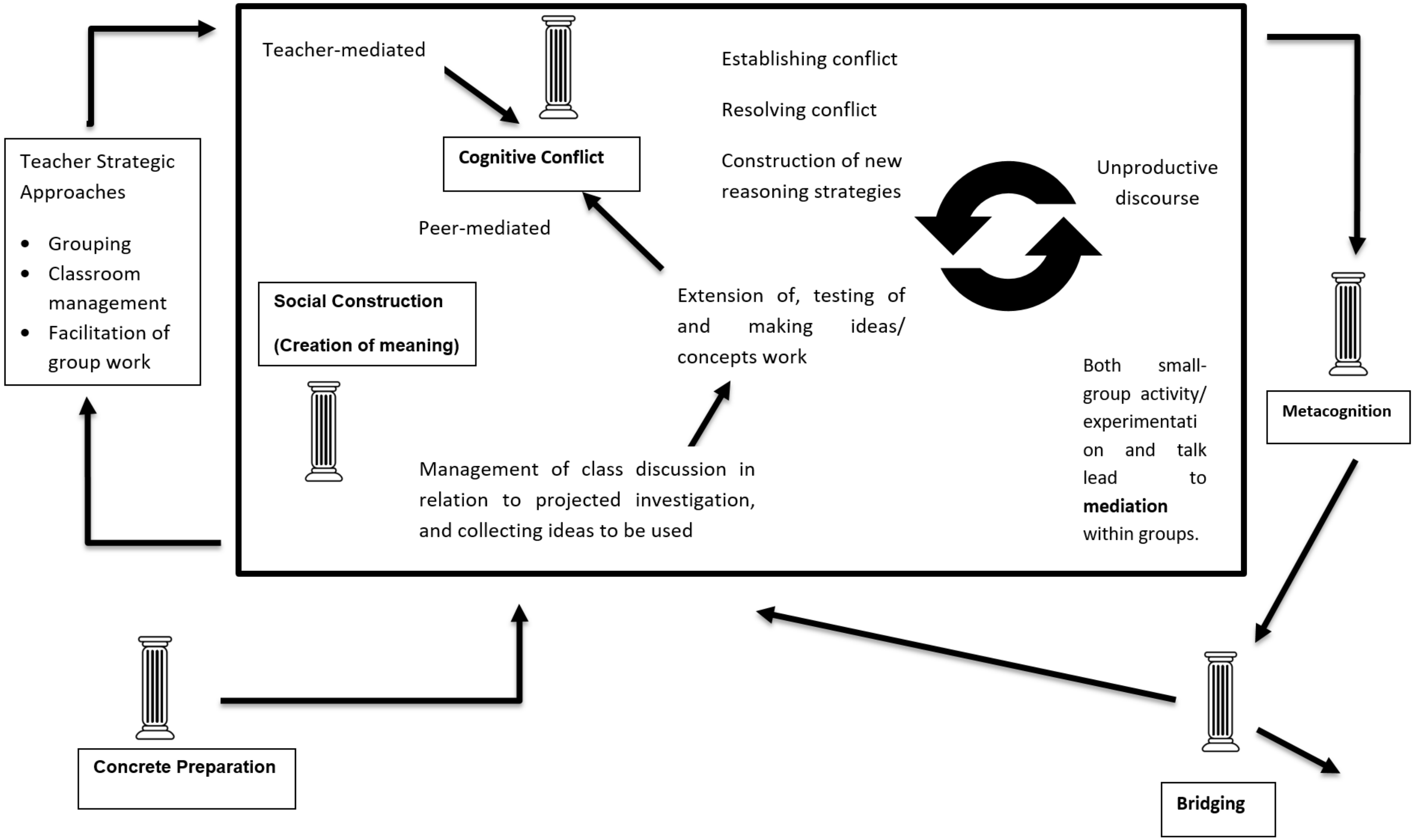

Figure 6 *Construction Zone Activity within Thinking Science Lessons (adapted from Shayer, 2003).*

6.3 Study Limitations

This study is limited in that it was conducted in a single school in Western Australia that comprises a cohort with a high proportion of students who are selected for their giftedness and talentedness in the Arts and have a comparatively high Index of Community Socio-Economic Advantage (ICSEA). Furthermore, it attracts and retains high quality teaching staff who all receive a minimum level of training in pedagogy and delivery of the program and may deliver it to multiple groups of students each year. It is, therefore, inappropriate to generalise the findings from this study. Given the detailed focus of the case study, some of the findings may be transferrable to other contexts. However, studies that analyse CZA in TSA lessons in other contexts are required to more fully understand how teachers and their students perceive what happens in CZA episodes and whether the findings are applicable in other schools, including those with lower ICSEA values, which may see lower relative gains that reflect lower staff and student stability, participation in professional development and fidelity with respect to the program (see Jones & Gott, 1998; Venville & Oliver, 2016). The disproportion of female teachers in the sample and disproportionate numbers of Year 7, 8 and 9 students, and academic enrichment students in both Year 7 and 9 may also limit applicability to other contexts. Furthermore, whilst there was recognition of potential impacts of individual learner attributes on student responses to CZA (see Leo & Galloway, 1995; McLellan, 2006; Venville & Oliver, 2015), this study did not directly seek to validate the relationship between student motivational world-views and their approach to TSA.

A significant weakness outlined in the study is the novice nature of the researcher, particularly with respect to their use as an instrument for data collection. According to Simons (2009), interviewers must employ good general communication skills, active listening and follow-up questions, without leading questioning or restricting the field of inquiry. These are skills that develop in this context with practice. Further, responses to the semi-structured interview questions indicate that whilst yielding rich data, students and teachers may have struggled to fully articulate some of their perceptions, and in the case of teachers, their existing perceptions and understandings of TSA pedagogy.

6.4 Concluding Comments

Teachers of science are under pressure to arrest declines in achievement, participation and retention in their disciplines and in line with national agendas for STEM Education, develop students' thinking skills that prepare them successfully for their future. As teachers negotiate pedagogical approaches that help them bridge this divide, programs like TSA are appealing. They offer resources and mechanisms to help teachers and have an underlying pedagogy that has power when brought in to mainstream educational discourse (Oliver & Venvile, 2016).

For teachers to adopt pedagogies for teaching thinking, they must understand them and well. Part of making sense of what happens when students engage in these episodes of small-group discourse, activity and experimentation is understanding it through the eyes of its participants. Where these perspectives differ, there is room to better understand just how such pedagogies work and, as a result, where teachers can develop their pedagogy further in ways that empower their own practice. This makes the findings of the research significant because they provide an in-depth exploration of a critical phase of a cognitive acceleration lesson from the perspectives of participants, thus contributing to the ability of teachers to improve their pedagogy.

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APPENDIX A Information Letter (Principal)

THE UNIVERSITY OF WESTERN AUSTRALIA
Achieving International Excellence

Professor Grady Venville
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Telephone: +61 8 6488 3811
Fax: +61 8 6488 1052
Email: grady.venville@uwa.edu.au
Web www.education.uwa.edu.au
CRICOS Provider Code: 00126G

[DATE]

PRINCIPAL INFORMATION FORM

Project Name: Student and Teacher Perspectives of Construction Zone Activity (group work) in the Thinking Science Australia Program

Dear [Principal],

My name is Professor Grady Venville and I am writing to you on behalf of the University of Western Australia (UWA). Mr Nathan Curnow is a Masters student at UWA and I am his supervisor. Mr Curnow is conducting a research project related to the *Thinking Science Australia* lessons that are currently being implemented in Year 7, 8 and 9 science classes at [name of school]. As you know, these lessons are conducted every two weeks and help students to think in scientific ways, such as being able to use variables and to classify.

I am requesting that you consider giving consent for this research to be conducted in your school. Participation in the research is voluntary and you are under no obligation to do so. Your decision not to participate will be respected. If you agree to allow the research to be conducted in your school, you may withdraw from the research up to two months prior to submission of the Mr Curnow's thesis which is scheduled for December 2015. This form contains important information for participants relating to the aim, benefits and risks, methods of data collection, the reporting of the findings, anonymity and ethics approval for this research. Please read the information carefully and store it in a safe place for future reference.

Aim
The aim of this research is to examine how both teachers and students perceive group work activities within *Thinking Science* lessons and how this impacts students' thinking skills and cognition.

Benefits and risks
This research is planned to provide information to teachers so they can improve their delivery of *Thinking Science* lessons. Students will benefit from improved quality of teaching and involvement in group work. The research has negligible or low risk to participating teachers and students because there is no foreseeable risk of harm or discomfort, and any foreseeable risk is no more than inconvenience. In the unlikely event that something happens during the research that causes any distress or embarrassment to any participant, data collection will be immediately stopped and any data that caused offence will be destroyed.

Data collection

Only teachers and students who volunteer to participate in the research will be involved in data collection.

This research will involve three methods of data collection.

1. Classroom observation: Classroom observation of one *Thinking Science* lesson that is part of the normal school routine will occur in one class of each teacher who volunteers to participate in the research. The researcher will observe, but not participate, in the lesson and will collect data by a pencil and paper schedule. He will be observing the students' participation in concrete preparation, cognitive conflict, social construction, metacognition and bridging. Parents will be instructed to notify the Head of Science if they do not wish for their child to participate in the research. Those students who do not want to participate in the classroom observation or who have parents/guardians that do not consent to participation will be given the option of sitting in a place in the classroom where they will not be the focus of the observation and data collection.
2. Teacher interviews: One-on-one interviews with volunteer teachers will take about 45 minutes and will be conducted by the researcher at a time convenient to the teacher. The interview will focus on the teachers' perspectives of the group work during the observed *Thinking Science* lesson. Teachers will be provided with guiding questions to allow them to consider their answers before the interview. Field notes and a digital audio recording will be used to record the interview, from which a transcript will be produced. Teachers will be provided with a copy of all data collected from the observation conducted in their classroom and their interview and they will be given the opportunity to provide feedback.
3. Student focus group interviews: A 30 minute focus group interview will involve approximately 4-6 volunteer students from each participating teachers' class and will occur at a time that will not disrupt the students' learning. These interviews will focus on the students' perspectives of the group work during the observed lesson. Students will be provided with the discussion topic in advance. The focus group interviews will be recorded by the researcher by pencil and paper notes and an audio recording. Students will be provided with a copy of all data collected from their focus group interview and they will be provided with the opportunity to provide feedback. Only students who volunteer to participate in the focus group interviews and who provide written permission and written permission from their parents will be included as participants.

Findings of the research

The findings from this research will be reported in Mr Curnow's Masters thesis and may be published in national and international conference presentations and academic and professional journals. Participation will be strictly confidential. Moreover, the name of the participating school, teachers and students will not be used in any publications and participants will remain anonymous.

The data collected from this research will be stored in a de-identified manner in a password protected computer. All data collected from the classroom observations and teacher interviews will be destroyed seven years after completion of the research. Data collected from students will be destroyed at the end of the year they turn 25 years of age.

Ethics approval

Approval to conduct this research has been provided by the University of Western Australia, in accordance with its ethics review and approval procedures. Any person considering participation in this research project, or agreeing to participate, may raise any questions or issues with the researchers at any time.

In addition, any person not satisfied with the response of researchers may raise ethics issues or concerns, and may make any complaints about this research project by contacting the Human Ethics Office at the University of Western Australia on (08) 6488 3703 or by emailing to humanethics@uwa.edu.au

All research participants are entitled to retain a copy of any Participant Information Form and/or Participant Consent Form relating to this research project.

If you would like to discuss any aspect of this research or have any questions please contact Mr Nathan Curnow on or me using the contact details below.

If you are willing to volunteer as a participant, please complete the **Consent Form** on the following page and return it to your Science Head of Department.

Yours faithfully,

[redacted]

Chief Investigator	Primary Researcher
Professor Grady Venville Graduate School of Education (M428) The University of Western Australia Telephone: (08) 6488 3811 e-mail: grady.venville@uwa.edu.au	Mr Nathan Curnow Masters by Coursework & Thesis Candidate Graduate School of Education (M428) The University of Western Australia Telephone: (08) 94337200 e-mail: nathan.curnow@research.uwa.edu.au

PRINCIPAL CONSENT FORM

Research Project: Student and Teacher Perspectives of Construction Zone Activity (group work) in the Thinking Science Australia Program

- I have read and understood the information letter about the study, or have had it explained to me in language I understand.
- I have taken up the invitation to ask any questions I may have had, and am satisfied with the answers I received.
- I understand that participation in the project is entirely voluntarily.
- I am willing to allow the project to be conducted in my school, as described.
- I understand I am free to withdraw from participation up to two months prior to Mr Curnow submitting his Masters thesis for examination without affecting my relationship with the research team or the Graduate School of Education, UWA.
- I understand that if I decide to participate and then later change my mind, I am able to withdraw participation up to two months prior to Mr Curnow submitting his Masters thesis for examination. If I choose to withdraw, all data collected from the school will be destroyed.
- I understand that participation in this research project will involve classroom observation of 3-5 Year 8 or 9 *Thinking Science* lessons, a semi-structured interview with 3-5 science teachers and focus group interviews with approximately 18 students.
- I understand that the interviews will be audio recorded.
- I have been advised as to what data is being collected, what the purpose is, and what will be done with the data upon completion of the research.
- I understand that all information collected will be kept confidential, and will only be used for the purposes of the research project. I understand the school, teachers and students will not be identified in any publication or presentation that results from this study. All information provided will be treated as strictly confidential and will not be released by the investigator to anyone. The only exception to this principle of confidentiality is if documents are required by law.
- I agree that the research data may be published provided that the name of the school, teachers and students or other identifying information is not used.

Principal's Name	Date	Principal's Signature

Approval to conduct this research has been provided by the University of Western Australia, in accordance with its ethics review and approval procedures. Any person considering participation in this research project, or agreeing to participate, may raise any questions or issues with the researchers at any time.

In addition, any person not satisfied with the response of researchers may raise ethics issues or concerns, and may make any complaints about this research project by contacting the Human Ethics Office at the University of Western Australia on (08) 6488 3703 or by emailing to humanethics@uwa.edu.au

All research participants are entitled to retain a copy of any Participant Information Form and/or Participant Consent Form relating to this research project.

APPENDIX B Information Letter (Teacher)

THE UNIVERSITY OF WESTERN AUSTRALIA
Achieving International Excellence

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Web www.education.uwa.edu.au
CRICOS Provider Code: 00126G

[DATE]

TEACHER INFORMATION FORM

Project Name: Student and Teacher Perspectives of Construction Zone Activity (group work) in the Thinking Science Australia Program

Dear [Teacher],

My name is Professor Grady Venville and I am writing to you on behalf of the University of Western Australia (UWA). Mr Nathan Curnow is a Masters student at UWA and I am his supervisor. Mr Curnow is conducting a research project related to the *Thinking Science Australia* lessons that are currently being implemented in Year 7, 8 and 9 science classes at [name of school]. As you know, these lessons are conducted every two weeks and help students to think in scientific ways, such as being able to use variables and to classify.

I am requesting that you consider participating in this research. Participation in the research is voluntary and you are under no obligation to do so. Your decision not to participate will be respected. If you agree to participate, you may withdraw from the research up to two months prior to submission of the Mr Curnow's thesis which is scheduled for December 2015. This form contains important information for participants relating to the aim, benefits and risks, methods of data collection, the reporting of the findings, anonymity and ethics approval for this research. Please read the information carefully and store it in a safe place for future reference.

Aim
The aim of this research is to examine how both teachers and students perceive group work activities within *Thinking Science* lessons and how this impacts students' thinking skills and cognition.

Benefits and risks
This research is planned to provide information to teachers so they can improve their delivery of *Thinking Science* lessons. Students will benefit from improved quality of teaching and involvement in group work. The research has negligible or low risk to participating teachers and students because there is no foreseeable risk of harm or discomfort, and any foreseeable risk is no more than inconvenience. In the unlikely event that something happens during the research that causes any distress or embarrassment to any participant, data collection will be immediately stopped and any data that caused offence will be destroyed.

Data collection

This research will involve three methods of data collection.

1. Classroom observation: Participating teachers and students will be observed in their classrooms during one *Thinking Science* lesson, which will form part of their normal classroom routine/curriculum. The researcher will observe, but not participate, in the lesson and will collect data by a pencil and paper schedule. He will be observing the students' participation in concrete preparation, cognitive conflict, social construction, metacognition and bridging.
2. Teacher interviews: One-on-one interviews with the teacher will take about 45 minutes and will be conducted by the researcher at a time convenient to the teacher. The interview will focus on the teachers' perspectives of the group work during the observed *Thinking Science* lesson. Teachers will be provided with guiding questions to allow them to consider their answers before the interview. Field notes and a digital audio recording will be used to record the interview, from which a transcript will be produced. Teachers will be provided with a copy of all data collected from the observation conducted in their classroom and their interview and they will be given the opportunity to provide feedback.
3. Student focus group interviews: A 30 minute focus group interview will involve approximately 4-6 students from each participating teachers' class and will occur during a time that will not disrupt the students' learning. These interviews will focus on the students' perspectives of the group work during the observed lesson. Students will be provided with the discussion topic in advance. The focus group interviews will be recorded by the researcher by pencil and paper notes and an audio recording. Students will be provided with a copy of all data collected from their focus group interview and they will be provided with the opportunity to provide feedback.

Findings of the research

The findings from this research will be reported in Mr Curnow's Masters thesis and may be published in national and international conference presentations and academic and professional journals. Participation will be strictly confidential. Moreover, the name of the participating school, teachers and students will not be used in any publications and participants will remain anonymous.

The data collected from this research will be stored in a de-identified manner in a password protected computer. All data collected from the classroom observations and teacher interviews will be destroyed seven years after completion of the research. Data collected from students will be destroyed at the end of the year they turn 25 years of age.

Ethics approval

Approval to conduct this research has been provided by the University of Western Australia, in accordance with its ethics review and approval procedures. Any person considering participation in this research project, or agreeing to participate, may raise any questions or issues with the researchers at any time.

In addition, any person not satisfied with the response of researchers may raise ethics issues or concerns, and may make any complaints about this research project by contacting the Human Ethics Office at the University of Western Australia on (08) 6488 3703 or by emailing to humanethics@uwa.edu.au

All research participants are entitled to retain a copy of any Participant Information Form and/or Participant Consent Form relating to this research project.

If you would like to discuss any aspect of this research or have any questions please contact Mr Nathan Curnow on or me using the contact details below.

If you are willing to volunteer as a participant, please complete the **Teacher Consent Form** on the following page and return it to your Science Head of Learning Area (HOLA).

Yours faithfully,

Chief Investigator	Primary Researcher
Professor Grady Venville Graduate School of Education (M428) The University of Western Australia Telephone: (08) 6488 3811 e-mail: grady.venville@uwa.edu.au	Mr Nathan Curnow Masters by Coursework & Thesis Candidate Graduate School of Education (M428) The University of Western Australia Telephone: (08) 94337200 e-mail: nathan.curnow@research.uwa.edu.au

TEACHER CONSENT FORM

Research Project: Student and Teacher Perspectives of Construction Zone Activity (group work) in the Thinking Science Australia Program

- I have read and understood the information letter about the study, or have had it explained to me in language I understand.
- I have taken up the invitation to ask any questions I may have had, and am satisfied with the answers I received.
- I understand that participation in the project is entirely voluntarily.
- I am willing to become involved in the project, as described.
- I understand I am free to withdraw that participation up to two months prior to Mr Curnow submitting his Masters thesis for examination without affecting my relationship with the research team or the Graduate School of Education, UWA.
- I understand that if I decide to participate and then later change my mind, I am able to withdraw my participation up to two months prior to Mr Curnow submitting his Masters thesis for examination. If I choose to withdraw, all my data will be destroyed.
- I understand that participation in this research project will involve classroom observation of a Year 8 or 9 *Thinking Science* lesson, followed by a semi-structured interview that will be conducted at a time and place that is convenient to me and the school and will last for 45 minutes.
- I understand that this interview will be audio recorded.
- I have been advised as to what data is being collected, what the purpose is, and what will be done with the data upon completion of the research.
- I understand that all information collected will be kept confidential, and will only be used for the purposes of the research project. I understand I will not be identified in any publication or presentation that results from this study. All information provided will be treated as strictly confidential and will not be released by the investigator to anyone. The only exception to this principle of confidentiality is if documents are required by law.
- I agree that the research data that I provide for the study may be published provided my name or other identifying information is not used.

☐

Please tick the above box to indicate you are willing to participate in an audio recorded interview.

Teacher's Name	Date	Signature

Approval to conduct this research has been provided by the University of Western Australia, in accordance with its ethics review and approval procedures. Any person considering participation in this research project, or agreeing to participate, may raise any questions or issues with the researchers at any time.

In addition, any person not satisfied with the response of researchers may raise ethics issues or concerns, and may make any complaints about this research project by contacting the Human Ethics Office at the University of Western Australia on (08) 6488 3703 or by emailing to humanethics@uwa.edu.au

All research participants are entitled to retain a copy of any Participant Information Form and/or Participant Consent Form relating to this research project.

APPENDIX C Information Letter (Student/Parent)

THE UNIVERSITY OF WESTERN AUSTRALIA
Achieving International Excellence

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Web www.education.uwa.edu.au
CRICOS Provider Code: 00126G

[DATE]

PARENT/GUARDIAN INFORMATION FORM

Project Name: Student and Teacher Perspectives of Construction Zone Activity (group work) in the Thinking Science Australia Program

Dear Parent,

My name is Professor Grady Venville and I am writing to you on behalf of the University of Western Australia (UWA). Mr Nathan Curnow is a Masters student at UWA and I am his supervisor. Mr Curnow is conducting a research project related to the *Thinking Science Australia* lessons that are currently being implemented in Year 7, 8 and 9 science classes at [name of school]. These lessons are conducted every two weeks and help students to think in scientific ways, such as being able to use variables and to classify.

I am requesting that you consider allowing your child to participate in this research. Participation in the research is voluntary and you are under no obligation to allow your child to do so. Your decision not to allow your child to participate will be respected. If you agree to allow your child to participate, you may withdraw your child from the research up to two months prior to submission of the Mr Curnow's thesis which is scheduled for December 2015. This form contains important information for participants relating to the aim, benefits and risks, methods of data collection, the reporting of the findings, anonymity and ethics approval for this research. Please read the information carefully and store it in a safe place for future reference.

Aim
The aim of this research is to examine how both teachers and students perceive group work activities within *Thinking Science* lessons and how this impacts students' thinking skills and cognition.

Benefits and risks
This research is planned to provide information to teachers so they can improve their delivery of *Thinking Science* lessons. Students will benefit from improved quality of teaching and involvement in group work. The research has negligible or low risk to participating teachers and students because there is no foreseeable risk of harm or discomfort, and any foreseeable risk is no more than inconvenience. In the unlikely event that something happens during the research that causes any distress or embarrassment to any participant, data collection will be immediately stopped and any data that caused offence will be destroyed.

Data collection

This research will involve two methods of data collection that may involve your child.

1. Classroom observation: Participating teachers and students will be observed in their classrooms during one *Thinking Science* lesson, which will form part of their normal classroom routine/curriculum. The researcher will observe, but not participate, in the lesson and will collect data by a pencil and paper schedule. He will be observing the students' participation in the group work and the way they interact with the teacher and other students during learning. If you are happy to allow your child to participate in the classroom observation you do not need to return the attached form to the school. If you do not want your child to participate in classroom observation you may notify the Head of Learning Area – Science, Mr. David Webster (ph: 98433 7200 or e-mail dave.webster@education.wa.edu.au) and s/he will be able to sit in a place in the classroom that is not the focus of the observation.

2. Student focus group interviews: A 30 minute focus group interview will involve between 3-6 volunteer students from each participating teachers' class and will occur during a time that will not disrupt the students' learning. These interviews will focus on the students' perspectives of the group work during the observed lesson. Students will be provided with the discussion topic in advance. The focus group interviews will be recorded by the researcher by pencil and paper notes and an audio recording. Students will be provided with a copy of all data collected from their focus group interview and they will be provided with the opportunity to provide feedback. If you are happy to allow your child to participate in a focus group interview please return the attached form.

Findings of the research

The findings from this research will be reported in Mr Curnow's Masters thesis and may be published in national and international conference presentations and academic and professional journals. Participation will be strictly confidential. Moreover, the name of the participating school, teachers and students will not be used in any publications and participants will remain anonymous.

The data collected from this research will be stored in a de-identified manner in a password protected computer. All data collected from the classroom observations will be destroyed seven years after completion of the research. Data collected from student focus group interviews will be destroyed at the end of the year they turn 25 years of age.

Ethics approval

Approval to conduct this research has been provided by the University of Western Australia, in accordance with its ethics review and approval procedures. Any person considering participation in this research project, or agreeing to participate, may raise any questions or issues with the researchers at any time.

In addition, any person not satisfied with the response of researchers may raise ethics issues or concerns, and may make any complaints about this research project by contacting the Human Ethics Office at the University of Western Australia on (08) 6488 3703 or by emailing to humanethics@uwa.edu.au

All research participants are entitled to retain a copy of any Participant Information Form and/or Participant Consent Form relating to this research project.

If you would like to discuss any aspect of this research or have any questions please contact Mr Nathan Curnow on or me using the contact details below.

If you are willing to allow your child to volunteer as a participant for the focus group interviews, please complete the **Parent/Guardian Consent Form** on the following page and give it to your child to return to his/her science teacher.

Yours faithfully,

[redacted]

Chief Investigator	Primary Researcher
Professor Grady Venville Graduate School of Education (M428) The University of Western Australia Telephone: (08) 6488 3811 e-mail: grady.venville@uwa.edu.au	Mr Nathan Curnow Masters by Coursework & Thesis Candidate Graduate School of Education (M428) The University of Western Australia Telephone: (08) 94337200 e-mail: nathan.curnow@research.uwa.edu.au

PARENT/GUARDIAN CONSENT FORM

Research Project: Student and Teacher Perspectives of Construction Zone Activity (group work) in the Thinking Science Australia Program

- I have read and understood the information letter about the study, or have had it explained to me in language I understand.
- I have taken up the invitation to ask any questions I may have had, and am satisfied with the answers I received.
- I understand that participation in the project is entirely voluntarily.
- I am willing to allow my child to become involved in the project, as described.
- I understand I am free to withdraw that participation up to two months prior to Mr Curnow submitting his Masters thesis for examination without affecting my relationship with the research team or the Graduate School of Education, UWA.
- I understand that if I decide to allow my child to participate and then later change my mind, I am able to withdraw my participation up to two months prior to Mr Curnow submitting his Masters thesis for examination. If I choose to withdraw, all data collected from my child will be destroyed.
- I understand that participation in this research project will involve classroom observation of a Year 8 or 9 *Thinking Science* lesson, and a focus group interview that will last up to 30 minutes and will be conducted at a time that will not disrupt my child's learning.
- I understand that the focus group interview will be audio recorded.
- I have been advised as to what data is being collected, what the purpose is, and what will be done with the data upon completion of the research.
- I understand that all information collected will be kept confidential, and will only be used for the purposes of the research project. I understand that my child will not be identified in any publication or presentation that results from this study. All information provided will be treated as strictly confidential and will not be released by the investigator to anyone. The only exception to this principle of confidentiality is if documents are required by law.
- I agree that the research data that my child will provide for the study may be published provided my child's name or other identifying information is not used.

☐

Please tick the above box to indicate you are willing to allow your child to participate in an audio recorded interview.

Child's Name	Date	Parent's Signature

Approval to conduct this research has been provided by the University of Western Australia, in accordance with its ethics review and approval procedures. Any person considering participation in this research project, or agreeing to participate, may raise any questions or issues with the researchers at any time.

In addition, any person not satisfied with the response of researchers may raise ethics issues or concerns, and may make any complaints about this research project by contacting the Human Ethics Office at the University of Western Australia on (08) 6488 3703 or by emailing to humanethics@uwa.edu.au

All research participants are entitled to retain a copy of any Participant Information Form and/or Participant Consent Form relating to this research project.

APPENDIX D Lecky Observation Schedule

Lesson observation schedule for CASE lessons

Date____________ Teacher____________Observer____________Class_________ Lesson____________No of students_______

Cognitive Activity /Time (mins)	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63	66	69	72	75	78	81
Concrete Preparation																											
Recall and/or application of concepts previously learnt																											
Recall and/or application of reasoning patterns																											
Apparatus																											
Identifying variables, characteristics, and/or their values																											
Activity to be done																											
New technical word																											
Data collected (for recording, not interpreting)																											
Other concrete preparation activity																											
Cognitive conflict and construction																											
Deducing and or using relationship between variables																											
Giving evidence of relationship																											
Explaining observation																											
Making predictions																											
Appreciating the cognitive conflict																											
Giving a general rule for solving similar problems																											
Other cognitive conflict and construction activities																											
Metacognition																											
Explaining how a problem was solved																											
Explaining why the task was easy or difficult																											
Explaining how their thinking has changed																											
Explaining what they have learnt in the lesson																											
Other metacognitive activities																											
Bridging																											
Stating reasoning pattern just learnt																											
Suggesting situation where reasoning pattern learnt could be used																											
Apply reasoning pattern just learnt to a new situation																											
Other bridging activity																											
Designing further investigations to be done																											
Using a different reasoning pattern (far transfer)																											

APPENIDX E CODES USED TO ASSIST DATA ANALYSIS AND EXAMPLES FROM TRANSCRIPTS

TEACHERS		
Category:	**Aims, Intentions of Teachers for CZA**	
Code	**Explanation of Code**	**Example from Transcripts**
Thinking Diff	Improved or different thinking as a result of working in the CZA	"I'm wanting them to work with different people so they get exposed to different people's opinions and ways of thinking. Because if they constantly work with their friends, they're not going to branch out and be exposed to new ideas and new things."
Social construction	Using discussion and peer-mediated discourse to collaborate on answers or solve problems.	"Also the fact that they can use this social construction… that they can sit there and talk it out and it allows and gives them time to be able to do that."
Participation	Participation of students in the group work activities.	'To make sure every person in the group is responsible for something and to try and get students that are perhaps shy or work avoiders… to get them involved.'
Knowledge/ Understanding	Development of conceptual understandings, knowledge or specific information in Science	"I'm hoping that they get something they can bring to a serious conversation either in that lessons or more likely on the next lesson."
Application	Applying skills or knowledge to other contexts	"My aim is to provide those students with a conflict where they then have to use and apply what they've learnt, either in that lesson or a previous lesson or even just knowledge that they already have and apply it to those particular situations."
Justification	Providing reasoning for answers.	"I'm wanting them to be able to justify their beliefs. There's a question they have to answer…. But I want them to be able to verbally justify their decisions. I think that being able to talk about their decisions is another skill they need to have."
Resilience	Development of resilience when working collaboratively or solving problems	"I find that some students aren't prepared to handle situations that require resilience and determination and the fact that failure can be a motivation rather than a deterrent."
Skill Dvlpment	Related to any number of 'skills' as referenced by the students. Could include teamwork, communication, problem solving etc.	"They're also building , I suppose, a network by working with different students. So they're problem-solving, networking which are big things in the workforce. I feel that they're skills that… they're life skills. They're practicing life skills as well."
Category:	**Strategies Used by Teachers to integrate CZA into TSA**	
Code	**Explanation of Code**	**Example from Transcripts**
CM Strat	Classroom management strategies of a teacher including proximity, monitoring, dealing with distractions during CZA.	"Being a bit more explicit with instructions… you gauge it and you walk around and that constant monitoring of the classroom and their group work indicates to you whether or not students are on task… You stop the class and give instructions in a clearer way if it needs to be... defined. It saves a lot of time in the long run and utilises the time you have on that activity."
Grouping	Dynamics and composition of student groups, intentional or otherwise.	"I've tried putting them in different groups to see what happens... I've tried putting all the bright ones together and the lower ability

		ones together and I've tried putting them with their friendship groups."
N8 Qns	Nature of questions being asked, may be quite targeted/specific or broad, depending on purpose.	"I will be aware of what questions they need to answer… "Why did your group decide on that answer? Did anyone disagree with that answer? And how did you come to an agreement." I find that those three questions work for not only me but my students as well… to make them feel safe"
TchrFacilitator	Teacher acting as facilitator for engagement of students in CZA.	"Come back, find out who the reader is for the day, get them to read it out, get other group members to ask those questions so be more of a facilitator for them getting there than say "It's this, this, this and this." Try and get the students to work it out for themselves rather than relying on someone to tell them."
Tchr Prep	Preparation by the teacher to meet their aims or intentions for CZA during the lesson and maximise outcomes. This can include management of resources such as equipment or time.	"To try and get them in groups to begin with and normally I would have set groups up that they would know about to get into to try and get them in quicker… making surew all my stuff's there… trying to look at the mechanics and work out, 'Ok. The students only need dice for the first activity.'"
Category:	**Teacher Perceptions of Student Responses to working in CZA in TSA**	
Code	**Example from Transcripts**	**Example from Transcripts**
On-task	Behaviour that is considered on-task, which can include discussion, collaboration and consensus building in the context of solving a problem during CZA.	"They are trying to work together… They are all putting bits into the puzzle and then assembling it all together… having lots of evidence and working through it logically in a group, saying "No. Well, we think this because of this…" and having to prove your argument against others."
Off-task	Behaviour that is considered off-task, which can include being distracted by peers or discussion that is 'off-topic'.	"They can sit and stare into space. They can play with the equipment… They call out into the classroom and to other people and that's quite distracting to themselves and others."
Learner Diff	Differences between individual learners and thus, their responses to CZA or activities contained within.	"We have students that are shy. Students that are introverts… Introverts are very happy working by themselves… but other students who are work avoiders, these are guys that respond differently."
Social	Social factors or pressures that may influence engagement or involvement.	"Their need to look cool and their peer… identity is more important than actually saying 'Yeah. Actually, I do enjoy these activities.' "
Category: **Teacher Expectations of Student Engagement in CZA**		
Code	**Example from Transcripts**	**Example from Transcripts**
Evidence/ Justification	Evidence, justification or reasoning to support their contributions or thinking.	"I hope that it is giving them a little more evidence towards supporting the idea I'm trying to get them to understand…. Often it gives them more examples of what we are talking about."
Skill Dvlpment	Development of skills, specified or unspecified, perceived to be pertinent to students' needs.	'It's all about the way they handle the situation and how they develop that into skills and strategies to cope with different situations and how they equip themselves to deal with different problems…providing a kid

		with a transferrable skill and pushing them out of their comfort zone in regards to thinking and working.'
Think Diff	A change in thinking as a result of working with others and hearing other ideas.	"Just to be aware of why they thought what they did. To be metacognitive. And I want them to be able to justify why they made a decision, I guess. And even if they say, 'Well, I was wrong.' That still… if they can describe why they were wrong or why they felt that they were right, even though that's not really what the case always, but if they can talk about why they're thinking something, I think we've achieved what we want to in Thinking Science."
Knowledge/Conceptual Understanding	Improved or deeper understanding of Science concepts/knowledge as an outcome.	"A greater understanding of concepts because there are lots of concepts that run through these, great science concepts… the more able students are able to strengthen their concepts by explaining them to other students."
STUDENTS		
Category:	**Aims, Intentions and Significance of CZA**	
Code	**Explanation of Code**	**Example from Transcripts**
Think Diff	Improvement or different thinking as a result of participation	"It's gotten us to think outside the box a bit more because the experiments usually … aren't really related to the topic that we're doing in class a lot of the time so when like it gets us to take our minds away from the topic that we're doing and open our minds again to something new."
Grp Work/TmWrk	Working as a group or team to solve a problem.	"It's a lot about team work, in a group, that you try and work something out together."
Other Perspectives	Exposure to the thinking or ideas of other participants in their group or class through CZA.	"I like to hear other people's opinions, like I think I do better hearing other people's opinions than working by myself."
Efficiency	Completing activities more effectively or efficiently.	"And when you get to doing the actual task, you have more people to do it so you get it done quicker and more efficiently."
Better Learning/Ideas/ Answers	Improving the quality of answers or ideas.	"Because then you have more ideas put into it and that way you can get a better result out. So if someone has like half the idea and someone has the other half then you'll figure out the whole thing instead of someone just putting in what they sort of think…"
Skill Dvlpmnt	Related to any number of 'skills' as referenced by the students. Could include teamwork, communication, problem solving etc.	"It gives you not only better social skills … yeah it can really help you to actually conduct these experiments on your own in the future."
Category:	**Student Perspectives of Small-Group Discourse**	
Code	**Explanation of Code**	**Example from Transcripts**
Procedural	Discourse specifically on how to conduct the experiment or activity, e.g. how to use equipment, collect data etc.	"You talk about what's happening like if you were counting like how you would… some of it's really hard to count or whatever so you'd have to find a way to do that and you have to talk about how you would actually get on with the task."

Discussion	Discourse around the problem, including areas of cognitive conflict. May include propositions, suggestions etc.	"I remember there was like a dispute if there was an animal… if something was an animal because it looked like a little piece of string, so we weren't sure if it was an animal. And then someone didn't know what a duck was. Someone didn't know if a duck was a bird. Or, and I told them it was a bird, so that kind of solved that problem."
Justification	Reasoning or evidence to support a position or idea.	"Yeah they kind of prove their point and you go, 'Well I think this because…'… "They're like, 'No. I'm right because of this.'…and then they show you…"
Regulation	Discourse that internally regulates or modifies individual or group behaviour.	"You try and get them involved. You go, 'Oh, what do you think of this? What's your opinion? How would you do it differently? Or would you do it differently?' Or something and try to get them involved more."
Consensus	Related to the agreement of a common final answer.	"If well agree on one thing, I guess that's the main answer. And instead of one person agreeing on one thing and two others agreeing on one thing and then it's all split up. It's one big group… so even if we get it wrong, we've worked together and we've got an answer that we all think is right."
Right/Wrong	Related to whether the answer is correct or not, e.g. if it matters if the answer is correct.	"Yeah. So Even if we get it wrong, we've worked together and we've got an answer that we all think is right… because every answer's right… if it actually is wrong we won't know because we're not told that its wrong."
Dynamics	How the different group members interact and respond to each other.	"Someone will just step up and go, 'Well…' They won't even say they're the leader, just everyone was like, 'Oh, well, they're telling us what to do, they're the leader.'"
Off-topic	Discourse that is unproductive in the sense that it is not related to solving the problem.	"We talk about cars, bikes and cool things like that. Weekends."
Category:	**Student perspectives on how other students respond to CZA**	
Code	**Explanation of Code**	**Example from Transcripts**
On-Task	Behaviour that is related to solving the activities.	"…we categorised different shopping items. We had a group of five and then you had all sorts of cut-outs of different food items from a magazine or something and you had to arrange them into three different categories."
Off-Task	Behaviour that is not related to solving the activities.	"They'll turn around and talk to the person behind them. Or they'll just sit there and do nothing."
Learner Diff	Differences between individual learners and thus, their responses to CZA or activities contained within.	'Some people might like it, like working in a group but some people might prefer to have their own answer and go it on their own.'
Social	Social factors or pressures that may influence engagement or involvement.	"… you would be more comfortable with your friends but then when you do get in a group and there's two best friends there, like it's a group of four, and then there's two best friends and they're just completely talking about

Category:	**Expectations of the perceived outcomes for students in CZA**	
Code	**Explanation of Code**	**Example from Transcripts**
Enjoyment/Engagement	Whether students enjoyed activities or not.	"Some people don't have a very positive attitude towards like doing Thinking Science… they think maybe it's a bit boring because they are never… listened to."
Other Ideas	Being able to recognise other people's contributions or perspectives as an outcome of participation.	"I guess it's not necessarily knowing how to you know, classify, and different variables. I guess this probably isn't the point of it, but it's like accepting other people's ideas. I guess that's one thing you could get out of it."
Skill Dvlpmnt	Development of skills as an outcome, especially transferrable ones, that may relate to students' futures, other contexts or the real world.	"You're always working with other people which is a really good life skill to have. They're kind of the same and different. More different because its different subjects but the same because it's the same."
Improve Knowledge or Conceptual Understanding	Improved understanding or knowledge as an outcome of participation.	"Yes, because some concepts I didn't understand, like I just couldn't get what the teacher was saying. When I was in the groups I actually understood what was happening."
Effort of Learner	Outcome of CZA varies with the effort, input or other attributes of the learner.	'Depends how involved they are… I've seen some people aren't… they just sit there and don't really do much and I don't think they get anything out of the lesson. But then some people, you can see they're focusing, but then other times, they're talking to someone or doing something else. So it really depends on how much you want to learn.'
Learner Diffs	Differences in outcomes resulting from individual attributes of learners.	"…everybody's mind is different, like everybody thinks different… some people will like benefit out of doing group work but then some people will be I hate this so much, it's so boring… not everyone's going to get the same thing out of it because everyone's mind works differently…"
Confidence	Specifically related to improved student confidence or socialisation from participating.	"I was always shy to talk to people that were older than myself, so I found that it was easier to talk to more people. I've got a variety of people I can talk to now that I haven't met before."

APPENDIX F Semi-Structured Interview Questions

SEMI-STRUCTURED INTERVIEW QUESTIONS FOR TEACHERS

Construction Zone Activity refers to the small group activity, experimentation and group talk that occurs in Thinking Science lessons when students are engaged with cognitive conflict and social construction of knowledge.

1. Is there value to using Thinking Science in your classroom? If there is, what do you see as being of value or importance?

2. Could you share your thinking about the pedagogy behind the Thinking Science program? Is it effective?

3. As you are planning your lessons, do you have aims and intentions for construction zone activity in a Thinking Science lesson? If so, what are they and why?

4. Are there any strategies or approaches that you use in these lessons to make construction zone activity part of your Thinking Science lessons? If you do, how or why do you choose these?

5. Is construction zone activity an important part of Thinking Science lessons? Why might this be the case?

6. What do students do during construction zone activity? Is this what you expect? Why or why not?

7. Have you noticed how students respond to construction zone activities in these lessons? Why might they respond in this way?

8. Do all students respond the same way? Why or why not?

9. What outcomes, if any, do you expect students to get out of construction zone activity in these lessons? Is it the same for all students?

SEMI-STRUCTURED INTERVIEW QUESTIONS FOR STUDENTS

1. What do you do in Thinking Science lessons? How are they different to normal lessons?

2. What is the value of doing Thinking Science lessons? Are they useful?

3. Can you give me some examples where you have worked together in Thinking Science lessons? What were you trying to do when you were working together? How successful were you?

3. Do you think it is important to work together in these lessons? Why or why not?

4. Can you think of any examples where you have benefitted by working in a small group? Is this similar for Thinking Science lessons? Why?

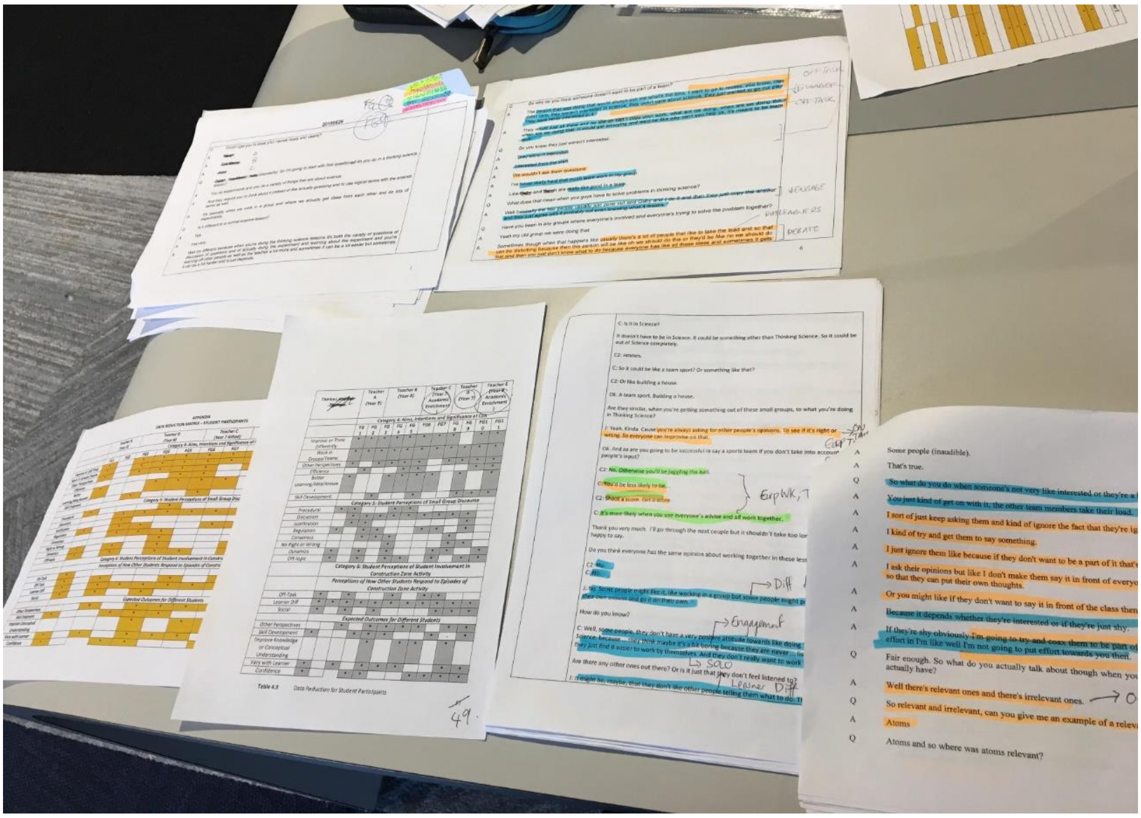
5. Does everyone think the same way about working together in these lessons? How do you know?

5. What things do you talk about when you are working together in your groups in Thinking Science lessons? Why?

6. What do you expect to get out of working together in Thinking Science lessons? Why?

7. Does every student get the same thing out of working in groups in Thinking Science lessons? Why or why not?

APPENDIX G Audit Trail Example



APPENDIX H Ethics Approval (UWA)

THE UNIVERSITY OF WESTERN AUSTRALIA

Human Ethics
Office of Research Enterprise
The University of Western Australia
M459, 35 Stirling Highway
Crawley WA 6009 Australia
T +61 8 6488 4703 / 3703
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E humanethics@uwa.edu.au
CRICOS Provider Code: 00126G

Our Ref: RA/4/1/7122 17 December 2014

Professor Grady Venville
Staff Dept Code Not On Infoed File
MBDP: M466

Dear Professor Venville

HUMAN RESEARCH ETHICS APPROVAL - THE UNIVERSITY OF WESTERN AUSTRALIA

Student and Teacher Perspectives of Construction Zone Activity in the Thinking Science Australia Program

Student(s): Nathan Curnow - Masters - 10226538

Ethics approval for the above project has been granted in accordance with the requirements of the *National Statement on Ethical Conduct in Human Research* (National Statement) and the policies and procedures of The University of Western Australia. Please note that the period of ethics approval for this project is five (5) years from the date of this notification. However, ethics approval is conditional upon the submission of satisfactory progress reports by the designated renewal date. Therefore initial approval has been granted from 17 December 2014 to 01 December 2015.

You are reminded of the following requirements:

1. The application and all supporting documentation form the basis of the ethics approval and you must not depart from the research protocol that has been approved.
2. The Human Ethics office must be approached for approval in advance for any requested amendments to the approved research protocol.
3. The Chief Investigator is required to report immediately to the Human Ethics office any adverse or unexpected event or any other event that may impact on the ethics approval for the project.
4. The Chief Investigator must submit a final report upon project completion, even if a research project is discontinued before the anticipated date of completion.

Any conditions of ethics approval that have been imposed are listed below:

Special Conditions

None specified

The University of Western Australia is bound by the *National Statement* to monitor the progress of all approved projects until completion to ensure continued compliance with ethical principles.

The Human Ethics office will forward a request for a Progress Report approximately 30 days before the due date.

If you have any queries please contact the Human Ethics office at humanethics@uwa.edu.au.

Please ensure that you quote the file reference – RA/4/1/7122 – and the associated project title in all future correspondence.

Yours sincerely

[redacted]

Dr Caixia Li
Manager, Human Ethics

APPENDIX I Ethics Approval (Department of Education)

Government of **Western Australia**
Department of **Education**

Your ref :
Our ref : D15/0098794
Enquiries :

Mr Nathan Curnow
11/52 Samson St
WHITE GUM VALLEY WA 6162

Dear Mr Curnow

Thank you for your application received 22 December 2014 to conduct research on a Department of Education site.

The focus and outcomes of your research project, *Student and Teacher Perspectives of Construction Zone Activity in the Thinking Science Australia Program*, are of interest to the Department. I give permission for you to approach the Principal of John Curtin College of The Arts to invite his school's participation in the project as outlined in your application. It is a condition of approval, however, that upon conclusion the results of this study are forwarded to the Department at the email address below.

Consistent with Department policy, participation in your research project will be the decision of the school invited to participate, individual staff members, the students and their parents. A copy of this letter must be provided to the Principal when requesting the school's participation in the research. For the purpose of this research project, you will be required to sign a confidential declaration at the school, before commencing your research project.

Responsibility for quality control of ethics and methodology of the proposed research resides with the institution supervising the research. The Department notes a copy of a letter confirming that you have received ethical approval of your research protocol from The University of Western Australia Human Research Ethics Office.

Any proposed changes to the research project will need to be submitted for Department approval prior to implementation.

Please contact Mr Adriaan Wolvaardt, Research and Evaluation Officer, on (08) 9264 5522 or researchandpolicy@education.wa.edu.au if you have further enquiries.

Very best wishes for the successful completion of your project.

Yours sincerely

[redacted]

ALAN DODSON
DIRECTOR
EVALUATION AND ACCOUNTABILITY

26 March 2015

151 Royal Street, East Perth Western Australia 6004

APPENDIX J Instructions to HOD and Teacher Participants

Instructions Given to Head of Science Department for Sampling

Instructions for the Head of Science Department including criteria for selection of prospective participants.

Step 1: Distribute an e-mail (see attached) to all Science staff inviting them to volunteer their participation in the research project.

(As per the recommendations of UWA Human Research Ethics Office, involvement in the project is purely voluntary and as such there is no 'recruitment' of staff participants).

Step 2: Upon expression of interest by e-mail, forward further information (include participant information form and letter of consent) to staff as digital/physical copies. You may field questions or concerns or direct the volunteers to contact the supervisor or the UWA HREO if possible volunteers have further questions.

Step 3: Collect signed consent forms from volunteer participants still wishing to participate.

Step 4: After an appropriate time period (e.g. two weeks since the initial e-mail invite) collate the names of volunteers to participate and select 3 – 5 teachers using the following criteria:

Criteria for Teacher selection

The mix of teacher participants should as much as possible comprise:

- both genders
- a range of experience with the program (including teachers new to teaching the program as well as those who have taught the program for some time; those who have taught both years of the program and those who have taught one year group primarily etc.)
- a range of teaching experience and backgrounds, excluding new graduate/beginning teachers. Characteristics could include subjects taught, educational history (e.g. further study), previous careers, time spent teaching, types of schools previously taught at such as government, private, international, low SEI etc.

This is to enable a range of diverse, informed viewpoints amongst those interviewed with a view towards obtaining maximum variation in the perspectives sampled as part of this research.

Step 5: Once selected, forward participant names to the researcher. The name of staff members who have declined to participate will not be given, only the names of those willing to participate and selected.

Step 6: Forward consent forms to the researcher before research commences.

Step 7: After the teachers have introduced the project to their class, there may be parents who decline participation for their child. They have been instructed to notify the Head of the Science Department (yourself).

Please collate these names and forward to the relevant teachers and the researcher to ensure that students in each observed class are placed in an area that will not be the focus of observation.

Instructions Given to Teacher Participants

Instructions for consenting staff participants including distribution and recollection of information and consent forms and criteria for selection of prospective student participants.

Step 1: After consenting to participate as a volunteer in the research, please introduce the research project (including aims, nature and timing of research; voluntary nature of participation in focus groups) to the class.

Step 2: Provide Information and Consent forms to students.

These will be pre-copied and are to be provided to students (with copies of parent/guardian forms to be taken home). Students are to be given sufficient time (e.g. a week) to ask questions (as appropriate to the research) and read/return the signed consent forms.

At this time also clearly communicate that only students with signed consent form will be able to participate in the focus group sessions.

Step 3: As forms are returned, signed and completed, please tick them off against the provided roll and place them in the provided document wallet for subsequent collection by the researcher.

Step 4: Organise with the researcher an appropriate and mutually agreeable time for observation of a lesson to occur, and for conduction of the interview and focus groups related to the observation. Please inform the Head of the Science Department of this time.

At this time, provide a recommended composition for student focus groups based upon those students indicating willingness to participate.

Criteria for participation in the student focus groups:

As per the request of the UWA HREO, students may volunteer their participation for the focus group. It is the intent of the researcher to conduct focus groups with two groups of students (aiming for 3 to 6 students from each class).

In the event that more students are interested in participation than this number, then additional focus groups will be conducted in order to minimise potential discomfort to students who may wish to contribute but would otherwise not be selected for participation.

It is up to the teacher to decide on the composition of the focus groups. As such, it is recommended that focus groups contain:

- a range of ability levels
- articulate students where possible
- students who express different attitudes towards the program/classwork
- student mixes devoid of persistent or significant conflict between individuals that may otherwise suppress contribution

<u>Step 5:</u> Please clearly communicate the time of both the interview and the focus groups to students and ask these to be placed into their diaries.

<u>Step 6:</u> At the beginning of the lesson to be observed by the researcher, provide students an opportunity to express their consent by asking students who do not consent to being in the area that is the focus of observation (or have parents/guardians who have informed the Head of the Science Department that they do not wish for their child to participate) to place themselves in specific places in the room that will not be the focus of observation.

Prior to the lesson, a list of students who have not got consent for participation (and therefore direct observation) will be provided by the Head of the Science Department to both you and the researcher.