Transitions, aspirations and capitals:

Science education in a globalised policy field

Thesis submitted by

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B. Sc. (JCU), Grad.B.Ed. (Hons-Class 1), JCU

in July, 2014

In fulfilment of the requirements for the

Doctor of Philosophy

In the School of Education at James Cook University

Statement on the Contribution of Others

I acknowledge the intellectual support of my advisory team, Professor Angela Hill, Associate Professor Leanne Dalley-Trim, Professor Sue McGinty and Dr Louisa Tomas Engel, who provided ongoing contributions to my research design, proposal writing, data analysis and also editorial assistance with this thesis.

I have received financial assistance from the School of Education in accordance with the *James Cook University Minimum Resources Policy*. Grants from the James Cook University Faculty of Arts Education and Social Sciences' Graduate Research Scheme enabled me to attend two national and international conferences. Additionally, I have received a scholarship in the form of an Australian Postgraduate Award. I have not sought or received any other contributions.

The research presented and reported in this thesis was conducted within the guidelines for research ethics outlined in the National Statement on Ethical conduct in Human Research (2007). The proposed research methodology received ethics clearance from the James Cook University Ethics Review Committee (approval number H3866) and the project was approved by the Queensland Department of Education and Training (reference number 10/243984).

Tanya Doyle Date

Acknowledgements

First and foremost, I wish to acknowledge and thank the students and teachers who were willing to be interviewed for this study, as well as the school administrative staff who helped access the records necessary for data collection at each school site. Without their generosity, this study would not have been possible. I hope that as a result of this research, more can be done to support the work of teachers and administrators in Queensland's state schools, with a view to supporting more students to realise their goals and aspirations.

Next, I would like to acknowledge and thank my advisory team — Professor Angela Hill, Associate Professor Leanne Dalley-Trim, Professor Sue McGinty and Dr Louisa Tomas Engel — for their patience, support, encouragement, guidance and critical insight. I extend my sincere gratitude to you all. Without you, and all that you have offered, I would not have completed this study. In particular, I would like to thank and acknowledge Angela, as my primary advisor. The opportunity for me to conduct this work, and to complete this thesis, would not have been possible without you.

I would also like to thank and acknowledge other colleagues who have supported and encouraged me along the way, including staff in the School of Education and in the School of Indigenous Australian Studies and the staff of the Teaching and Learning Development Unit, James Cook University, alongside the JCU FAESS post-graduate community. In particular, I would like to thank and acknowledge Dr. Fiona Navin and Dr. Andrea Lynch. I am truly grateful for your friendship and support.

To my own family — Jason, Henry and Amelia — I could not have completed this work without your love, understanding and support. I would also like to thank and acknowledge the wider circle of family and friends who have supported me, encouraged me and, surprisingly,

continued to invite me out to social events. I am grateful to you all for sticking with me through this endeavour.

Last, but not least, I would like to acknowledge the significant impact that my own high school Chemistry teacher had on my life. I began to study Chemistry in a Queensland State School in Year 11 in 1989. I asked my teacher for some help with some molarity calculations that I was finding particularly challenging. In response he stated that "Chemistry is not a subject for girls", and he advised that "if I was such a smart girl, I should be able to figure it out for myself". Despite now having completed a Bachelor of Science, and worked as a secondary school science teacher, his comment has stayed with me. In fact, I have been left wondering — for some years now — how could Chemistry ***be*** for some students and not others? If what my Chemistry teacher said is true, then ***who is Chemistry for***? And, ***who gets to decide*** which students are in and which students are out? I am certain that encouragement was not at the heart of my teacher's comment; nevertheless, encourage me it did.

Abstract

For over two decades, Science, Technology, Engineering and Mathematics (STEM) education in Australia has been described as being at 'crisis point' (Adams, Doig, & Rosier, 1991; Goodrum, Hackling, & Rennie, 2001; Goodrum & Rennie, 2007; Lyons, Cooksey, Panizzon, Parnell, & Pegg, 2006; Masters, 2006; Osborne, 2006; Teese & Polesel, 2003) with calls in the literature to re-imagine science education (Tytler, 2007) in order to address the crisis. Over the same time frame, Australia's economy has transitioned to post-Fordism and consequently Australia, as a nation-state, seeks to galvanise its future economic security through an innovation-led economy (Bullen, Fahey, & Kenway, 2006; Kenway, Bullen, & Robb, 2004). It is through policy that such attempts at galvanisation are made, with 'Innovation' positioned as a force critical to Australia's future economic prosperity. Simultaneously, at the Federal level, the Australian education policy moment is dominated by the articulation of an Education Revolution which seeks to widen the participation of non-traditional students in the Higher Education sector (Bradley, Noonan, Nugent, & Scales, 2008; Department of Education Employment and Workplace Relations, 2009).

This study focuses on Chemistry as an enabling science, and its role in navigating access to the innovation agenda. Chemistry serves as a pre-requisite subject for entry into many science, engineering, technology and allied health courses at universities throughout Queensland (Queensland Tertiary Admissions Centre, 2010) and yet there is little reported literature that examines the ways in which subjects such as Chemistry, enable or constrain access to STEM courses. Consequently, the secondary school subject of Chemistry, defined here by the 2007 Queensland Studies Authority Syllabus, has been selected as a vehicle, or point of focus, for this study. Concomitantly, policy centrally positions education generally

and education in the “enabling science” of Chemistry (Tytler, 2007, p. 7) more specifically, as key to the transformative development of an ‘Innovative’ Australian citizenry. It is argued in this thesis that despite the Federal political agenda to transform the Australian citizenry into ‘Innovators’, many students who attend secondary schools experiencing high levels of social and economic disadvantage continue to study in fields outside of the ‘enabling sciences’.

This thesis seeks to re-frame the STEM crisis as one of demand rather than supply. On that account, this thesis also seeks to problematise the notion of Chemistry working as an ‘enabling science’. Instead, it presents an argument that as the purpose of STEM education has been transformed, so, too, has the role of Chemistry been transformed. Chemistry is now primarily conceived of, by the students and teachers at the school sites under study, as well as by universities in Queensland, as a commodity with strategic value, rather than as a discipline that provides foundational knowledge for further STEM study.

This investigation was implemented using a critical sequential, mixed model design (Elliott, 2008; Tashakkori & Teddlie, 1998; Teddlie & Tashakkori, 2011), and presents data analysed in three intersecting and reciprocating units of analysis, namely: policy production, policy articulation and policy reception (Blackmore, 2010). During the policy production phase of this project, qualitative data was generated through a critical policy analysis. In this phase, critical discourse analysis informed by Fairclough (2010) was employed to analyse an assemblage of policy documents drawn from both the Australian Federal and State (Queensland) government jurisdictions. The analysis found intersecting spheres of policy that underpin STEM education, with significant leverage derived from the sphere of economic productivity. Furthermore, the discursive categories of ‘security’, ‘risk’ ‘opportunity’ and ‘quality’ were found to be operationalised in the policy assemblage under study; working to leverage a multi-scalar continuum between ‘innovation’ and ‘security’, directing the imperative for individuals and nation-states alike to embody Innovation, in order to secure their futures in 'uncertain' and 'changing' times. STEM education, then, constitutes part of the armoury rhetorically required by citizens to secure their own opportunities, as well as those of the nation-state, in the new economy.

During the policy articulation phase of the research, the role of Chemistry in gaining access to the Innovation agenda was explored by examining tertiary entrance procedures for Queensland universities. Two key findings were revealed as a result of these analyses. Firstly, 'Chemistry', as a pre-requisite to tertiary entrance, is itself a problematic notion. Over the period 1992 to 2011, five different official versions of Chemistry have been enacted in Queensland secondary schools. In some years, as many as three official versions of 'Chemistry' were in use at one time. From this finding, it is clear that 'doing Chemistry' cannot be regarded as a stable or homogenous experience for Queensland secondary school students. Secondly, and despite this instability, Chemistry was found to be differentially deployed as a pre-requisite to entry by universities across the state of Queensland. Arguably, in this way, Chemistry is implicated in marking out graduates, courses, institutions and fields of distinction thereby highlighting tensions between the construction of Chemistry as an 'enabling science' and the deployment of Chemistry as a 'mark of distinction'.

During the policy reception phase of this project, descriptive statistics pertaining to student participation in Chemistry in the senior years of schooling at each of the three state secondary schools under study were generated by document analysis of Senior Education and Training (SET) plans held at each school. These data are presented alongside interview data collected from staff and students at each of the three school sites. The notion of 'choice' is explored in this chapter by employing a commodification thesis to analyse the SET planning process. These analyses found that secondary school teachers' work is transformed such that they act as 'brokers' of the choice-making process, with students positioned as 'entrepreneurs of the

self'. In addition, these findings problematise the extent to which authentic 'choice-making' and validation of students' aspiration occurs in secondary schools experiencing high levels of social and economic disadvantage. Overall, the thesis suggests new approaches to considering Australia's STEM crisis.

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Section 1 Framing the Study

This section of the thesis frames the background, purpose and significance of this study. It introduces ideas and concepts central to the thesis, in particular the notion of a crisis in Science, Technology, Engineering, and Mathematics (STEM) education in Australia and the role that Australia's supply side of the science system (Office of the Chief Scientist, 2012a) is to play in addressing this crisis. Section 1 also details the methodological approach taken in realising the study's broad aims.

Chapter 1 Background to the Study

1.1 Introduction

In his seminal report *Reimagining science education: engaging students in science for Australia's future*, Tytler (2007) stated that "science education in Australia, as in other post-industrial countries is in a state of crisis" (p. 1). In the literature, this crisis is commonly referred to as the STEM crisis. Tytler considers this 'crisis' to be comprised of four main aspects, with each having both quantitative and qualitative dimensions. These four aspects are outlined below:

- decreasing participation in post-compulsory science subjects, especially the 'enabling' sciences of Physics, Chemistry and higher Mathematics.
- evidence of students developing increasingly negative attitudes to Science over the secondary school years.
- a shortage of qualified science teachers, and
- a shortage of science-qualified people in the skilled workforce (Tytler, 2007, p. 7).

These four aspects of the crisis are related back to the work of both teachers and schools, and the associated pedagogical decisions, as the social agents that enact science curricula. Following on, declining participation in STEM studies results in "shortages" of science-qualified human capital, and hence, the crisis is conceptualised as one of supply. Conceptualising the STEM crisis, as a crisis of supply, implies that Australia, as a nation-state, is both experiencing and responding to unmet labour market demand for people with STEM qualifications.

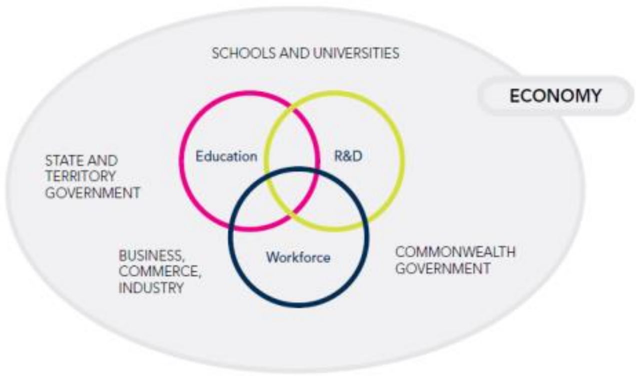
The magnitude of this demand is registered by the Office of the Chief Scientist (2012b) in a report entitled *Mathematics, Engineering and Science in the National Interest*: "there is a global perception that a workforce with a substantial proportion educated in Mathematics, Engineering and Science (MES) is essential to future prosperity" (p. 6). The assumption upon which the STEM crisis is premised is that an increased supply of STEM-qualified human capital is essential to leverage economic growth and to advance Australia's competitive standing in a globalised knowledge economy. Schools and school science, then, are largely charged with meeting this demand.

The *Health of Australian Science* (Office of the Chief Scientist, 2012a) states that in order to address the perceived labour market demand, it is necessary to increase the nation-state's "*capacity to supply* the talents and *skills we need and will likely need even more* [emphases added]" (p. 4). To increase this capacity, the Office of the Chief Scientist states that it is necessary to focus on "the supply side – the schools and universities" (p. 4) of the system. Here, the term "supply side", refers to elements of "Australia's science system" (Office of the Chief Scientist, 2012a, p. 23). Figure 1.1 is drawn from the *Health of Australian Science* report. It represents Australia's science system and highlights the system's four main institutional components and three main functional elements. The relationship between the institutional components and the functional elements of the science system are described in *Health of Australian Science* as follows:

> The *functional* elements are *education*, research and development, and workforce [emphases added]. The system delivers *educational outcomes in the form of a science-literate society* and a *science-trained general and* [Research and Development] *R&D workforce* [emphases added]. Its R&D supports the activities of business, commerce and industry – in the form of innovation and translation. For example, R&D also supports government activities relating to policy development and regulation. Through the system's workforce function, these educational and R&D outcomes are disseminated to all sectors of the economy. Schools bring a level of

science literacy to all Australians and provide the fundamental science competency on which universities build when training the general science workforce and the science teaching and R&D workforce….The Commonwealth and the state and territory governments are major contributors to the funding of the functional elements, as well as major beneficiaries of the outcomes. (Office of the Chief Scientist, 2012a, p. 23)

Figure 1.1 Principal institutional components and functional elements of the Australian science system



Note: Institutional components are in capital letters; the functional elements are in the circles.

Source: Office of Chief Scientist, 2012, Health of Australian Science, p. 23.

In other words, education is regarded as a function of the science system. This view positions STEM education as an outcome of the science system, rather than STEM education being just one of many outcomes of an education system. In this way, the primary function of schools and universities is positioned as the supply of scientifically-literate citizens and science-trained workers. Concurrently, the Federal government is positioned as the major investor in the schooling and education of individuals, and as the major beneficiary of the products of this investment. Further to this, business, industry and commerce also contribute to the supply side of the science system – "they invest in their own funds in R&D, as well as taking advantage of government instruments to leverage these funds (for example, the R&D tax credit)" (p. 23). The work of schools and universities, then, given the Office of the Chief

Scientist's view of the Australian science system, centres on the production of human capital with the balance of skills and training required to meet the demands of government and business sectors. While many initiatives have been funded and implemented in order to achieve this goal, patterns of student participation in STEM subjects continued to decline (Goodrum & Rennie, 2007).

1.2 Locating the Research

This study is positioned to take a policy approach to interrogating the STEM crisis. Such an approach is supported by Fensham (2009) who stated that, for too long, science education has been naive to the role of policy in science education, and further consideration of the "interplay between the stakeholders beyond and in-school who determine the nature of the curriculum for science education" is warranted.

Framed by an approach to policy analysis that sees policy as practice (Blackmore, 2010), this study seeks to address three overarching research questions, in relation to three units of policy analysis:

Focus of research	**Overarching research question**
Policy production	What is the 'official' rendition of the STEM crisis?
Policy articulation	How is Chemistry positioned in the field of Education?
Policy reception	How do secondary school students navigate the process of 'choosing' Chemistry

This study builds on the extensive body of research that considers the causes, and possible ways to address, the STEM crisis. However, this study takes a different approach. It calls for the re-conceptualisation of the crisis, such that new insights can be made into why some students, particularly students from low socio-economic backgrounds, rural and remote schools, and students who attend state schools are less likely to participate in the study of 'enabling sciences' such as Chemistry.

1.3 The Significance of this Study

The research undertaken here is significant in a number of respects. Firstly, extensive literature reviews have not located a study such as this that has been undertaken in the Australian context. Secondly, the study occurs at a policy moment which sees the intersection of Federal Education and Innovation policy. As such, calls for increased student participation in STEM converge with policy imperatives to instigate a demand-driven higher education sector in Australia, and to increase the number of students enrolled in university study from those groups traditionally under-represented in the higher education sector. At this policy moment, the social, economic and political conditions are poised to address the STEM crisis, as defined by Tytler (2007) above. Thirdly, this study contributes to research for social justice. Student voices are largely marginalised in accounts of the STEM crisis. More often than not, students are positioned either as empty vessels to fill with science, or as victims of poor teaching which has failed to inspire them to study science. It is already well reported in the literature (Lyons & Quinn, 2010; Thomson, De Bortoli, & Buckley, 2013) that students from low socio-economic backgrounds, rural and remote schools, and students who attend state schools are less likely to participate in the study of 'enabling sciences' such as Chemistry. This study seeks to provide a space for student voices to be heard, and to hear, from their perspective, what navigating the 'choice' to study Chemistry entails.

1.4 The Organisation of this Thesis

This thesis is divided into four sections. The first section, Section 1, includes this first chapter, in which the reasons for undertaking this research — at this moment in time — have been outlined. Section 1 also includes Chapter 2, which details the methodology that frames this research study. As mentioned above, the research methodology is framed by a view of policy as practice, and as such, the remainder of the thesis is presented in relation to phases of inquiry.

Section 2 of the thesis focuses on the policy production phase of the research and, through a critical literature review, presents the official rendition of the STEM crisis, that is, the rendition that dominates Federal policy discourse. Chapter 3 focuses on data used to construct the notion of “decreasing participation” while Chapter 4 examines the ways in which teachers (and their work) are blamed for both decreasing participation and a perceived decline in students’ performance in scientific literacy against international benchmarks.

Section 3 of the thesis, also presents analysis that pertains to the policy production phase of the research, and suggests that the crisis should be re-conceptualised as a crisis of demand, rather than a crisis of supply. Chapter 5 examines the nexus between the STEM crisis and the Innovation agenda. Chapter 6 employs critical discourse analysis to expose the categories of discourse that are operationalised in attempts to legitimate innovation as an order of discourse. These two chapters, together, describe the ideological conditions that underpin students’ choices to participate (or not) in the study of STEM subjects during their post-compulsory years of schooling. Chapter 7, then, presents the tensions evident in the efforts to construct Innovation as an order of discourse.

The final section of the thesis, Section 4, contains three chapters. Chapter 8 attends to the policy articulation phase of the research and examines the role of Chemistry in relation to university entrance, and the production of skills and capacities that are considered valuable in the innovation agenda. Chapter 9 attends to the policy reception phase of the research and includes data from document analyses as well as interview data from students and teachers from three secondary schools, regarded as low socio-economic status schools, in remote, rural and urban settings in North Queensland. Finally, Chapter 10 summarises the key findings of the research, addresses the research questions, discusses the limitations of the research and offers some suggestions for future research arising from this study.

1.5 Summary

This chapter has provided an introduction to the research reported in this doctoral thesis. It has framed the overarching research questions and stated the significance of this investigation. It then provided an overview of the chapters, and analytical units to follow. In the next chapter, Chapter 2, a more detailed rationale for this study, along with the theoretical framework underpinning the study and the guiding research questions relating to each unit of analysis are presented.

Chapter 2 Methodology

2.1 Introduction

In light of the STEM crisis and the widening participation agenda, as outlined in Chapter 1, occurring in the Australian field of education, this project established three broad aims. Firstly, this study aimed to explicate the current policy moment in which secondary school students are deciding whether to study STEM subjects or not. Surveying the construction of the STEM crisis, as a crisis of supply, is central to this explication, as is unpacking the notion of Chemistry as an 'enabling science'. Secondly, this study aimed to examine the range of processes that impact upon student transitions during their study of STEM subjects; namely, those related to policy processes, those related to school systemic issues and those related to student agency. The third aim of this study was to scrutinise the processes directing the choice-making of secondary school students at a key transitional juncture in their schooling; that is, as students move from Year 10 to Year 11. Moreover, the role of teachers and schools in directing student choice is to be examined. Each of these aims was framed in relation to notions of social and cultural capital (Bourdieu, 2000; Bourdieu & Passeron, 1990), neoliberal constructions of students (Beck & Beck-Gernsheim, 2003; Rose, 1990, 1998), and globalised policy fields (Apple, 2010; Rizvi & Lingard, 2010).

In brief, the research took a critical (Apple, 1986, 1995, 2000, 2004, 2006, 2007, 2010; Apple, Au, & Gandin, 2009; Apple & Buras, 2006; Bacchi, 2009; Ball, 1990, 1994, 2003, 2008; Ball, Maguire, & Macrae, 2000; Teese, 2000; Teese & Polesel, 2003), sequential mixed-model (Elliott, 2008; Tashakkori & Teddlie, 1998; Teddlie & Tashakkori, 2011) approach, and contained three units of analysis, namely: policy production, policy articulation and policy reception (Blackmore, 2010). The secondary school subject of Chemistry, the form and nature of which is defined by the 2007 Queensland Studies Authority Syllabus, has been selected as a vehicle, or point of focus, for this study. In science-education policy, Chemistry is positioned as an “enabling science” (Tytler, 2007, p. 7) as it serves as a pre-requisite subject for many science, engineering, technology and allied health courses at a tertiary level. The project received ethics approval from James Cook University (approval number H3866) as well as from Education Queensland (Reference: 10/243984). Appendices 1 and 2 contain copies of the ethics approval notifications. Data collected from each unit of analysis (policy production, policy articulation and policy reception) is presented and analysed in the subsequent chapters of this thesis.

During the policy production phase of this project, qualitative data was generated through critical discourse analysis, informed by Fairclough (2010), of policy documents drawn from Australian Federal and State of Queensland government jurisdictions as relevant to the policy moment under study. These analyses were undertaken to explicate the current policy moment in which students make choices about their study in STEM subjects. The data arising from this analysis are presented in Chapters 3, 4, 5, 6 & 7 of this thesis. The data pertaining to the State of Queensland policy assemblage is used to contextualise the analyses presented in Sections 3 and 4 of this thesis.

The policy articulation phase of the analysis involved document analysis of two key documents: The QTAC course guide (Queensland Tertiary Admissions Centre, 2010), and the QSA Chemistry Syllabus (2007). These analyses seek to examine the skills, attributes and capacities developed by Chemistry students, and the deployment of Chemistry as a pre-requisite to tertiary entrance by Queensland universities. These findings are presented in Chapter 8 of this thesis. Finally, in the policy reception phase of the study, teachers and students from three state secondary schools located in North Queensland were interviewed: Emu State High School (located in remote North Queensland), Brolga State High School (located in rural North Queensland) and Ibis State High School (located in a large urban centre in regional North Queensland). Each school is officially recognised as a low socio-economic status school due to the Index of Community Socio-Educational Advantage (ICSEA) value it has been assigned. In total, six teachers and twelve Year 12 students were interviewed. In addition to interviews, a document analysis of subject selection forms and SET plans of the Year 12 cohort from each school was also conducted. From these analyses, patterns of student engagement with the study of Chemistry were able to be determined.

2.2 Research Questions and Potential Outcomes

This study is structured to address both overarching and guiding research questions. The overarching research questions are summarised in Table 2.1:

Table 2.1
Summary of overarching research questions

Focus of research	Overarching research question
Policy production	What is the 'official' rendition of the STEM crisis?
Policy articulation	How is Chemistry positioned in the field of Education?
Policy reception	How do secondary school students navigate the process of 'choosing' Chemistry

The guiding research questions are presented in Section 2.4 of this thesis, as they relate directly to each unit of analysis outlined in Section 2.1 above. The research outcomes will be used in the following ways:

- As the basis for my doctoral thesis.
- To contribute to the literature about barriers to student participation in the study of STEM subjects

- To inform universities about potential factors impacting on transitional junctures that may relate to the widening participation policy agenda, particularly with respect to STEM studies in higher education.
- To provide insights into preparing Senior Chemistry pre-service teachers for their work in disadvantaged and remote/rural contexts.
- To inform the systemic career planning processes utilised in Queensland schools.

2.3 Methodological Rationale

2.3.1 Why a critical approach to policy analysis?

'Critical' work in contemporary education policy studies needs to be framed in ways that no longer assume that education is solely the business of a nation state, and is no longer restricted to production within what has been known as the education sector. Robertson and Dale (2009), along with Apple (2010) and Rizvi and Lingard (2010), call for critically conceived studies to reconsider their ontological and epistemological positions, and their methodological conceptions in light of "challenges posed by the wider social, political and economic transformations for education systems" (Robertson & Dale, 2009, p. 24).

Robertson and Dale (2009) go on to argue that the historical, problem-solving approach to policy analysis is no longer adequate. The education sector is now engaged with significant transformations, and education policy can no longer be conceived as providing a nation state with the 'steerage' it may have in the past. Globalisation has seen policy production and mediation become the work of new and various transnational actors, some of whom "operate well outside the traditional education system" (Robertson & Dale, 2009, p. 27). This position is echoed by Rizvi and Lingard (2010) who argue that doing policy analysis in the context of globalisation needs to reject 'methodological nationalism' and deparochialise research methodologies and theories, in the process rejecting any assumption of ‘epistemological innocence’, thereby further reinforcing the need to take a critical approach to the research project at the centre of this thesis.

As opposed to policy being seen as a solution to a problem inside the boundary of a nation state, the production of policy now takes place across various spatial, temporal and economic scales, and has become more concerned with “problem-*framing*”:

> In a neo-liberal age…the problems that nation states face, and their means of addressing them, are both framed by representative institutions of neo-liberalism. Thus, the way we see the prescriptions and advice of international organizations is not so much as problem-solving contributions, but as *problem-defining and framing interventions*. Essentially, it is through these agencies that states learn what their problems really are. (Robertson & Dale, 2009, p. 33)

This is a position that is echoed by Rizvi and Lingard (2010) and paralleled by Bacchi (Bacchi, 2009, p. ix), who suggests that the “whole idea of ‘policy’ is a subject for interrogation”, particularly in relation to ways in which the notion of ‘policy’ is located within a particular way of understanding how governing takes place, and the implications for those who are governed. Bacchi (2009) posits that traditional policy analysis is grounded in a sense that policy is designed to solve social problems. However, as an alternative, Bacchi’s (2009) “What’s the problem represented to be (WPR)?” approach shows that:

> policies by their very nature imply a certain understanding of what needs to change (the ‘problem’) which suggests that ‘problems’ are endogenous – created within – rather than exogenous – existing outside – the policy making process. Policies *give shape* to ‘problems’; they do not *address* them. (Bacchi, 2009, p. x)

The WPR approach directs attention to the ways in which particular representations of problems play a central role in the way we are governed. In other words, in order to understand how we are governed, we need to first understand the ways in which representations of problem “lodge within public policies” (Bacchi, 2009, p. xii). This methodological approach to policy analysis allows the opportunity to problematise taken-for-granted assumptions that underpin particular problem representations, and, thereby to “think deeply about the assumptions and presuppositions that lie behind and shape selected policies” (Bacchi, 2009, p. xiv). The way in which a problem is represented is important for these representations translate into real, lived experience through the way that the people involved “are evoked to think about themselves” (Bacchi, 2009, p. 1).

> A WPR approach starts from the presumption that some problem representations create difficulties (forms of harm) for members of some social groups more so than for members of other groups. By interrogating the problematisations on offer, we can see where and how they function to benefit some and harm others, and what can be done about this. (Bacchi, 2009, p. 15)

The capacity of the WPR approach to problematise embedded problem representations in policy will be of great value to this research, with neoliberalism identified as one way to categorise governmental rationalities that pervade current policy (Bacchi, 2009). Foucauldian genealogy is identified by Gale (2001) as another method that can uncover the thought that lies behind specific problem representations and works to identify the silences that are present in the problem representations that are lodged in public policy. Bacchi (2009, p. 20) highlights the need to consider the complexity and the context of the policy texts that are selected for analysis, and the importance of “acknowledging contesting positions within a document when they are apparent". Furthermore, Bacchi states that discourse analysis is useful as a means of understanding how a problem comes to be shaped. In particular, the discourse analysis undertaken should "identify and interrogate the binaries, key concepts, and categories operating within a policy" (Bacchi, 2009, p. 7). Binaries – as constructs – operate to privilege one position over another, and work to shape an issue embedded in a policy. The ways in which meanings are assigned to key concepts are also significant in showing how a policy is working to represent a problem. Categories, in particular 'people categories', are significant as they work in ways that shape how people think about themselves, about others, and their worlds. They indicate ways in which governing will take place.

Techniques of quantitative measurement, such as surveys, are integral to the construction of people categories, and to the work of governing – as "to govern it is necessary to know" (Rose, 1999, p. 209). Such techniques "form part of the non-discursive practices that allow specific problem representations to gain dominance" (Bacchi, 2009, p. 11). Hacking (1986 cited in Bacchi, 2009, p. 11) notes that "statistics create knowledge of a particular kind". It then follows, that the WPR approach needs to ask: "Why these statistics and not others? Who gets counted? How do they get counted? How does their counting feed into the specific policy and its implied problem representation?" (Bacchi, 2009, p. 11). These questions lead to the next section of the methodological rationale, that is, the justification for a mixed model design.

2.3.2 Why a mixed methods approach?

As argued by Elliott (2008), a recognition of the narrative character of much quantitative research, particularly those with a chronological nature, or that which is focussed on a cohort of people, could usefully lead to greater reflexivity among quantitative researchers and assist productive methodological discussions about how quantitative and qualitative approaches to analysis may be combined. The nature of cohort data means that the members of the cohort are located within a specific temporal and spatial context, contributing to the narrative quality of the data. In fact, such data can be thought of as meta-narratives, in that they are not about specific individuals but factors/conditions at an aggregate level. Having said this, there are limitations for quantitative data alone to "produce narratives that allow for the reflexivity of the individual to be appreciated and the perspectives of the respondents themselves to be heard" (Elliott, 2008, p. 415). Further to this, Elliott (2008, p. 415) argues that "there is scope for innovative work that weaves together the different types of [qualitative and quantitative] evidence to produce new narrative forms". This research project aims to explore Elliott's (2008) assertion methodologically.

Elliott (2008) posits that longitudinal data allows for qualitative and quantitative techniques to be combined in new ways. She suggests three ways in which statistical models and numerical summaries can be understood and presented in more narrative terms. Firstly, just as an effective narrative involves the selection of important events, rather than the inclusion of every detail, statistical modelling enables the researcher to identify the most salient factors, or those variables that are most strongly associated with later outcomes. Secondly, while conventional quantitative analysis often obscures the individual through the aggregation of data, disaggregated chronological forms of data make it possible to re-construct quantitative biographies of individuals through time. However, what is missing from such reconstructed life stories is the "individual's evaluation of the events that are recorded" (Elliott, 2008, p. 413). Elliott goes on to elaborate:

> There is a danger that, unlike a fully formed narrative, a life history based on quantitative data does not so much conclude as simply terminate; typically it lacks closure, that summing up of the meaning of a chain of events with which it deals that we normally expect from the well-made story. (Elliott, 2008, p. 413)

To acknowledge and attempt to reconcile this ‘danger’, data from semi-structured narrative interviews, analysed using narrative analysis, will be employed in the second and third phases of this proposed research and used to provide individual voice to sets of quantitative data concerning the transitions of students through senior schooling and into a tertiary field of study. Thirdly, the collection and analysis of textual material, such as paper based subject selection forms completed by students during the SET planning process in Year 10, “increasingly makes it possible to produce case studies that draw on a combination of qualitative and quantitative material to produce understandings of individual lives within a broader social context” (Elliott, 2008, p. 414). As a final note from a more pragmatic perspective, “researchers wanting to use research to inform policy, can find multivariate statistical analyses rather dry and impenetrable, and do not do justice to the … individuals who are the subjects of the research” (Elliott, 2008, p. 416).

Consequently, this research has been framed as a “sequential, mixed model investigation” as defined by Tashakkori and Teddlie (1998, p. 150). Mixed model approaches are drawn from the paradigm of pragmatism – “instead of searching for metaphysical truths, pragmatists consider truth to be what works” (Tashakkori & Teddlie, 1998, p.12). In a methodology underpinned by pragmatism, the design of the study, including methods of data collection and analysis, is informed by the research questions. A sequential mixed model design, as a methodological framework, incorporates numerous phases and each phase of the research may use multiple approaches to data collection and analysis. In addition, each phase in the research should provide conceptual and/or methodological grounds for the next phase in the sequence (Tashakkori & Teddlie, 1998). In addition, the typology of this methodological approach requires mixing such that quantitative and qualitative approaches appear together in at least one phase of the study. A phase is defined as “a complete research effort consisting of a number of stages. Each phase is a part of the overall study” (Tashakkori & Teddlie, 1998, p.151). The objective of such an approach is that the data in one phase can be used to make data in another phase more meaningful and understandable. It is clear that this approach differs from the "fixed, random design" employed in positivist statistical paradigms which are also referred to as a mixed model investigations. Tashakkori & Teddlie's (1998) typology of a sequential mixed model design, as described here, allows for methodological rigour whilst engaging in exploratory methodological work.

2.4 Methods

Blackmore (2010) calls upon the critical policy researcher to consider which unit of the policy process the analysis will focus on: policy production, policy articulation or policy reception. It was decided that for the purposes of addressing the overarching research questions of this research, and to facilitate alignment with the typology of a sequential, mixed model investigation, that it would be necessary to formulate a methodological approach for each of these three units of analysis, or phases — as each phase allows the critical researcher to reveal different facets of the "social practices of educational policy" (p. 101). The methodological approaches, then, framed for each unit of analysis/phase are presented in the following sub-sections.

2.4.1 Phase 1: Policy production

The first unit of analysis, centred on policy production, will result in a policy genealogy methodologically informed by Scheurich and McKenzie (2005). The analytical framework will be informed by Bacchi (2009) and Gale (2001) and privileges the notion of a globalised education policy field, informed by Rizvi and Lingard (2010) and Apple (2010). This approach makes it possible to attend to Robertson and Dale's (2009, p. 33) point that "a critical theory perspective needs to be continually vigilant in making clear for whom and for what purposes it is working". Table 2.2 summarises the approach to the research, along with relevant guiding research questions for this policy production phase of the study.

Table 2.2
Summary of the methodological approach for Phase 1 - Policy production

Unit of Analysis	Phase/Focus	Methodological Approach	Analytic Tools	Guiding Research Questions	Relevant Chapter(s)
Policy Production *The STEM crisis*	Critical Literature review of science education policy and literature use to frame the STEM crisis	policy genealogy	Critical discourse analysis	How is the 'crisis' in STEM education framed in policy discourse?	3 and 4
				How did Chemistry come to regarded as an 'enabling science'?	5, 6 and 7

The goal of this research phase is to critique the framing of the science-education 'crisis' as it appears in the scope of policy. Further, critical discourse analysis informed by the work of Fairclough (2010) will draw attention to the 'official knowledge' that frames the construction of the STEM crisis as it appears in contemporary Federal policy.

2.4.2 Phase 2: Policy articulation

The second unit of analysis centres on policy articulation. According to Blackmore (2010), the circulation of policy between policy actors or agents involves "the articulation and vernacularisation of policy through the processes of its reception" (p. 101). In addition, Blackmore (2010) highlights the significance of "what policy sociologists refer to as the dangers arising from 'travelling policies' and how policy texts are taken up and circulate internationally to be imposed in different local contexts as if context does not matter" (p.

110). As such, policy analysis, with a focus on policy articulation, requires consideration of how a given context shapes the possibilities of a policy. Further to this, Apple, Au and Gandin (2009) state that one of the key tasks of critical analysis (and the critical analyst) in education is to “bear witness to negativity, that is, to illuminate the ways in which educational policy and practice are connected to the relations of exploitation and domination – and to struggles against such relations – in the larger society” (p. 4). Comparatively, Ball (1994) points out that policy is “a set of technologies and practices which are realized and struggled over in local settings” (p. 10). Apple, Au and Gandin (2009) assert that “rather than assuming that neo-liberal and neo-conservative policies dictate exactly what occurs at the local level, we have to study the re-articulations that occur on this level to be able to map out the creation of the alternatives” (p. 12). It is with consideration of these theoretical conceptions that the proposed unit of analysis centred on policy articulation was conceived. As is noted by Denscombe (2007), theory building can be achieved through the use of an illustrative case-study. This phase of the research examines the case of Chemistry, as defined by the QSA (2007) syllabus, and its articulation with tertiary entrance procedures in Queensland universities. In particular, this research phase seeks to investigate “the contradiction between widening participation and the consolidation of social positions” (Clegg, 2011, p. 93) evident in the Higher Education system in the state of Queensland. Courses naming Chemistry in relation to entry requirements will be identified using the *2010 QTAC Guide*. A summary of these courses, by field of education will be generated and used to compare the scope of Chemistry’s involvement in entry to Bachelor level degree courses in Queensland universities. Comparisons will be made between fields of education, as well as between universities representing different university interest groups. These findings will primarily be examined in light of Bourdieu’s (1999) notions of field and habitus, Bernstein’s notions of horizontal and vertical pedagogical discourse (1986) provides insight into the equity stances available to universities in light of the widening participation agenda (Gale, 2011) and the trends of governance evident in so-called ‘enterprise universities’ (Marginson & Considine, 2000). Moreover, the attributes, skills and capacities that individuals are held to develop through participation in Chemistry were drawn out through critical discourse analysis, with findings analysed in relation to critiques of the explanatory power of human capital theory and embodied labour power (Adkins, 2003, 2005) in the context of the knowledge economy. The methods employed in the policy articulation phase of this research are summarised in Table 2.3 below.

Table 2.3
Summary of the methodological approach for Phase 2 - Policy articulation

Unit of Analysis	Phase/Focus	Methodological Approach	Analytic Tools	Guiding Research Questions	Relevant Chapter(s)
Policy articulation *Policy is struggled over in local settings*	QTAC course guide	Case study and Critical Discourse Analysis	Summary of Bachelor degree course codes offered by Queensland universities that name Chemistry in relation to entry	How is Chemistry related to tertiary access?	8
	QSA 2007 Chemistry syllabus	Case Study and Critical Discourse Analysis	Critical discourse analysis of the QSA Chemistry syllabus document	What skills/abilities/capacities does participation in Chemistry foster?	8

				What is being enabled by calls for increased participation in the enabling sciences?	8

2.4.3 Phase 3: Policy reception

The reception of policy — as a unit of analysis — is concerned with the effects of policy in a given context (Blackmore, 2010). In the case of this research, the potential effects of current policy imperatives, from economic and education fields, on the 'choice' of senior school students to undertake the study of Chemistry will be investigated. This phase of the research is framed as an illustrative case study (Denscombe, 2007). Data generated in this phase will be both qualitative and quantitative, and used to illustrate potential effects of STEM policy production and articulation in three secondary schools in rural and regional Australia, and the relationships between school curriculum, career guidance and the higher education sector in Queensland. The methodological approach implemented in the policy reception phase of this research is summarised in Table 2.4 below.

Table 2.4
Summary of the methodological approach for Phase 3 - Policy reception

Unit of Analysis	Phase/Focus	Methodological Approach	Analytic Tools	Guiding Research Questions	Relevant Chapter(s)
Policy reception	Year 10 into senior schooling: SET plans	Mixed methods:	Summary statistics	How do systemic pathway and planning initiatives influence pathways through secondary school Chemistry, and to	9

Aspirations, capitals and transitions				STEM fields of study at university?	
	Student voice	Mixed methods:	Narrative Analysis of Interview transcripts	How do students in low SES secondary schools in rural/regional Queensland navigate the process of ‘choosing’ Chemistry?	9
				Who is being enabled by the study of Chemistry?	9

The purpose of this phase of the research is to firstly, examine the process that Queensland students are exposed to as they ‘choose’ subjects to study in their secondary years of schooling, that is, authoring a Senior Education and Training (SET) plan. In particular, the ways in which Chemistry features in relation to the SET planning process is the focus of this phase of the study. SET plans are a policy initiative of Education Queensland, that involves each student in planning his/her learning path to achieve a Year 12 certification (Queensland Certificate of Education) or a vocational qualification. As is described in depth in Chapter 9 of this thesis, SET planning is process of active negotiation between a student, a teacher and, ideally, the student’s parent or guardian. The outcome of SET planning is an ‘official’ account of the student’s study plan and aspirations for their future.

Further to ways in which student choice-making is directed or shaped, the proposed research seeks to explore the potential interactions between globalised education policy fields and the aspirations and choices of students at “exposed sites” (Teese, Lamb, & Helme, 2009, p. 6) – that is, those sites with less capacity to invest in the codification and hierarchical power of the curriculum. This research goal is formulated with a critical eye to the neoliberal conception of the individual as a rational chooser within markets; as “an autonomous entrepreneur responsible for his or her own self, progress or position” (McCarthy, Pitton, Kim, & Monje, 2009, p. 40). In sum, neoliberal subjects become “entrepreneurs of themselves” (Foucault, 1979, as cited McCarthy et al., 2009, p. 40). Such a view serves to frame the guiding research questions for Phase 3.

The quantitative data from Phase 3 was generated through document analysis conducted at three secondary school sites in North Queensland, representing urban, rural and remote geographies. The ‘low SES’ status of the schools, as defined by their ICSEA index, identify each of these school sites as ‘target schools’ under the widening participation agenda of the higher education sector. While it is recognised here that the ICSEA index itself is a problematic measure of socio-economic status, a critique of this index is not the focus of this study, herein. Raw data was obtained through an examination of paper-based subject selection forms completed by students in 2008. Data from 2008 was used as the students who completed these forms commenced Year 12 in 2010. These data were used to generate a count of the number of students who expressed an interest in studying Chemistry in their senior years of schooling. The data collected from the subject selection forms were then compared to the ‘official’ SET plans completed by students as they transitioned from Year 10 to Year 11. This data gathering process involved spending not more than two working days in each of the school sites.

As a result of the analysis of student SET Plans, counts of the numbers of students who (i) began to study chemistry, (ii) the number who withdrew from chemistry prior to completing four semesters of study, and (iii) the number who did not study chemistry, despite expressing aspirations to do so were generated. As a result, a longitudinal data set exposing potential relationships between initial subject ‘choice’ and subsequent student transitions through senior secondary school was generated. The data were analysed using summary statistics and interpreted in light of the notion of the diversification (Harreveld, 2007; Harreveld & Singh, 2007) and intensification of teacher's work (Apple, 1986), commodification of the curriculum (Marginson, 1997), and risk mitigation in light of narrow, neoliberal measures of accountability (Rizvi & Lingard, 2010).

The qualitative data gathered during Phase 3 was the result of individual, semi-structured narrative interviews conducted with staff and students at each of the schools under study. Where possible, the Deputy Principal, Head of Department: Science, and Head of Senior Schooling were interviewed at each school. In addition, not more than six volunteer Year 12 students were interviewed at each school site. Students who had engaged in Senior Chemistry in a range of ways were invited to participate. That is, students who had completed four semesters in Chemistry and passed each semester; students who completed four semesters of Chemistry but did not pass; as well as those who completed between one and three semesters of study in Chemistry.

Narrative interviews are among the least structured of all interview genres, with the overall goal being to find the most comfortable grounds for people to tell their stories. The justification for applying narrative analysis as an analytical tool is informed by Apple and Buras (2006), Chase (2005), Dauite and Lightfoot (2004) and Elliott (2005), and lies primarily with its ability to give voice to those who are under-represented in 'official' descriptions of a problem in policy. Prior to conducting the interviews with the volunteer participants, trial interviews using the proposed interview schedule were conducted with friends and family. This allowed the researcher to engage in a critical reflection process in regards to the techniques and protocols employed in the interview. Conducting a semi-structured, narrative interview requires the researcher to rapidly establish rapport with the participants. Rapport begins with the researcher's clarity of purpose. As such, participants were given clear, honest reasons for why they were contacted, what the project goals are, and how the interview will be conducted. In addition, interviewer self-disclosures were used as a means of signalling the equal-footing of those involved in each interview.

Interviews were semi-structured for three key purposes. Firstly, to allow for the coverage of themes deemed to be theoretically relevant to the investigation. Secondly, to provide opportunities to illicit narratives from the interviewees in their own language and with their own perspectives of significance insofar as is possible, and thirdly, to respond to issues raised by the interviewees and to seek clarification of these. An interview guide — as opposed to an interview schedule — was employed, with an emphasis on the goals of the interview in terms of the topics to be explored and the criteria of a relevant and adequate response. This interview guide is included as Appendix 2 to this thesis.

Each interview was approximately one hour in duration, and took place at each of the three school settings. Interviews were recorded using a digital audio recorder, and files were identified by code only. Files were securely stored, with any incidental identifiers (of individuals or schools) edited out. Coded copies were then transcribed and analysed for *content* (Mishler, 1995), *structure* (Patterson, 2008) and *context* (Lieblich, Tuval-Mashiach, & Zilber, 1998), with a view to providing data to address the guiding research questions for this phase of the research, as outlined in Table 2.4.

In summary, the methodological framework described herein, represents the rationale for the adoption of a critical policy analysis approach across three phases of analysis that frames "policy as practice in terms of the social practices involved in the production of policy, the practices involved with the articulation and vernacularisation of policy through processes of its reception, as well as the intent and effects of policy changing practice" (Blackmore, 2010, p. 101). The elements of the methodology align with the definition of a "sequential, mixed model investigation" as defined by Tashakkori and Teddlie (1998, p. 150), as the study is comprised of three phases of study and incorporates quantitative and qualitative approaches to data collection, analysis and interpretation. This methodological approach has been formulated to allow the three broad aims of the research, as outlined in Section 2.1 of this thesis, to be realised. As a final point, the methodological framework described herein seeks to engage with one element of Nancy Fraser's (2005) framework for Social Justice (as cited in Robertson & Dale, 2009, p. 298), namely "representation". The proposed research seeks to make evident the relationships between the globalised education policy field, the 'crisis' in science education, and the 'take up' of neoliberal subjectivities in school sites experiencing high levels of social and economic disadvantage. It also seeks to attend to one of the key tasks of critical analysis (and the critical analyst) prescribed by Apple, Au and Gandin (2009, p. 5), namely, to take the "privileges afforded to me as a [novice] scholar and to make use of them to open the spaces at universities and elsewhere for those who are not there, for those who do not now have a voice in that space and in the 'professional sites' to which [I] have access".

Section 2 Critiquing the Crisis: Supply

This section of the thesis attends to the methodological phase of policy production. The analyses presented in Chapters 3 and 4 aim to achieve two analytical goals. Firstly, in light of the first overarching research question: *What is the 'official' rendition of the STEM crisis*? a critical review of the substantial body of literature concerned with establishing reasons for the STEM crisis, as well as strategies to address is undertaken. This review seeks to firstly, establish that previous studies have framed the STEM crisis as a crisis of supply, and secondly, to offer a critique of this framing.

The notions of supply and demand employed throughout Section 2 are conceptualised in relation to human capital theory (Sweetland, 1996), but, as noted by Bowles and Gintis (1975, p. 79) "the human capital analyst, equipped with nothing more than a black box theory of both the firm and the school, is forced to offer explanations which are either superficial (supply and demand) or misleading (the interaction of tastes, technologies and abilities)." When attempts are made to view the STEM crisis through the lens of human capital theory, blame is attributed to agents working within the current macro-economic conditions, rather than critically examining the structural conditions that are in place, and may be contributing to the STEM crisis.

Therefore Section 2 of this thesis seeks to provide evidence that the crisis itself is superficially conceptualised, and therefore policy responses developed in relation to this framing do little to address the crisis. Furthermore, it is argued here that the crisis is a particular discursive construction that legitimates political intervention in people's aspirations, in order to attempt to construct a human capital profile that suits the aspirations of the nation-state. That is, a human capital profile imbued with STEM-qualifications in order to leverage competitive advantage to an Innovation-led knowledge economy (Bullen et al., 2006). While this political goal, *per se*, is not under critique here, what requires further thought is the ways in which students and teachers navigate and respond to these broader political aspirations.

To begin the critique of the crisis, Chapter 3 examines the ways in which data are employed in order to render an official version of the STEM crisis, as a crisis of supply.

Chapter 3 “Decreasing participation”: Evidencing the STEM crisis as an issue of supply

3.1 Introduction

As noted previously, an element of the STEM crisis established by (Tytler, 2007, p. 1) is the declining numbers of students participating in the study of post-compulsory STEM subjects. Here, the term post-compulsory refers to study undertaken in Year 11 and/or Year 12 in secondary school, or STEM study undertaken in a Higher Education setting. In contrast, ‘compulsory education’ in Australia refers to the years of schooling between the Foundation or Preparatory Year of full-time schooling and the completion of Year 10. The Office of the Chief Scientist (2012a) and Tytler (2007) both link “decreasing participation” in secondary school sciences with declining participation in STEM courses in universities. According to Fairclough (2010), political efforts to legitimate particular responses are achieved through official representations of the crisis. In relation to the STEM crisis, data describing a decline in student participation in the study of STEM subjects works to legitimate the crisis as one of supply. A critical examination of the data used to construct the crisis is presented as follows. Section 3.2 summarises and interrogates the secondary data sources used to establish “decreasing participation” in STEM subjects in the post-compulsory years of schooling (Years 11 and 12). Following on from here, Section 3.3 summarises and interrogates the secondary data sources used to establish “decreasing participation” in STEM courses in the Higher Education sector.

3.2 STEM participation in the post-compulsory years of schooling

Over the last decade, a great deal of research has been commissioned and conducted in an attempt to quantify the patterns and trends of STEM participation in the post-compulsory years of schooling in Australia. It is important to note that, historically, data collection methods lacked clarity and consistency between states, making the task of accurately quantifying trends in student participation difficult for researchers. Indeed, Goodrum, Hackling and Rennie (2001, p. 38) note that this lack of data was "lamented" by the Australian Council of Deans of Science (ACDS). Table 3.1 summarises a range of key studies that reported or attempted to ascertain trends in student participation in STEM subjects in the post-compulsory years of schooling in Australia. Furthermore, Table 3.1 draws attention to the agency that commissioned each report as well as the data sources cited within each report.

Table 3.1
Summary of key reports investigating trends in student participation in STEM subjects in post-compulsory years of schooling

Report Author and Year	Report Title	Commissioned by:	Cites data reported by:
Goodrum, Hackling & Rennie (2001)	The Status and Quality of Teaching and Learning Science in Australian Schools	Department of Education, Training and Youth Affairs	Dekkers & DeLaeter (2001) Dobson & Calderon (1999) for the Australian Council of Dean of Science
Department of Education, Science and Training (2006)	Audit of science, engineering & technology skills	Australian Government	Department of Education, Science and Training Higher Education Dataset 2004.
Goodrum & Rennie (2007)	Australian School Science Education National Action Plan 2008 – 2012	Department of Education, Science and Training	Goodrum et al (2001) DEST (2006)
Tytler (2007)	Re-imagining science education: engaging students in science for Australia's future	Australian Council for Educational Research	DEST (2003) *Attracting and Retaining*

			Teachers of Science, Technology and Mathematics Masters (2006) – which cited data by the Australian Council of Deans of Science and graphs showing declines that were not referenced, but appeared to be the similar to the graphs published in Ainley, Kos & Nicholas (2008) Osborne (2006)
Venville (2008)	Is the crisis in science education continuing? Current senior secondary science enrolment and tertiary entrance trends in Western Australia.	Peer reviewed journal article	Primary data
Ainley, Kos & Nicholas (2008)	Participation in Science, Mathematics and Technology in Australian Education	Department of Education, Employment and Workplace Relations (DEEWR) to the Australian Council for Educational Research	Data for the period 1990 to 2007 were provided by DEEWR and drawn together from information provided from the assessment,

			curriculum and accreditation authorities in each jurisdiction. Data published by Dekkers, de Laeter and Malone (1991) were used as the source for the period from 1976 to 1989. Longitudinal Surveys of Australian Youth data
Anlezark, Lim, Semo, Nguyen (2008)	From STEM to leaf: Where are Australia's science, mathematics, engineering and technology (STEM) students heading?	NCVER	Longitudinal Surveys of Australian Youth data
Lyons & Quinn (2010)	Choosing Science: understanding the declines in senior high school science enrolments.	National Centre of Science, ICT and Mathematics Education for Rural and Regional Australia (SiMERR Australia),	Ainley, Kos & Nicholas (2008) Dekkers & DeLaeter (2001)
Goodrum, Druhan & Abbs (2012)	The Status and Quality of Year 11 and 12 Science in Australian Schools.	Office of the Chief Scientist and funded by the Australian Government Department of Innovation,	Ainley, Kos & Nicholas (2008) – data until 2007 only

		Industry, Science, Research and Tertiary Education.	
Office of the Chief Scientist (2012a)	Health of Australian Science		National Schools Statistics Collection, Australian Bureau of Statistics for 2009 - Lyons (2012) pers comm

In their 2001 report, commissioned by the then Howard Government's Department of Education, Training and Youth Affairs, Goodrum, Hackling and Rennie — citing data compiled by Dekkers and DeLaeter (2001) — construct an argument of declining numbers of students participating in the sciences in the post-compulsory years of schooling. Goodrum et al. stress that these declines must be contextualised against an increase in the number of Australian students completing Years 11 and 12, with student retention having increased from 30 per cent in 1970 to 73 per cent in 1995. The data compiled by Dekkers and DeLaeter showed that between 1980 and 1988 the number of science subject enrolments exceeded the number of students, that is, on average, each student was enrolled in more than one science subject. However, between 1990 and 1998, this trend was no longer evident, with the ratio of subjects to students being less than 1. These data were employed by the government to indicate a decline in students participating in the study of STEM subjects in the post-compulsory years of schooling.

In 2006, following a ministerial re-shuffle, the Australian Government commissioned its newly formed Department of Education, Science and Training to conduct an audit of the nation's human capital – with a particular emphasis on the scope and nature of the science, engineering and technology skills evident. The audit involved an investigation of the trends in school enrolments. While differences between state classification systems hindered the collection of data, the audit found that enrolment patterns varied from state to state. In addition, the audit report states that the proportion of science enrolments declined from 19.1 per cent of total enrolments in 1993 to 15.4 per cent of total enrolments in 2003 (DEST, 2006, p. 18). These declines were reported to be of concern to stakeholders, and were attributed to a greater range of subjects available to students and decisions related to career choice.

Following from here, declining student participation continued to be reported in government commissioned reports. For example, Goodrum and Rennie (2007) released a report to evaluate the impact of a range of initiatives aimed at increasing student participation in STEM in the post-compulsory years of schooling. These authors concluded that, despite many initiatives, the numbers of students participating in the sciences in the post-compulsory years of schooling continued to decline. However, the data cited in the 2007 report were the same data cited by Goodrum et al. (2001) along with the same data presented by DEST in 2006. So, despite claims that declines were persisting, there was no new data reported to either support or refute these assertions.

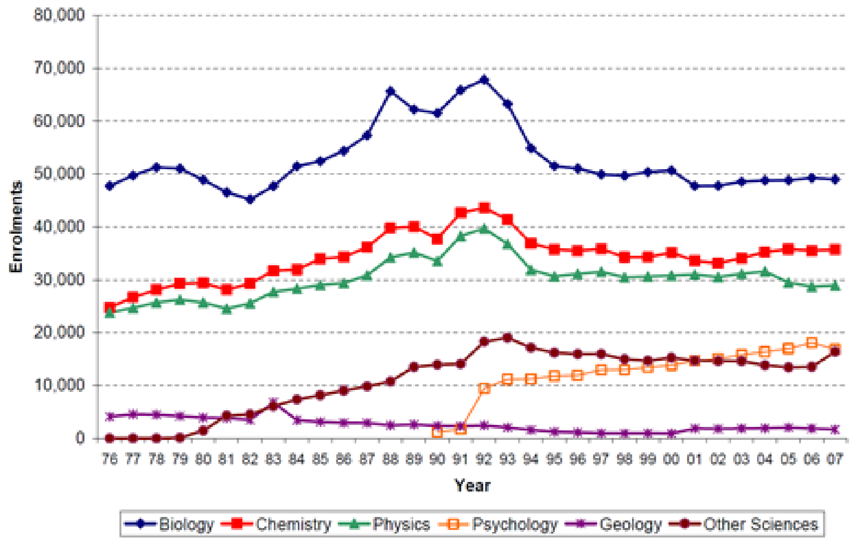
However, new data was presented in 2008, which showed there had been a short-lived — yet dramatic — decline in student participation in STEM subjects in the post-compulsory years of schooling. A report entitled, *Participation in Science, Mathematics and Technology in Australian Education* (Ainley, Kos, & Nicholas, 2008) is, arguably, the most comprehensive report produced for the Australian context that attempts to ascertain the numerical trends in student participation in STEM subjects across compulsory and post-compulsory education providers. This report focuses on data from 1991 to 2006 – a period during which consistent data was available from DEEWR. Furthermore, Ainley et al. (2008) is the first report to employ definitions for the measurement of participation. Three parameters were used to describe student participation in the post-compulsory years of schooling. These parameters are: (i) enrolments; (ii) subject participation rates; and, (iii) enrolment indices. Enrolments are defined as the number of students enrolled in a given subject. Moreover, Ainley et al. (2008) note that trends in patterns of enrolment reflect not only the propensity of students to enrol in science, but also fluctuations in the size of the Year 12 cohort over time. The second measure of participation — subject participation rates — is defined as the percentage of Year 12 students enrolled in a given subject, and it is calculated as the number of students enrolled in a specified subject divided by the total number of students in Year 12. Finally, the third measure of participation — enrolment indices — is defined as the percentage of students in a subject area (e.g. Science) divided by the total number of enrolments. Ainley et al. (2008) note that enrolment indices are difficult to interpret, and since it is an aggregated measure, a rise in enrolments in one subject (e.g. Psychology) can mask a decline in enrolments in another subject (e.g. Chemistry). Ainley et al. (2008) also note that due to the wide variety of subject names used across schools nationally, subject titles are used to cover various subjects deemed to be equivalent. Overall, the trends in STEM participation reported by Ainley et al (2008) are as follows:

> For Biology, Chemistry and Physics there were sharp declines over the period 1991 to 1995 (the enrolments in 1992 were the highest recorded) followed by smaller changes from 1996 to 2007. In the case of Biology, the maximum was 67,833 in 1992 and the minimum was 47,770 in 2002 (a drop of 20,063 or 42%). Those enrolments then rose to approximately 49,000 in 2006 and 2007. In Chemistry, the maximum was 43,594 in 1992 and the minimum was 33,105 in 2002 (a drop of 10,489 or 24%). Those enrolments then rose to just over 35,700 in 2005 and remained at that level through 2006 and 2007. In Physics, there was a fall in enrolments from 1992 to 1995 after which they remained almost relatively constant at approximately 31,000 through to

> 2004 before falling again in to just under 29,000 in 2007. In 1992, Physics enrolments were 39,690 and by 2006 they had declined to 28,730 which was a drop of 10,959 (or 28%). (p. 14)

For Chemistry, the field of science of particular relevance to this thesis, this extract alongside Figure 3.1 shows that despite an overall increase in the number of students enrolled in a science subject in the period between 1996 and 2007, a period of rapid decline occurred between 1992 and 1995. Since then, enrolment numbers rose until 2005, at which point enrolments remained steady through both 2006 and 2007.

Figure 3.1 Year 12 science enrolments in Australian schools: 1976 to 2007



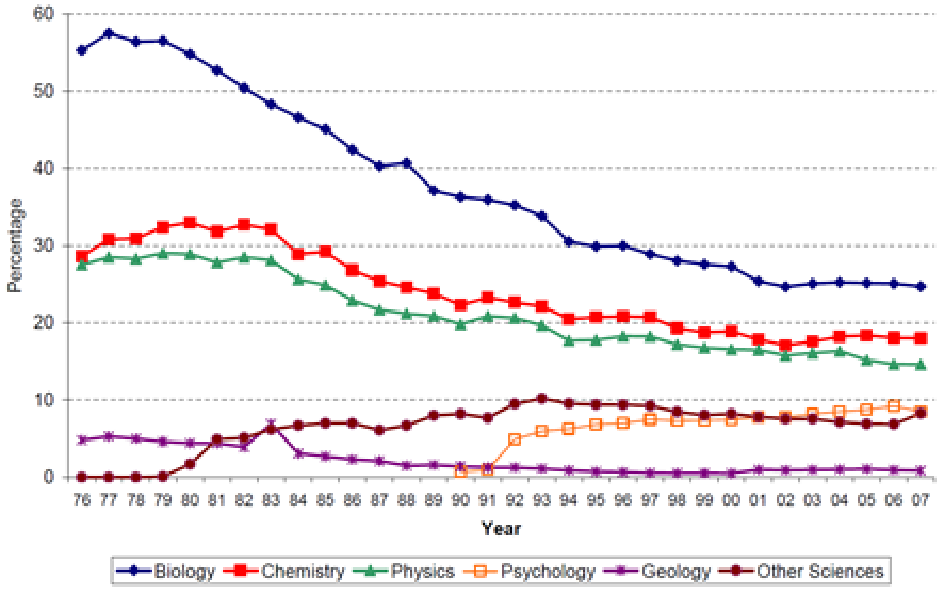
Source: Ainley, Kos & Nicholas (2008, p. 14).

However, when participation is reported using the measure of subject participation rates (see Figure 3.2) rather than enrolment numbers, declining rates of participation are evident for both Chemistry and Physics:

> Participation rates in Chemistry and Physics had peaked in 1980 at 33 per cent for Chemistry and 29 per cent for Physics. In 1991, the participation rates were 23 per

cent and 21 per cent respectively and by 2007 the participation rates had declined to 18 per cent for Chemistry and less than 15 per cent for Physics. (Ainley et al., 2008, p. 20)

Figure 3.2 Year 12 science participation as a percentage of the Year 12 cohort in Australian schools: 1976 to 2007



Source: Ainley, Kos & Nicholas (2008, p. 17).

In combination, these enrolment and participation rate data present different perspectives on the "decrease in participation". For instance, the enrolment data (Figure 3.1) shows that despite a sharp and rapid decline in student enrolments in the period between 1992 and 1995, the total number of students enrolling in Chemistry between 1976 and 2007 had, in fact, increased. In contrast, the percentage of Year 12 students participating in Chemistry had steadily declined. In addition to this reported decline, Ainley et al. (2008) state that "the trend [in post-compulsory years of schooling] since 1990 is one of a *substantial decline in the percentage of students studying two sciences in Year 12* [emphasis added]" (p. 22). Taken together, these data give shape to the "decrease" in question; that is, it pertains to the proportion of Year 12 students studying a STEM subject, rather than the absolute enrolment data. Despite this, there is slippage in official renditions of the nature of the "decrease", as is evident in this extract from *Health of Australian Science*: “the fact is that enrolment of senior school students in science subjects is at present on a long-term declining trend in both absolute numbers and as a proportion of the total cohort” (Office of the Chief Scientist, 2012a, p. 10).

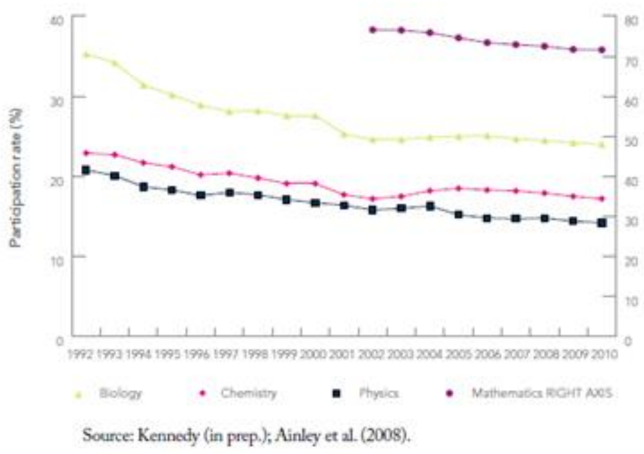
In addition to declining proportions of students studying STEM in post-compulsory years of schooling, finer detail regarding combinations of STEM subjects studied is also provided (Ainley et al., 2008). This analysis draws on Longitudinal Survey of Australian Youth (LSAY) data and it shows that:

> the most common combination of science subjects across each of the LSAY waves was Chemistry and Physics, while the least common combination was Physics and Biology. Further, while the proportion of Year 12 students studying most science combinations has remained relatively stable, the proportion of students studying Chemistry and Physics has gradually declined over time. (Ainley et al., 2008, p. 21)

Further analysis conducted by Ainley et al. (2008) revealed “a strong association between participation in particular science subjects in Year 12 and various characteristics, including; earlier mathematics achievement, socioeconomic background, sex, parental language background, school sector and location” (p. 24). For instance, earlier achievement in mathematics was strongly associated with participation in Chemistry or Physics. In the 2004 – 2006 cohorts, students in the highest achieving mathematics group were 11 times more likely to study Chemistry, and 15 times more likely to study Physics, than the students in the lowest mathematical achievement group. Socioeconomic background was also strongly associated with studying Chemistry or Physics in Year 12. Ainley et al. (2008, p. 23) found that “the participation rate in Chemistry and Physics among Year 12 students from the highest of four socioeconomic groups was almost twice that of students from the lowest socioeconomic group.” Students who completed Year 12 in an Independent school were more likely to having completed Chemistry than students from either Government or Catholic schools. Some variation in participation could also be attributed to the location of school setting – with metropolitan schools having slightly higher participation rate than rural school settings. Here, differential participation rates are identified, with the rates of participation being of more concern in relation to some groups — those that could be regarded as traditional equity groups (Gale, 2011; James, 2001) — than others.

Data presented by Ainley et al. (2008) is cited in the *Health of Australian Science* (HAS) report (Office of the Chief Scientist, 2012a). The HAS report presents a graph (see Figure 3.3) showing a continuation of the steady decline in participation rates reported by Ainley et al. (2008). The data source used to extend this graph is shown as Kennedy (in press) – the HAS report’s reference list reveals that this is a PhD thesis. In addition, the OCS (2012a) report states that there is very little national data available that quantifies the extent of student participation in the sciences in the post-compulsory years of schooling. Nevertheless, the Office of the Chief Scientist asserts that the declines are continuing.

Figure 3.3 Year 12 Science participation rates in Australian schools: 1992 to 2010



Source: Office of the Chief Scientist (2012a, p. 44, Fig. 3.2.1).

Aggregated data sets work to construct the declines as unproblematic knowledge. For example, the HAS report also includes a table (reproduced as Table 3.2 below) that reports aggregated student enrolment data in science subjects for 2009 across Australia. The source of these data is listed as “T Lyons, University of New England (pers. comm., February 2012)—based on data made available by state and territory boards of study and the Australian Bureau of Statistics” (Office of the Chief Scientist, 2012a, p. 24). It is argued here that the conceptualisation of the STEM crisis, as a crisis of supply, as is articulated by the Office of the Chief Scientist (2012a), is too shallow. The crisis is constructed as a one-size-fits-all problem. It fails to account for variation in patterns of participation between demographic groups and between contexts, such as those elucidated by Ainley et al. (2008). Furthermore, such an aggregation implies that these STEM subjects are uniformly available across all Australian jurisdictions, and does little to problematise the differential patterns of participation evident in earlier data sets, for example, those reported by DEST (2006) which noted that student enrolment patterns varied from state to state. Meanwhile, these differential patterns of participation expose an important feature of the crisis: low socio-economic status students, students studying in government schools, and students in rural settings are least likely to participate in the study of ‘enabling sciences’ such as Chemistry.

Table 3.2
Summary of secondary school student enrolments in STEM subjects, 2009

Subject	Students enrolled (no.)	Proportion of cohort (%)
Biology	49 681	24.1
Chemistry	35 867	17.4
Geology and Earth science	2 201	1.1
Mathematics	148 097	71.7
Physics	29 532	14.3

Other science	16 655	8.1

***Note*. Source: Health of Australian Science (Office of the Chief Scientist, 2012a, p. 24).**

More nuanced examinations of trends in STEM participation in the post-compulsory years of schooling may be more helpful in ascertaining the critical features of the crisis. For instance, Venville (2008) investigated patterns of science enrolment in the senior years of schooling in Western Australia between 2002 and 2007. Venville found that while the total number of science enrolments did not change considerably (from 13,854 in 2002 to 13,896 in 2007), what did change was that the number of Chemistry enrolments increased, and the number of Biology enrolments decreased. When examined as a percentage of the students eligible for tertiary entrance, an increase in Chemistry enrolments (from 31.14 per cent in 2002 to 34.76 per cent in 2007) and a decrease in Biology enrolments (from 18.35 per cent in 2002 to 15.57 per cent in 2007) was again evident (Venville, 2008, p. 42). However, when science enrolments were represented as a percentage of the total number of students enrolled in Year 12 in Western Australia, decreases in the proportion of students studying science were evident. In her discussion, Venville states that the rate of decline reported nationally was not as dramatic in Western Australia. Instead, Venville suggests that the participation rates in Western Australia to be "stagnant" and "maintained at an artificially high level" (2008, p. 43) because students choose a science subject such as Chemistry primarily to improve their Tertiary Entrance Rank score or to improve future job prospects. Venville's (2008) findings underscore the connection between the notions of 'participation' and 'student choice'. The relationship between choice and participation was also elucidated by Lyons and Quinn (2010) in their landmark research project conducted through the National Centre of Science, ICT, and Mathematics for Rural and Regional Australia (SiMERR). The role of student agency, as expressed through the choices each student makes, will be unpacked in Chapter 4 of this thesis.

Overall, these studies by Venville (2008) and Lyons and Quinn (2010) highlight the importance of considering differentiated patterns of student participation rather than examining aggregated trends which fail to account for contextual and demographic factors that may reveal barriers to student participation. While declines in participation rates in the study of STEM subjects have been recorded for the post-compulsory years of schooling — particularly during 1991 to 1995 — these rates have since stabilised. Arguably, what is presently of more concern are trends indicating that low socio-economic status students, along with students from government schools and rural schools, are among those least represented in the study of 'enabling sciences' such as Chemistry in the post-compulsory years of schooling. These trends are particularly significant to this thesis for three key reasons. Firstly, contemporary reports by the OCS (2012a, b) fail to take these differential patterns into account, and these omissions work to legitimate the strategic actions recommended by the report. Secondly, aggregating the data in this way works to universalise the crisis; making it seem as though it is a problem affecting all Australian students. However, failure to account for differential patterns of participation significantly undermines attempts to legitimate the STEM crisis. The particular needs and experiences of students identified as belonging to target equity groups are fused with a broader political agenda and this is counterproductive to the calls made by the widening participation agenda which seeks to increase participation of low SES Australians in higher education. Efforts to increase participation could be well informed by better understanding the differential patterns of participation. Thirdly, these trends call into question the extent to which students attending low socio-economic schools, state schools, and rural and regional schools can gain entry to STEM courses at university. Having presented an analysis of the data that attempts to ascertain trends in STEM participation in the post-compulsory years of schooling, focus will now shift to examine trends in the higher education sector.

3.3 STEM participation in the Higher Education sector

Patterns of student participation in STEM courses offered by Australian universities are chiefly described in research reports commissioned by either the Australian Council of Deans of Science (ACDS) (Dobson, 2003, 2007, 2012; Dobson & Calderon, 1999) or, from reports compiled by the Australian Federal government (see for example Department of Education Science and Training, 2006; Office of the Chief Scientist, 2012a, b). Throughout these reports, "decreasing participation" is evidenced by a number of measures including course enrolment data and course completion data. In addition, qualitative dimensions of decreased participation were also identified by these reports. Each of these facets of "decreasing participation" will be discussed.

In 2006, the then Department of Science, Education and Training (DEST) noted that most STEM enrolments in Australian universities were at the undergraduate level. In addition, the proportion of students studying in STEM courses at university (17%) (DEST, 2006, p. 20) had remained relatively stable between the years 1989 and 2004. However, while the proportion of the cohort studying in STEM courses had remained relatively constant, the demographic composition of the student cohort had changed. The data reported by DEST showed that the number of international students studying STEM in Australian universities had doubled, while the number of domestic students studying in STEM courses had decreased by approximately two per cent. This trend was particularly evident in the enabling sciences, and it was noted that the additional funding associated with an increase in international student enrolments had helped to ensure the sustainability of some of these courses. The other feature of the cohort reported to have changed was the perceived "quality" of the students entering STEM related courses — as defined by the Tertiary Entrance Ranking (TER) scores of the enrolling students — along with the perceived under-preparedness of school leavers entering STEM study in the Higher Education sector. For example, students with higher TER scores were noted to be entering courses in the Health field subsequently "placing the fields of Education, Architecture, Natural and Physical Sciences and Agriculture, Environmental and Related Studies in the lower half of applicant student performance" (Department of Education Science and Training, 2006, p. 26). Taken together, these findings have established that while the proportion of students participating appears to have remained relatively stable, the 'quality' of students has emerged as a central issue of the crisis from the perspective of the higher education sector.

Quantifying "decreasing participation" in relation to the Higher Education sector was made difficult by irregularities in data collection and enumeration methodologies used between institutions. Two ACDS commissioned reports: *Trends in Science Education: Learning Teaching and Outcomes 1989 – 1997* (Dobson & Calderon, 1999), followed by *Science at the Crossroads? A study of trends in university science from Dawkins to now 1989 – 2002* (Dobson, 2003) note the complexities involved in attempting to track the number of students who are studying in a STEM related field across Australian universities. For example, in 2001, many of the courses and subjects that were once classified under the auspices of the Natural and Physical Sciences Field of Education moved into their own Fields of Education. As such, the number of courses and subjects that could be counted as belonging to the Natural and Physical Sciences Field decreased. In addition, in the year 2002, the method used to account for student enrolments changed from counting students enrolled at March 31 census date, to counting all students enrolled at any point in an academic year.

These methodological complexities continued to be noted through time. In a third report commissioned by the ACDS, *Sustaining Science: University Science in the Twenty-First*

Century, (Dobson, 2007), the enumeration and coding methodologies enacted by DEST between the years of 2002 and 2005 are sharply in focus. Dobson (2007) notes that changes (both inclusions and exclusions) made to the coding of courses and subjects, along with some errors in data submitted to DEST by universities, made the task of counting the number of students in university courses in Natural and Physical sciences difficult. Subsequently, producing a dataset that accurately reflects trends in enrolments over time was also a complex and problematic endeavour. Despite these complexities, Dobson's (2007) report represents what is, arguably, at the heart of the crisis from the perspective of university science faculties, as is exemplified by the following extract:

> Between 1989 and 1997 there had been an expansion of over 35,000 enrolments in science courses, which represented an increase over the period of about 58 per cent. On the surface, this seemed like a very positive outcome, because sector-wide growth had been more modest, at 49 per cent. Since science was expanding at a relatively fast rate, one could have been forgiven for thinking that all was well in Australia's science faculties. However, from the perspective of Australian universities' science faculties, much of this growth had been 'illusory'. The expansion in 'science' enrolments did not represent an expansion of teaching in the enabling sciences, but rather came from an expansion in the behavioural and biological sciences, and even in the 'non-sciences'. As such, much of the teaching provided to many of the new 'science' students was not being provided by traditional university enabling science departments. For example, the behavioural sciences are often taught by faculties of arts or medicine. Similarly, at some universities many of the biological sciences might be taught by medical or other health-related faculties.
>
> It has also been the case that as time goes on, many more students now take 'science' as part of a combined course (eg science/arts or science/law), and although this is

> hardly a negative thing, some of the expansion in the 'non-science' component of 'science' degrees is due to the fact that non-core subjects are no longer taken from among the science disciplines, but from the course being studied in combination with the science degree…. The combined effect of these trends has meant declining enrolments in subjects taught by some departments, and severe financial constraints within faculties of science, including cutbacks in the numbers of academic and general staff in those departments. (Dobson, 2007, p. 1)

Here, the financial impact of the STEM crisis for faculties of science is made clear. The ACDS, then, represents a body of stakeholders with a vested interest in increasing the number of enrolments in the enabling sciences, and therefore in conceptualising the STEM crisis as, predominantly, a crisis of supply. Dobson (2007) presented comparative participation data for the years 1989 to 2005 and the variability in participation between the broad fields of STEM study across this time period is noted by Dobson to be of particular concern. For example, undergraduate enrolments in the Chemical sciences declined by 5.3 per cent, while enrolments in Biological Sciences increased by 74.9 per cent over the same period. These data, once again, indicate the STEM crisis is characterised by differential patterns of participation, with Chemistry among the science courses reporting declining enrolments.

Table 3.3
Summary of students enrolled in Natural and Physical Sciences courses at Australian Universities, 1989 to 2005

All Students	**1989**	**1997**	**2005**	**Variation 2005 - 1989**	
				Number	**Per Cent**
Mathematical Sciences	7520	6512	4988	-2532	-33.7%
Physical Sciences	3612	3351	2911	-701	-19.4%

Chemical Sciences	5932	6753	5617	-315	-5.3%
Earth Sciences	2173	3106	2195	22	1.0%
Biological Sciences	10648	18658	18624	7976	74.9%
Other Sciences	1617	3375	4007	2390	147.8%

***Note.* Source: Dobson, 2007, p. 71: Table 78 Student Load 1989 - 2005: Teaching to students enrolled in Natural and Physical Sciences Courses by Discipline Group**

In 2012, Dobson produced the most recent examination of patterns of participation in the Sciences in Australian Universities entitled *Unhealthy Science? University Natural and Physical Sciences 2002 to 2009/10*. The 2012 report was commissioned by Office of the Chief Scientist, under the auspices of the Department of Innovation, Industry, Science, Research and Tertiary Education, with the Australian Council of Deans of Science providing support for the final design and layout of the report. The data presented in this report is from the period 2002 to 2009/10. During these years the methods used by DEEWR to count students and to classify courses and subjects were unvarying. As such, data consistency issues are avoided in this data set. However, the change in methodology employed by DEEWR after 2002 means that accurate and detailed longitudinal comparisons between this data set and earlier data, such as those reported in Dobson (2007), are not possible. Table 3.4 below compares the patterns of participation for all students enrolled across Broad Fields of Education to those enrolled in the field of Natural and Physical Sciences.

The total rate of growth across all Fields of Education is reported as 33 per cent. In comparison, enrolments in the Natural and Physical Sciences increased by 30.1 per cent, which is slightly less than the system-wide average. Engineering outperformed the system-wide average, experiencing increases of 39.8 per cent. Meanwhile, the Health field experienced a substantial increase of 68 per cent. Overall, Dobson (2012) concludes that student participation in the Natural and Physical Sciences is comparable to the system-wide results. This conclusion implies that there is no inherent 'crisis' in participation in the Natural and Physical Sciences as a Field of Education. However, Dobson (2007) supplements this finding with a cautionary note: "in societies where economic growth is based on innovation and technology-driven change, perhaps 'holding ground' is not good enough" (p. 13). Here, a shift in the discursive construction of the crisis is evident; the data cannot reasonably be used to construe the crisis as an issue of supply, so instead the focus of the crisis shifts to that of needing to fuel growth in an innovation-led economy.

Table 3.4
Growth in enrolments for Natural and Physical Sciences, compared with other broad fields of education, 2002 to 2010

	2002		2005		2009		2010		Growth	
	No.	%	No.	%	No.	%	No.	%	No.	%e
Broad Field of Education										
Agriculture, Environment& Related	18341	2.0%	17004	1.8%	17199	1.5%	18245	1.5%	-96	-0.5%
Architecture & Building	17756	2.0%	19697	2.1%	26043	2.3%	27533	2.3%	9777	55.1%
Creative Arts	53214	5.9%	58318	6.1%	75845	6.7%	79973	6.7%	26759	50.3%
Education	85149	9.5%	91273	9.5%	100503	8.9%	105416	8.8%	20267	23.8%
Engineering	59863	6.7%	64191	6.7%	77564	6.8%	83666	7.0%	23803	39.8%
Food. Hosp. Pers.	150	0.0%	90	0.0%	1148	0.1%	1099	0.1%	949	632.7%
Health	96318	10.7%	108360	11.3%	150800	13.3%	162611	13.6%	66293	68.8%
Information Technology	73402	8.2%	59825	6.3%	48153	4.2%	48068	4.0%	-25334	-34.5%
Management & Commerce	228789	25.5%	260748	27.2%	318468	28.1%	325508	27.3%	96719	42.3%

Natural & Physical Sciences	60601	6.8%	65204	6.8%	72789	6.4%	78858	6.6%	18257	30.1%
Society & Culture	178868	19.9%	188173	19.7%	217911	19.2%	232624	19.5%	53756	30.1%
Mixed Field	1893	0.2%	1861	0.2%	6513	0.6%	7577	0.6%	5684	300.3%
Non-Award	22277	2.5%	22433	2.3%	21930	1.9%	21479	1.8%	-798	-3.6%
Total	896621	100.0%	957177	100.0%	1134866	100.0%	1192657	100.0%	296036	33.0%

***Note.* Source: Dobson, 2012, p. 13. Table 3.5: Enrolments 2002 – 2010. Students by Broad Field of Education**

In relation to Bachelor degree enrolments, student demographic trends are also evident (as can be seen in Table 3.5). For instance, growth in international students enrolling in the sciences (86.9%), has surpassed their enrolment in all other fields of education (61.1%). On the other hand, domestic enrolments in science fields (8.2%) have been weaker than growth for all other fields (11.9%). While these broad trends indicate a proportional decline in the enrolment of domestic students in science fields in the Higher Education sector, a detailed examination of participation in the narrow field of science reveals further patterns of significance.

Table 3.5
Demographic data associated with student enrolments by broad field of education, 2002 to 2009

Gender Total	2002		2005		2007		2009		Growth	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
All fields of education	62389		652731		690393		751385		12756	20.4
Science – primary	48867		51794		521997793		55272		6405	13.1
Science – supplementary	7587		9369		61972		9369		1782	23.5
Science –All	56454	9.0	61163	9.4		9.0	6461	8.6	8187	14.5

Female Students										
All Fields of Education	35337		36837		390850		42659		73242	20.7
Science	30430	8.6	32933	8.9	32902	8.4	33899	7.9	3469	11.4
Male Students										
All fields of education	270482		284424		299546		324786		54304	20.1
Science	26024	9.6	28230	9.9	29070	9.7	30742	9.5	4718	18.
International										
All fields of education	108019		133741		146469		173994		65975	61.1
Science	4538	4.2	7397	5.5	7847	5.4	8481	4.9	3943	86.9
Domestic										
All fields of education	515820		518990		543924		577391		61571	11.9
Science	51916	10.1	53766	10.4	54125	10.0	56160	9.7	4244	8.2
Indigenous Students										
All fields of education	5209		5521		6131		6988		1779	34.2
Science	223	4.3	294	5.3	320	5.2	355	5.1	132	59.2
Science % of All	4.30%		5.30%		5.20%	5.1%				

Note. **Source: Dobson (2012, p. 33) Table 4.9 Enrolments 2002 – 2009. Bachelor's Degree Student Enrolments in All Fields of Education and Natural and Physical Sciences, by Gender, Citizenship Status and Indigenous Status.**

In order to examine the extent of student participation in the 'enabling sciences' in the Higher Education Sector, it is necessary to examine enrolment trends across the narrow fields of education. Table 3.6 below shows that the field with the largest growth is the 'Other Natural and Physical Sciences' group (23.7%). Meanwhile, negative growth is reported for both Chemistry (-23.6%) and for Physics (-22.8%).

Table 3.6
Enrolments in Natural and Physical Sciences course, by narrow field of education, 2002 to 2009

Narrow field of education	2002		2005		2007		2009		Growth	
	No.	%	No.	%	No.	%	No.	%	No.	%
Biological sciences	11583	20.5	12283	20.1	12248	19.8	11328	17.5	-255	-2.2
Chemical Sciences	1172	2.1	1217	2.0	1244	2.0	895	1.4	-277	-23.6
Earth Sciences	878	1.6	709	1.2	731	1.2	928	1.4	50	5.7
Mathematical Sciences	2510	4.4	2516	4.1	2268	3.7	2024	3.1	-486	-19.4
Physical Sciences	889	1.6	978	1.6	825	1.3	686	1.1	-203	-22.8
Other Natural and Physical Sciences	39422	69.8	43460	71.1	44656	72.1	48780	75.5	9358	23.7
Total	56454	100.0	61163	100.0	61972	100.0	64641	100.0	8187	14.5

Note. **Source: Dobson (2012, p. 35) Table 4.11 Enrolments 2002- 2009. Bachelor's degree Student enrolments in Natural and Physical Science courses by Narrow Field of Education**

Growth in the category of 'Other Natural and Physical Sciences' is also reflected in the changing composition of a Bachelor of Science degree. Table 3.7 shows that while the proportion of subjects from the traditional narrow fields of education (Biology, Chemistry and Physics) studied in a Bachelor of Science has increased over the period 2002 – 2009, these growth rates are surpassed by a marked increase (59.4%) in the degree content from sciences classified as "Other Natural and Physical Sciences". This otherwise unclassified group includes the narrow discipline groups of Medical Science (which exhibited a growth rate of 101.6 per cent between 2002 and 2009); Forensic Science (with a growth rate of 165.5 per cent between 2002 and 2009) and Pharmacology (with a growth rate of 104.6 per cent between 2002 and 2009) (Dobson, 2012, p. 39). However, as Dobson (2012) notes "it is difficult to tell if what is observable … represents changing study patterns by the nation's bachelor degree students, or changes in the way universities code their subjects to their discipline groups" (p. 38).

Table 3.7
Content of Natural and Physical Sciences Bachelor degrees by narrow discipline group

Narrow Field of Education	2002		2005		2007		2009		Growth	
	No.	%	No.	%	No.	%	No.	%	No.	%
Biological Sciences	13755	34.4	15415	36.4	15759	37.2	16184	35.8	2429	17.7
Chemical Sciences	4264	10.7	4732	11.2	4695	11.1	4757	10.5	493	11.6
Earth Sciences	1540	3.9	1504	3.6	1655	3.9	2128	4.7	588	38.2
Mathematical Sciences	4141	10.4	4267	10.1	4122	9.7	4660	10.3	519	12.5
Physical Sciences	1842	4.6	2020	4.8	1913	4.5	1948	4.3	106	5.8
Other Natural & Physical Sciences	2215	535	2861	6.8	3200	7.5	3531	7.8	1316	59.4

Non-science	12232	30.6	11559	27.3	11066	26.1	11958	26.5	-274	-2.2
Total	39989	100.0	42356	100.0	42409	100.0	45165	100.0	5176	12.9

***Note*. Source: Dobson (2012, p. 37) Table 4.13 Student Load 2002 – 2009. Content of Natural and Physical Sciences Bachelor's degrees by Narrow Discipline Group.**

Overall, these findings narrate a complex story. While the number of students studying a science degree at Bachelor level is increasing, these numbers are not keeping pace with the growth in enrolments across all other fields of education. Further to this, trends in the demographic make-up of the cohort are evident. The proportion of domestic students undertaking science at the bachelor degree level is in decline, while the proportion of international students undertaking science Bachelor degrees is on the rise.

Alongside patterns of enrolment, Dobson also considered course completion data. For Faculties of Science, a decline in rates of course completion has implications for financial viability as well as impacting on the availability of teaching roles within the Faculty. Dobson (2012) reported that the completion rate for Bachelor of Science degrees is less than the system-wide completion rate for all Bachelor degrees; 18.2 per cent compared to 24.8 per cent. Rates of course completion are especially low within particular narrow of fields within the Natural and Physical Sciences. For example, of the 15.4 per cent of students who commenced a degree in the Chemical sciences, only 6.5 per cent continued beyond their first year of study. Similar completion rates are evident in the mathematical sciences; while 17.9 per cent commence only 6.9 per cent continue. A more dramatic decline is evident for the Physical sciences; of the 11.2 per cent of students who commenced study in the Physical sciences, the continuance rate was reported at -0.6 per cent. So, in summary, not only is the overall growth rate of enrolment in science bachelor degrees lower than for all fields, so too are rates of course completion. These trends in course completions indicate that students are 'playing the market'. They are using a Bachelor of Science degree, with its lower ATAR requirements, to gain entry to the tertiary sector. Once accepted, a student can demonstrate their academic capacity through attaining the necessary Grade Point Average to then articulate into a degree with a more straightforward vocational pathway. In other words, commencing a Bachelor of Science leverages access to a professionally accredited degree in the health sciences. Perhaps, in such cases, completion of the Bachelor of Science was never the primary goal of the student.

For Faculty staff teaching in the Natural and Physical Sciences, the implications of declining course completions are evident in the extent of the 'service teaching' they conduct, as compared with the extent of service teaching undertaken by other broad fields of education. For instance, only 45.9 per cent of the Natural and Physical sciences teaching delivered in Australian universities was delivered to students enrolled in a Natural and Physical sciences course; this constitutes the lowest rate of teaching between a broad field of education and the courses classified under this field. In comparison, 92.9 per cent of Health discipline teaching was delivered to students enrolled in a Health course. Similarly, 87.4 per cent of all Engineering discipline teaching was delivered to students enrolled in an Engineering course. For Faculties of Natural and Physical sciences, an increase in service teaching results in less students available to move into Higher Degrees by Research within these fields which, in turn, has funding implications for these Faculties.

Despite overall figures indicating a rise in student enrolments within STEM related fields, declines in course completions — particularly in narrow fields of Chemistry, Mathematics and Physics — along with increases in service teaching, both coincide with students dissociating from courses in the Natural and Physical sciences. Instead, students are entering vocationally-oriented STEM courses, for example, courses in the health sciences fields. As Dobson (2012) suggests, this decline may be due to labour market demand or to the removal of compulsory participation in science subjects during senior secondary schooling. Given these trends, and the financial implications of these trends for Faculties of Natural and Physical Sciences, it is the decline in students *completing* a course in the Natural and Physical Sciences that is central to the version of the STEM crisis championed by the Australian Council of Deans of Science. Furthermore, declining course completions in the Natural and Physical sciences are held to compromise Australia's capacity to innovate (Dobson, 2012; Rice et al, 2009). These implications are particularly evident in reports that compare Australia's participation and completion rate data to that of its economic competitors and trade partners. For instance, the Office of the Chief Scientist (OCS) (2012b) compared participation data from 2002 for Australia to other countries in the Asian region, finding that, overall, Australia's graduation rates in Mathematics, Engineering and Science (MES) are low by international comparison:

> The international average for the ratio of STEM to non-STEM degrees was 26.4% in 2002. The Australian ratio in 2002 was 22.2 per cent, by 2010 it was 18.8 per cent. Australia is outstripped by China (ratio is 52.1%); Japan (ratio = 64.0%); South Korea (ratio = 40.6%). The Asian region broadly had a ratio of 33.3% (Office of the Chief Scientist, 2012b, p. 15).

Further to this, the OCS (2012b) then states: "It is no coincidence that the countries that now outperform us in PISA are those that have taken steps to increase the proportion of MES graduates" (p. 17). In this statement, the OCS (2012b) attempts to align the proportion of higher degree STEM graduates with the performance of primary school students against international testing benchmarks. Arguably, the position of the Office of the Chief Scientist is informed by human capital theory, and as is noted by Bowles and Gintis (1975), "the human capital analyst, equipped with nothing more than a black box theory of both the firm and the school, is forced to offer explanations which are either superficial (supply and demand) or misleading (the interaction of tastes, technologies and abilities)" (p. 79). In other words, while it is clear that the OCS (2012b) seeks to improve Australia's international ranking, and to leverage legitimacy for political action with regard to funding to address the STEM crisis, the comparisons drawn by the OCS (2012b) are superficial as they fail to take into account a range of factors that impact upon the 'supply-side of the science system'.

As noted earlier, Dobson (2012) suggested that patterns of course completion and participation in the Natural and Physical sciences may be attributed to macro-economic conditions, such as transitions in a globalised(/ing) labour market. Furthermore, as informed by Marginson (1997), "education can appear as either production or consumption" (p. 27). It is suggested here that the STEM crisis is largely shaped by market factors related to consumption, including exchange values and use-values, rather than by the "black-box" that is the education system, charged with the production of STEM-qualified human capital. Adding one idea to another, Robertson, Bonal and Dale (2002) also note that "although the goals and the means of the economic functions of education are not necessarily mutually exclusive, those aspects that may guide the expansion of education in the search of consumers may contradict those that guide education as an area of strategic investment for economic development" (p. 493). As such, while the reported relative declines in students completing particular Natural and Physical Science courses is not under dispute here, the extent to which schools and, more importantly, teachers can be held accountable for these declines, is. This point of contention is the focus of the following chapter, Chapter 4.

Chapter 4 Looking for Blame: Teachers' contributions to the STEM crisis

4.1 Introduction

As discussed in Chapter 3, decreasing participation is a central premise of the STEM crisis (Tytler, 2007) and the Office of the Chief Scientist (2012b) positions the work of schools and teachers as central to the supply-side of Australia's science system. Consequently, school and teachers alike are positioned as legitimate sites of action in political efforts to address 'decreasing participation'. In order to explore the work of teachers and schools in relation to decreasing participation, a critical literature review was undertaken. The results of this review revealed that teachers, and their work, are implicated in decreases in student participation in STEM subjects on three fronts. Firstly, the qualifications of teachers are positioned to be of concern. Secondly, the quality of the pedagogical decisions made by teachers is challenged and, thirdly, there is a perception that teachers bear significant influence over student decisions in relation to their career plans and future aspirations. These critiques of teachers' work originate in relation to the compulsory and post-compulsory years of schooling, as well as during pre-service teacher training.

The qualifications, pedagogical decisions and influence of teachers, as aspects of teachers' work, are often interconnected in the literature and, in some accounts, these issues are blamed for declines in student performance and participation. For example, the following quote from the Department of Education, Science and Training (DEST) attributes declines in student participation in the sciences to "too few, well qualified, committed and innovative teachers of mathematics, science and technology in schools" (2003, p. 3). In 2007, Tytler protracts this argument by suggesting the need for teacher education that supports the delivery of engaging science learning experiences, implying that current teaching practices failed to do so. Goodrum and Rennie (2007), also connect the work of teachers to declining participation, furthermore, they make calls to develop training resources for secondary school teachers of Physics, Chemistry and Biology that focus on improving pedagogical content knowledge. What is common to each of these accounts is that the work of teachers is linked to decreasing student participation in STEM subjects. The analysis presented in this chapter, Chapter 4, focuses on the extent to which teacher qualifications, pedagogical decisions and influence can be legitimately constructed as sites of action in efforts to address decreasing participation.

4.2 The Construction of Teacher qualifications and capacities

Australian Federal policy has identified the nexus of teachers, teaching and the production of human capital. Statements such as “teaching and teachers are central to the knowledge economy” (Department of Education Science and Training, 2003, p. 5) exemplify the centrality of teachers work to transitioning to a knowledge economy. The role of teachers, teaching and schools in addressing the crisis of supply is further explicated in the following extract from *Maths, Engineering and Science in the National Interest*:

> Whatever we choose to do (and doing nothing is surely not an option), we should understand that success will result from a long-term investment—spanning generations. Therefore what we do must be at the heart of our education system, indeed a central plank in our educational philosophy: *high quality, contemporary, engaging and equitable* [emphasis added]. The recommendations that follow *focus largely on schools* [emphasis added] —where most students clearly identify their future study options, *and teachers* [emphasis added], who have the greatest influence on the choices students make. While universities need to examine how they offer science and mathematics to their students—especially in the early years—*we need to*

> *ensure that the school sector maximises interest and provides opportunities for all students to study high quality mathematics and science leading to careers in those disciplines and in engineering* [emphasis added]. I note the *Smarter Schools National Partnerships,* in particular, the N*ational Partnership Agreement on Improving Teacher Quality* and concur with many of the objectives. I note also that responsibility for managing the school sector rests with states and territories, and there are imaginative ways to deliver the curricula being developed around Australia….We still fall short, however. After a lot of effort by many people, the proportion of mathematics and science students in schools still goes down; and in universities (as with engineering) it is virtually flat. Something different has to be done demanding a paradigm shift. There is a role for the Commonwealth working with states and territories to ensure that all Australians have access to *an education that meets a high threshold of quality* [emphasis added] — while the content of the curriculum is delivered to suit local circumstances. (Office of the Chief Scientist, 2012b, p. 6)

In this extract the Office of the Chief Scientist identifies the key roles that teachers and schools are to play in efforts to increase the proportion of students studying STEM subjects in their post-compulsory years of schooling. In particular, schools are charged with "providing opportunities" for "all students" to "study high quality mathematics and science subjects leading to careers in those disciplines". This is a notion that is of particular significance to this thesis, herein. In this declaration, schools, and the teachers who work within them, are encumbered with the responsibility to provide the opportunity for "all" students to study STEM. As will be argued throughout this chapter, such provision is not necessarily a straightforward endeavour. Moreover, the notion that teachers are able to provide STEM education that leads to careers is one that warrants critical consideration.

The concept of ‘quality’ is centrally positioned in strategies to increase student participation in STEM subjects. The term ‘quality’ is used repeatedly in the OCS (2012b, p. 6) extract cited above. In the first usage, the quality of the content or curriculum material itself is raised as a site of action in relation to the crisis. In its second usage, the term ‘quality’, used in conjunction with the term ‘threshold’, infers a set of standards, or benchmarks that need to be assured, before the educational experience can be regarded as one of ‘quality’. Given this notion, and the earlier statement referring to “teachers” as a “focus of the recommendations of this report”, it is argued here that the use of the term ‘quality’ is deployed to construct the quality of teaching and teacher qualifications as critical sites of action in addressing the STEM crisis. Semiotic construction, as is noted by Fairclough (2010), is comprised of two moments: the moment of “construal” (the fallible ideas that inform it) and the moment of “construction” (in the sense of the material processes, if any, that follow from it) ... “the relative success or failure of this construal depends on how both it and the construction respond to the properties of the materials (including social phenomena such as actors and institutions) used to construct social reality” (p. 209). The purpose of this section, then, is to explore the construction of teacher qualifications as a site of action in addressing the STEM crisis, and to draw attention to the moments in which the construal of the teacher’s role in the crisis fails.

In the recently released report *Mathematics, Engineering & Science in the National Interest* (Office of the Chief Scientist, 2012b), teachers’ capacities to implement “inspired teaching” were positioned as integral to any efforts aimed at increasing student participation in STEM:

> Inspired teaching is undoubtedly the key to the quality of our system, and to raising student interest to more acceptable levels. It is the most common thread running through the responses in every country where the issue has been assessed in any detail …. Inspiring teachers will generally be those confident that they know their subject well, and can transmit that confidence and their passion, into the classroom." (p. 7)

In this extract, the Office of the Chief Scientist constructs a framework for what counts as teacher quality: a strong background in discipline-specific content knowledge, and the ability to teach content in ways that "inspire" their students — presumably to continue to study in the STEM fields and to, ideally, pursue STEM studies in a higher education setting resulting in a career in these fields. Moreover, the OCS states that the "quality of the [science] system", hinges on the knowledge and training of the teachers working in the Australian schools. Despite the OCS's avowal of what counts as 'quality' teaching, deciding what counts as a teacher who is 'qualified' or perhaps more significantly 'unqualified' is a more complex issue. In response to this complexity, the OCS (2012b) propose the need to consider the qualifications of pre-service teachers as well as established teachers working in the field against a framework of standards.

The development and promotion of standards against which teacher qualifications are accredited is the responsibility of the Australian Institute for Teaching and School Leadership (AITSL). AITSL was established on 1 January 2010. This accrediting body was formed to "provide national leadership for the Commonwealth, State and Territory governments in promoting excellence in the profession of teaching and school leadership with funding provided by the Australian Government (Australian Institute for Teaching and School Leadership, 2012, p. 11). The establishment of this institution facilitated the move to national measures of teacher accreditation, as opposed to accreditation measures administered by each Australian State and Territory. AITSL is part of the advisory and support structure for the

Standing Council on School Education and Early Childhood (SCSEEC) — formerly the Ministerial Council for Education, Early Childhood Development and Youth Affairs (MCEECDYA).

SCSEEC was launched on 18th January 2012 and is one of twelve Standing Councils established under Council of Australian Governments (COAG) arrangements. The purpose of SCSEEC is to provide "a forum through which strategic policy on school education and early childhood development can be coordinated at the national level, and through which, information can be shared and resources used collaboratively towards the achievement of agreed objectives and priorities" (Standing Council on School Education and Early Childhood, 2012). SCSEEC is responsible for matters related to primary and secondary education as well as matters considered to be cross-sectoral such as transitions and careers. AITSL, under the auspice of SCSEEC, leads the enactment of reforms to teacher accreditation standards, as well as developing recommended processes for the review of teacher performance and development on behalf of the Commonwealth Government.

As part of the enactment of reform, AITSL have concurrently developed two documents against which teacher qualifications are evaluated and subsequently accredited. These are the *Australian Professional Standards for Teachers* (Australian Institute for Teaching and School Leadership, 2014a, b) — referred to hereafter as the Standards — and the *Australian Teacher Performance and Development Framework* (Australian Institute for Teaching and School Leadership, 2012). These documents underpin governmental efforts to construct teachers as a legitimate site of action in addressing the quality of teaching and learning experiences in Australian schools, as is exemplified the following extract:

> The Australian Professional Standards for Teachers *is a public statement of what constitutes teacher quality* [emphasis added]. The Standards define the work of

> teachers and *make explicit the elements of high-quality, effective teaching in 21st-century schools, which result in improved educational outcomes for students* [emphasis added]. The Standards do this by providing *a framework that makes clear the knowledge, practice and professional engagement required across teachers' careers*. They present a common understanding and language for discourse between teachers, teacher educators, teacher organisations, professional associations and the public. (Australian Institute for Teaching and School Leadership, 2014a, para. 1)

Here, AITSL claim that the Standards "define the work of teachers" which "results in improved educational outcomes for students". AITSL's claim is supported by the OCS (2012b), who state that teacher standards "should be applied rigorously" (p. 7) in order to provide "high quality" (p. 6) STEM education in Australian schools. However, not all authors would agree that rigorous application of teacher standards are the answer to improving the educational experience for students. For example, Apple (2007) argues that reducing teacher's work to a set of standards results in a narrowing of their professionalism and indicates a "change from licensed autonomy to regulated autonomy as teacher's work is more highly standardized, rationalized and policed … by statewide and national tests of both students and teachers" (p. 185).

The propensity for government to regulate and police both teachers and students is already underway in Australia's supply side of the science system. The *Australian Teacher Performance and Development Framework* (Australian Institute for Teaching and School Leadership, 2012), along with the Standards, constitute "the basis for a professional accountability model, helping to ensure that teachers can demonstrate *appropriate levels of professional knowledge, professional practice and professional engagement* [emphasis added]" (Australian Institute for Teaching and School Leadership, 2014a, para. 3). A shift toward regulated autonomy is dominated by a discourse of ‘standards’ ‘excellence’ and ‘accountability’, each of which are evident in the above quotation.

The political deployment of a discourse of ‘standards’ corresponds with attempts to construct an official version of teacher quality. According to Apple, (2007), the ultimate function of the neoconservative discourse of standards is to increase central control over “what should count as legitimate knowledge” (Apple, 2007, p. 184). This growth of the regulatory state contradicts the neoliberal ideology of market liberalisation, as constituted by the World Trade Organisation’s General Agreement on Trade in Services (GATS) (Robertson, 2003). Market liberalisation asserts that outcomes (including educational outcomes in a marketised education system) should be dictated by market logic. However, as is noted by Robertson et al. (2002):

> under GATS rules the national state may have more difficulties in generating discourses and practices to manage educational crises. It might be anticipated that a range of processes will emerge to deal with these problems. This might include recontextualization—that is, an attempt to achieve legitimation through transforming or rescaling the process to remove from view and therefore limit and manage struggles. (2002, p. 492)

According to Fairclough (2010, p. 76), the process of recontextualisation is the transformation of meaning and it is comprised of both “decontextualisation (taking meanings out their context) and recontextualising (putting meanings in new contexts)”. In light of the work of Robertson (2003), Robertson et al.(2002) and Fairclough (2010) outlined above, it is argued here that the move to position teachers, and in particular their qualifications, at the centre of the STEM crisis constitutes attempts to both leverage and legitimate state intervention in an otherwise market-based education system. Debate around teacher qualifications is, then, used to obscure weaknesses in the realisation of competitive advantage in a globalised knowledge economy.

Attempts to recontextualise the work of teachers in relation to standards is evident in calls made by the OCS (2012b) to "reinforce commitment to AITSL standards with the goal that only teachers who are qualified or accredited to teach mathematics and science subjects do so" (2012b, p. 7). Such calls infer that a significant proportion of teachers are not qualified to be teaching in STEM areas, thereby shifting the blame for the decreasing participation of students in STEM subjects to the qualities of the teaching workforce. However, the findings of numerous Australian research reports, published since 2007, show that the majority of STEM teachers working in Australian secondary schools hold the necessary STEM qualifications. For example, Goodrum, Druhan and Abbs (2012) surveyed 99 secondary school STEM teachers and overall, those surveyed were found to be qualified and experienced, with three quarters of the teachers surveyed holding a Bachelor of Science, and only seven per cent of respondents having no science qualifications. McKenzie, Kos, Walker, Hong and Owen (2008) also report that science teachers working in Australian secondary schools are both well qualified and well experienced, with at least 70 per cent of Year 11 and 12 Chemistry teachers having three years or more of Chemistry tertiary education, as well as having received training in the teaching of Chemistry, and having been teaching for more than five years. Less than six per cent of Chemistry teachers were found to have no Chemistry education. The findings of McKenzie et al. (2008) should temper concerns about the qualifications of all science teachers working in Australian schools, and consideration of these findings should call into question the need to rigorously apply standards to the entire teaching workforce in order to ensure a high quality education for all students.

While the McKenzie et al. (2008) report indicates that many teachers are qualified to teach in the STEM field, these findings contrast sharply with the concerns held by the Australian

Council of Deans of Science (ACDS) as informed by Harris, Jensz and Baldwin (2005), Harris and Jensz (2006), and Harris and Farrell (2007). These three reports, all commissioned by the ACDS raised concerns about the qualifications of Australia's science and mathematics teachers. Read together, these three reports indicate that it is not the proportion of 'qualified' teachers *per se* that may be at the centre of the issue. Rather, it is the notion of 'appropriately qualified' that is problematic. For example, McKenzie et al. (2008) chose to privilege the finding that 60 per cent of Physics teachers had completed three years of content relevant study, whereas Harris et al. (2005) chose to privilege the finding that 25 per cent of Physics teachers had completed only one year of content relevant study. These different readings of the quantitative data expose the notion of "appropriate qualifications" as problematic, as well as illustrating that this concept remains largely undefined in the literature.

While there are varying perspectives about which particularities may constitute an 'appropriate qualification', there is also variation in the terminology used to refer to 'appropriately qualified'. As is highlighted in Harris et al. (2005) there is a discrepancy among secondary school heads of department as to whether a major or a minor in a discipline area was sufficient discipline knowledge to acknowledge that a teacher is "suitably qualified" (p. 15). Marginson, Tytler, Freeman and Roberts (2013) report that "in Australia, teaching out-of-field is a major problem" (p. 116), noting that only 61.5 per cent of teachers working in Year 7 to 10 mathematics classes "had two or more years of tertiary mathematics (the minimum required to teach mathematics subjects in most countries)." However, the report notes that the case is "similar, if not quite so pressing" (p. 116) with regards to science teaching. Marginson et al. (2013) also report that the phenomena of 'teaching out-of-field' is more likely to occur in rural and regional schools, as well as State schools and Catholic schools serving low socio-economic status (SES) communities. Drawing the findings of these reports together, it is concluded that the notion of an 'appropriately qualified teacher' is a problematic conception. Further conversations are required in order to determine the depth and breadth of STEM-teacher qualifications Australia, as a nation-state, is satisfied to deem 'appropriate' across the compulsory and post-compulsory years of schooling.

The notion of out-of-field teaching is based on a divergence of teaching area and disciplinary expertise. For instance, in a statement concerning teaching out-of-field, Marginson et al. (2013) note that "while senior school physics and chemistry teachers are predominantly qualified and experienced, the majority of teachers of science across the 7-10 years are biology trained (p. 116). This statement implies that a Biology major is not an appropriate or adequate qualification to teach science in junior secondary classrooms. By default, a qualification in either Chemistry or Physics is positioned to prove more valuable for junior secondary school teachers, yet no further discussion is provided in relation to this inference. Osborne and Dillon (2010) also critique the reduction of 'good teaching' to qualifications associated with knowledge of a discipline area:

> the view that a mixture of good subject knowledge, pragmatism and ideology is sufficient to ensure excellent and exemplary teaching leaves no space for the teaching of science to progress. Rather, any weakness can be ascribed simply to teachers who are deficient in knowledge or skill. (p. 6)

It is argued here that attempts to determine 'appropriate' standards of teacher quality, qualifications and performance are undermined by a lack of consensus around what constitutes quality teaching, let alone quality STEM teaching. As a result, attempts to construe a lack of teacher qualifications as a legitimate cause of the STEM crisis are also undermined. Therefore constructing the work of teachers as a legitimate site of action in efforts to address the STEM crisis also becomes problematic. Despite a lack of agreement on what constitutes quality teaching, the AITSL (Australian Institute for Teaching and School

Leadership, 2014a) state the purpose of the new national standards of teacher accreditation is to achieve “improved educational outcomes for students”. This statement implies that students are currently under performing and that teacher quality is largely responsible for this underperformance. With regards to science teachers specifically, the quoted affirmation suggests that the number of ‘un-qualified’ STEM teachers in Australian schools is negatively impacting the performance of Australian students against international benchmarks. An examination of this proposition follows in the next section.

4.3 Teacher quality impacting student performance

The performance of Australian students in their compulsory years of science education is extensively measured and often cited in the science education literature, as well as in the media. For instance, an article published in the online magazine *The Conversation*, on 3rd December, 2013 states that “New international test results in reading, science and maths show that Australian education is going backwards – a declining trend that has been going on for the past decade” (Thomson, 2013). Similarly, as reported by the Australian Broadcasting Corporation on 4th December, 2013 “A new report comparing Australian high school students with 65 other countries shows the nation is slipping further behind in maths and reading skills” (ABC News, 2013). Regimes of international tests are routinely administered to primary and lower secondary school in Organisation for Economic Co-operation and Development (OECD) member countries around the globe. Two such tests that are employed as tools of comparison are the *Trends in International Mathematics and Science Study* (TIMSS) and the *Programme for International Student Assessment* (PISA). Dinham (2013) argues that there has been an increasing movement to associate student performance on these tests with teacher quality. Dinham’s (2013) position is clearly exemplified in the following extract from the *Teacher Performance and Development Framework* which works alongside the *Professional Standards* for teachers:

> Australia has a *high performing education system that fares well* on international comparisons. This has been achieved in large part through the efforts of *highly skilled and motivated teachers* and school leaders over generations. However, *the rest of the world is not standing still*. The Melbourne Declaration on Educational Goals for Young Australians makes clear that *Australia aspires not to be among the best in the world, but to be the best. … In seeking these goals, there is no more important endeavour than further improving the quality of teaching in Australia*. Nationally and internationally, there is unequivocal evidence that the quality of teaching is the most significant school factor affecting student outcomes [emphases added]". (Australian Institute for Teaching and School Leadership, 2012, p. 2)

Here, the role of quality teaching has become paramount to improved student performance. Dinham (2013) argues that the quality teaching movement "appears to have been hijacked" (p. 99), and the original work of Hattie (2009, cited in Dinham, 2013), that recognised the importance of teachers' work in classrooms has been misconstrued. Rather than validating the work of teachers, the need for "greater control over and surveillance of teachers" (p. 94) was instead delivered. As instructed by Fairclough (2010) "recontexualising should be seen as an appropriation/colonizing dialect: a matter of an opening to a potentially external presence which is however potentially appropriated and domesticated (p. 76)." In light of Fairclough's comments, it is argued here that the original meaning and intention of the work originating from the quality teaching movement has been recontextualised; its' meaning used to justify teacher reform agendas as legitimate means to address the decrease in student participation in STEM subjects in addition to masking the failures of the knowledge economy as a project conceived from neoliberal and neoconservative ideologies. What is evident in the AITSL extract (2012c, p.2), cited above, is an attempt to construct a legitimate account of the under-performance of Australian students, and then to conflate the under-performance of students with teacher quality.

Dinham (2013) also notes that “rather than being seen as education’s most important asset, teachers are being blamed when students fail to learn or to reach the standards set for them individually or collectively” (p. 92). Here, Dinham is identifying what Thrupp (1998) would refer to as a “politics of blame” which involves “an uncompromising stance on school performance in which the quality of student achievement is seen as the result of school policies and practices and any reference to broader sociopolitical factors is ruled out as an excuse for poor performance” (p. 196). However, as is evident in the extract from AITSL (2012c, p. 2), presented above, there is official recognition that “Australia has a high performing education system that fares well on international comparisons” and yet, this relative measure of performance is deemed inadequate. Instead, aspirations to be “the best” will require “improvements” to the quality of teaching occurring in Australian schools. The inference here, then, is that unless the quality of teachers and teaching improves, the performance of students cannot improve. The performance of Australian students on recent TIMMS and PISA tests are presented below, alongside considerations as to whether or not attempts to conflate student performance with teacher quality, in order to achieve legitimation for teacher qualification as a site of action in the STEM crisis, have been successful.

4.3.1 TIMSS performance

TIMSS testing has been carried out since 1995 by the International Association for the Evaluation of Educational Achievement (IEA) – an international organization of national research institutions and governmental research agencies. This test measures the performance of Year 4 and Year 8 students in relation to science and mathematics knowledge and cognitive domains. In 2011, TIMSS results for Year 4 students were obtained from 50 countries whereas results for Year 8 students were obtained from 42 countries. The performance of these student groups is then used to determine the relative ranking of each country. The ranking system is defined by the percentage of students reaching advanced international benchmarks in both Year 4 and Year 8. Table 4.1 presents countries' ranks based on 2011 TIMMS results. From this table it can be seen that East Asian countries were among the top performers in the TIMSS in 2011. In comparison, Australian Year 4 students are grouped with other countries at a ranking of 12th, and Australian Year 8 students are ranked at 7th. However, it is important to note that in both Year 4 and Year 8, the results of Australian students are above the international median.

Table 4.1
Countries ranked by the percentage of Year 4 and Year 8 students reaching the advanced international TIMSS benchmarks, 2011

Rankings by Year 4 students			**Rankings by Year 8 students**		
Rank	***Country***	***Percentage***	***Rank***	***Country***	***Percentage***
1	Singapore	33	1	Singapore	40
2	Korea	29	2	Chinese Taipei	24
3	Finland	20	3	Korea	20
4	Russian Federation	16	4	Japan	18
5	Chinese Taipei United States	15	5	Russian Federation England	14
6	Japan	14	6	Slovenia Finland	13
7	Hungary	13	7	Israel Australia	11
8	Romania England	11			
9	Sweden Czech Republic Slovak Republic	10			
10	Hong Kong	9			
11	Austria	8			

	Denmark	
	Serbia	
	Italy	
12	Australia	7
	Portugal	
	Germany	
	Kazakhstan	
	Ireland	
	Slovenia	

***Note.* The international TIMMS benchmark for Year 4 students is 5. In comparison, the international TIMMS benchmark for Year 8 student is 4.**

Overall, Martin et al. (2012) report that since testing first began in 1995, most countries showed gains in TIMMS performance in relation to the International Benchmarks. However, the proportions of Australian students reaching each benchmark have remained relatively stable over the period 1995 to 2011. The results for Australian Year 4 students are an exception to this trend. As can be seen in Table 4.2, the 2011 results for students in Year 4 at each of the advanced, high and intermediate benchmarks are significantly lower than those achieved in 2007. As such, the TIMMS performance of Year 4 students over the period 2007 to 2011 has declined.

Table 4.2
Performance of Australian Year 4 and Year 8 students on TIMSS testing, 1995 to 2011

	Percentage of Australian Year 4 and Year 8 students reaching TIMSS benchmarks 2011 - 1995							
	Year 4				Year 8			
Benchmark	**1995**	**2003**	**2007**	**2011**	**1995**	**2003**	**2007**	**2011**
Advanced International	13*	9	10*	7	10	9	8	11
High International	40*	38	41*	35	36	40	33	35
Intermediate International	72	74	76*	72	69	76*	70	70
Low Benchmark	89	92	93	91	89	95	92	92

Note. **Asterisk (*) denotes that the result for 2011 was significantly lower than the results indicated. Source: (Martin, Mullis, Foy, & Stanco, 2012, pp. 88,89)**

Further analysis of the performance of Australian students on TIMMS reveals areas of apparent strength and weakness in relation to science achievement. On the TIMMS assessment, science achievement is measured in two areas; namely, science content domains and cognitive domains. With respect to the science content domain, as summarised in Table 4.3, Australian Year 4 and Year 8 students performed with the most competence in the Earth Science content domain. Year 4 students performed with the least competence on the Physics content domain, while Year 8 students significantly underperformed in the Chemistry content domain. In summary, while Year 4 performance declined across all content areas between 2007 and 2011, Year 8 performance improved for all domains, except Chemistry, over the same time period.

Table 4.3
Trends in Achievement in Science Content Domains for Australian Year 4 and Year 8 students

	Year 4			Year 8			
	Life Science	**Physical Science**	**Earth Science**	**Biology**	**Chemistry**	**Physics**	**Earth Science**
2011 Average Scale Score	516	514	520	527	501	511	533
2007 Average Scale Score	529	521	536	519	504	509	521
Difference	-14	-7	-17	8	-3	2	13

Note. **Source: (Martin et al., 2012, pp. 156 - 159)**

With respect to the TIMMS cognitive domain, as summarised in Table 4.4, Year 4 students performed best in relation to *Reasoning*, followed closely by *Knowing*. However, between 2007 and 2011, Year 4 results declined across all three cognitive domains. With respect to the Year 8 cohort, *Reasoning* proved to be the strongest domain while results from the domain of *Knowing* proved to be the weakest. As with the trend evident in the science content domain, Year 8 students showed gains in average score scales across two of the three elements of the cognitive domain.

Table 4.4

Trends in Achievement in Science Cognitive Domains for Australian Year 4 and Year 8 students

	Year 4			Year 8		
	Knowing	**Applying**	**Reasoning**	**Knowing**	**Applying**	**Reasoning**
2011 Average Scale Score	517	513	518	514	517	526
2007 Average Scale Score	532	522	528	505	511	530
Difference	-14	-9	-11	9	6	-4

Note. **Source: (Martin et al., 2012, pp. 156 - 159)**

In summary, it can be said that Australia's overall science performance in the compulsory years of schooling, as evidenced by TIMSS results, is above the international median benchmark. In addition, some improvements in the performance of Year 8 students in relation to international benchmarks is evidenced by the data, but, trends also indicate declines in Year 4 student performance in the domains of both science content and science cognition. These data, taken as read, position Australia's performance as satisfactory, and therefore calls into question the notion of the under-performance of Australian students against international benchmarks. Moreover, Buckingham (2012) states that "data from international assessments can justifiably be used to show strength and weakness in education systems but offer little information about how to improve student performance." As such, associating improvement in student performance on international tests with teacher quality may be without basis.

Nevertheless, international benchmark data has already been used to enact measures aimed at improving teacher quality, as is evident in an example from the state of Queensland. In this particular case, the content and pedagogical knowledge of teachers working in the Preparatory Year to Year 6 was the target of an improvement program by the Queensland

Studies Authority (2011a). The impetus to improve teacher's knowledge came from a report which analysed the performance data for Queensland students from TIMSS 2007 (Year 4); NAP – Science Literacy 2006 (Year 6); TIMSS 2007 (Year 8) and PISA 2006 (Years 10 & 11). The analyses concluded that student performance improved significantly in the secondary schooling years of study and as such, student performance must have been linked to the content knowledge of teachers. As such, it was argued by the Queensland Studies Authority that professional development targeting teachers of Preparatory Year to Year 6 was warranted.

Given earlier accounts of the lack of clarity surrounding what counts as 'quality' science teaching, the decision to conflate student performance with teacher quality is arguably, rather narrow. Conjointly, this superficial assessment fails to consider that a range of social, economic and political factors, other than teacher knowledge, could have impacted on student performance in these tests. As is argued by Alexander (2012), analyses of this caliber "ignore the kinds of evidence that can provide a truer and more nuanced picture of education systems in action" (p. 4). Brown (1998) also negates the value of the TIMMS international benchmark as a measure of student performance: "information in international league tables is often too technically flawed to serve as an accurate measure of national effectiveness" (p. 33). Brown also stresses the need to "carefully examine differences in the samples from different countries, especially regarding the exclusion of low attaining students, before interpreting the results" (p. 41). What may, in fact, be at the root of concerns surrounding Australia's relative rank on international tests, is a phenomenon Dinham (2013, p. 94) refers to as "PISA envy"; a term which captures a sense of Australia's fixation on the performance of other countries relative to its' own, as is evident in AITSL's (2012c, p.2) perception that Australia, as a nation-state, aspires to "be the best". Following from there, the performance of Australian students on the PISA tests is presented below, alongside considerations on the extent to which teacher quality, as a site of action in addressing the STEM crisis, can be implicated in the achievement of these results.

4.3.2 PISA performance

PISA is an acronym which stands for the *Programme for International Student Assessment*. This program is an initiative of the OECD. Every three years, students from participating countries, aged 15 years, are tested in relation to three domains of literacy – mathematical literacy, reading, and scientific literacy. Three significant reports summarise Australia's PISA performance over the three most recent testing events: Thomson and De Bortoli (2008) summarises the results from the 2006 PISA test; Thomson, De Bortoli, Nicholas, Hillman and Buckley (2011a) summarises the results from the 2009 PISA test; and Thomson, De Bortoli and Buckley (2013) summarises the results from the 2012 PISA test. Mathematical literacy was the major domain assessed in the 2012 test, whereas reading literacy was the major domain assessed in 2009, and science literacy was the major domain assessed in 2006.

For each testing period since 2006, Australia's PISA results have remained above the OECD average in each of the scientific, reading and mathematical literacy domains. However, as was noted by Gonski et al.(2011), performance of the top achieving students has declined over the last decade, and these declines are particularly evident in comparison to the Asian countries neighbouring Australia, leading to an overall decline in Australia's international ranking (Office of the Chief Scientist, 2012b). Of additional concern to some authors (Thomson & De Bortoli, 2008; Thomson et al., 2013; Thomson et al., 2011a; Thomson, De Bortoli, Nicholas, Hillman, & Buckley, 2011b) is the gap between the highest and lowest performing students, and the link between PISA achievement and educational disadvantage. The major trends in scientific literacy performance of Australian students, as evidenced by PISA results drawn from each of these reports, will now be presented in relation to three lines of discussion. Firstly, the comparative performance of Australian students against international benchmarks will be examined. Secondly, the proficiency of Australian students in scientific literacy will be specifically considered. Thirdly, a range of contextual and demographic factors — including school type, geographical location and Indigeneity — will be treated in more detail. The implications of these analyses for this thesis herein, will then be presented in a summary discussion.

Performance on scientific literacy: international comparisons

Australia's mean scientific literacy score has remained relatively stable over the PISA testing cycles between the years of 2000 to 2012. Despite this stability, Australia's rank score has steadily declined. For instance, as can be seen in Table 4.5, only two countries outperformed Australia in the year 2000, whereas in 2006, Australia was outperformed in scientific literacy by three countries. By 2009, Australia's mean scientific literacy scores were found to be statistically lower than those of six countries. Then, by 2012, Australia's rank position had slipped, with seven countries receiving significantly higher results. Despite this apparent slippage, Australia's mean score had remained relatively stable and Australian students scored, and continue to score, well above the OECD average for scientific literacy. These data indicate that Australian students are performing relatively well against international PISA benchmarks, which calls into question the notion that Australian students are under-performing and, furthermore, questions the notion that STEM teacher quality is negatively impacting on student performance. Instead, while Australia's performance has remained the same, the performances of other jurisdictions and countries have improved. This is particularly visible for east Asian countries, including Australia's economic competitors.

Table 4.5

Comparison of Australia and other countries that have out-ranked Australia in the scientific literacy component of the PISA test, 2000 to 2011

2000 [1]		2003[2]		2006[3]		2009[4]		2012[5]	
OECD average 500								OECD average 501	
Country	**Mean score**	**Country**	**Mean score**	**Country**	**Mean score**	**Country**	**Mean score**	**Country**	**Mean score**
Korea	552	Finland	548	Finland	563	Shanghai-China	575	Shanghai-China	580
Japan	550	Japan	548	Hong Kong-China	542	Finland	554	Hong-Kong-China	555
Australia	528	Korea	538	Canada	534	Hong-Kong-China	549	Singapore	551
		Australia	525	Australia	527	Singapore	542	Japan	547
						Japan	539	Finland	545
						Korea	538	Estonia	541
						Australia	527	Korea	538
								Australia	521

Note. Source: [1] OECD (2001, p. 88); [2] OECD (2004b, p. 294); [3] Thomson & De Bortoli (2008, p. 63); [4] Thomson et al. (2011a, p. 222); [5] Thomson et al. (2013, p. 135)

The ascendancy of China's PISA performance, particularly over the last two testing cycles, is unmistakable. China's predominance in the international benchmarking has resulted in what Sellar and Lingard (2013) refer to as "PISA-shock" (p. 464). Despite China leading the rank, Buckingham (2012) suggests that there are a number of issues of comparability between the performance of students from the "Asian tiger economies" (p. 12), such as Shanghai, and the performance of students from Australia. Firstly, Buckingham (2012) argues that comparisons between Australia as a country, and Shanghai as a territory or city/state with "disparate … geography, history and culture" (p. 12) cannot be meaningful. Secondly, the same range of schooling alternatives is not evident across these jurisdictions. Moreover, students in Shanghai "are subjected to punishing study schedules that Australian families would consider excessive" (p. 1). Nevertheless, as noted by Sellar and Lingard (2013), China, through the results of students from Shangai, has become "an important reference society for the USA, England and Australia and is used in contemporary practices of externalisation in national policy developments and policy steerage in those nations" (p. 481). Sellar and Lingard (2013, p. 467) cite Schriewer (1990) to argue that "reference societies have also been essential to processes of 'externalisation' in policy production; that is, the use of policies in other systems to justify and legitimate the necessity of domestic reform". Sellar and Lingard (2013, p. 467) also cite Waldow (2012, p. 418) to construct a definition of externalisation as "a discursive formation that can become relevant in the context of borrowing, and lends itself easily to the purpose of producing legitimacy for national reforms in education." It is suggested here that attempts to construct the under-performance of Australian students in scientific literacy is, in fact, an example of externalisation, whereby Australia's position relative to Shanghai is used to both justify and legitimate policy reform in relation to the STEM crisis. In particular, teacher quality is construed as the reason for this relative under-performance. To progress this argument, specific scientific literacy scores of Australian students are presented and discussed in the following section.

Proficiency in scientific literacy

As the first major international assessment of scientific literacy, PISA 2006 established the baseline for trends in science performance and "it is therefore not possible to compare science learning outcomes from PISA 2006 with those of earlier PISA assessments as is done for reading and mathematics" (Thomson & De Bortoli, 2008, p. v). As such, comparisons are restricted to the years of 2006, 2009 and 2012.

The scientific literacy proficiency of Australian students is summarised in Table 4.6. It can be seen that student proficiency has remained largely unchanged in the years between 2006 and 2012 – a trend also evident for the OECD average in scientific literacy. For example, across each of the test years, three per cent of Australia's students achieved the highest scientific literacy proficiency level (Level 6), which was above the OECD average of one per cent. Similarly, the proportions of students who failed to reach Level 2 are comparable across the test years. This stability in scientific proficiency scores again calls into question the notion of declining student performance, and the need to improve teacher quality in order to address the STEM crisis.

Table 4.6
Comparison of scientific literacy proficiency, 2006 to 2012

Scientific Literacy Level	2006 Percentage of test cohort	2006 OECD average	2009 Percentage of test cohort	2009 OECD average	2012 Percentage of test cohort	2012 OECD average
6	3	1	3	1	3	1
5	12	8	11	7	11	7
4	25	20	25	21	23	20
3	28	27	28	29	29	29
2	20	24	20	24	21	25
1	10	14	9	13	10	13
Below Level 1	3	5	3	5	3	5

While Australian students scored well in international comparisons of PISA scientific literacy results, further analysis of PISA data reported by Thomson and De Bortoli (2008), Thomson et al. (2011a) and Thomson et al. (2013) reveal that the real issue for Australian students lies in the relative under-performance of specific groups of students as compared with other Australian students. Results reported in these reports state that Indigenous students, students from state schools, students from low socio-economic backgrounds and students from rural and remote schools repeatedly test well below other Australian students. For instance, across all three test years, the distribution of Australian students' scores between the 5th and 95th percentile were wider than the OECD average for scientific literacy – with the gap increasing over time (see Table 4.7). This wider-than-OECD-average distribution of scores indicates that there is a greater than average gap between the scientific literacy scores of the highest and lowest achieving Australian students.

Table 4.7
Summary of the difference between Australia's average scientific literacy score from the 5th to the 95th percentile, 2006 to 2012

	2006[1]	**2009[2]**	**2012[3]**
Difference between the 5th and 95th percentile	327	333	329
OECD average	312	308	304
Difference	15	25	25

Note. **Source: [1]Thomson & De Bortoli (2008, p. 63); [2] Thomson et al. (2011a, p. 222); [3] Thomson et al. (2013, p. 135).**

These wider-than-average achievement ranges, taken alongside data reported in Table 4.6 show that, on average, 13 per cent of Australian students score below the internationally assigned benchmark of Level 2, indicating that the scientific literacy performance of particular groups of students is of more significance to the notion of student under-performance, as a feature of the STEM crisis, than is the aggregated scientific literacy performance of Australian students as compared with international rankings. Each of the contextual and demographic factors related to under-performance will now be discussed in turn.

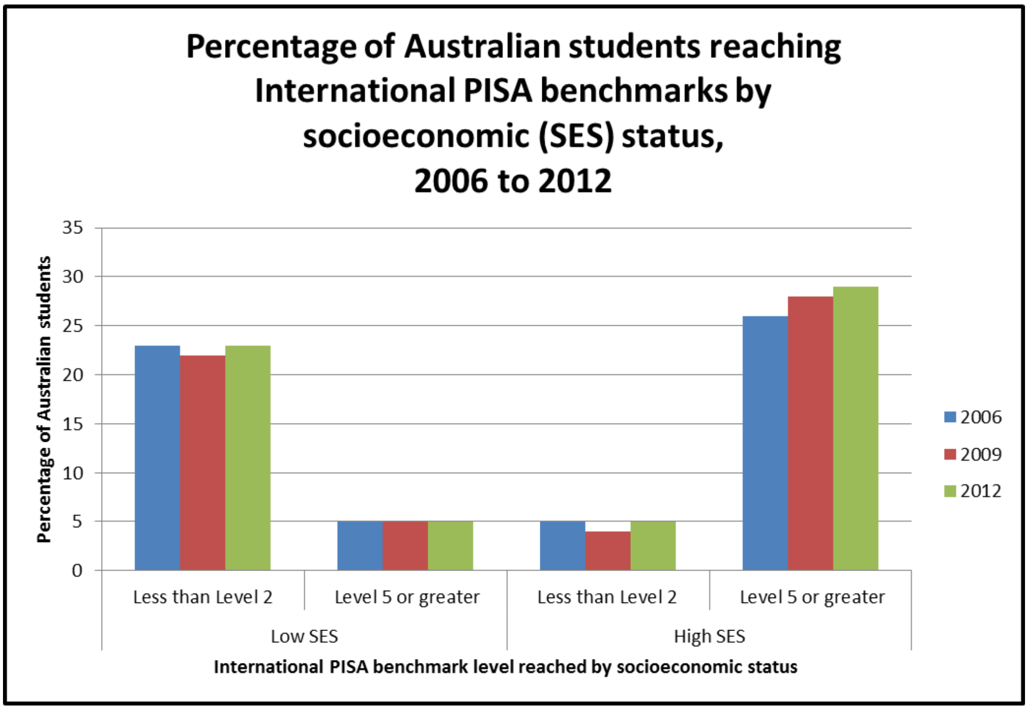
PISA and Australian school sectors

Analysis by school sector is provided for 2009 and 2012. As such, no comparison can be made to 2006. Thomson et al. (2013, p. 144) shows that there are differences in the percentage of students falling below the internationally accepted benchmark of Level 2. In government schools, 18 per cent of the students failed to reach this benchmark, as compared with 9 per cent in Catholic schools and 5 per cent in Independent schools. Furthermore, as is reported on pages 231 to 233 of Thomson et al. (2011a), the unadjusted mean scores of students attending government schools (511 score points) were lower than those of the Catholic school sector (540 score points) and the independent school sector (566 score points). However, once the socioeconomic background of both the student and the school was taken into account, there were no statistically significant differences in the scores of students. As such, Thomson et al. (2011a) concluded that an individual student's socioeconomic background, alongside the peer effect of the average socioeconomic level of the school itself, affects student performance in relation to scientific literacy as measured by the PISA test.

PISA and socioeconomic background

In PISA, socioeconomic background (SES) is determined by an index called the Economic, Social and Cultural Status (ESCS) index. This takes into account the parental occupation and educational background of the student and an index of home possessions, including access to educational and cultural resources at home. Australia's mean average for the ESCS index was 0.21, which was higher than the OECD average. A relationship exists between PISA achievement and the ECSC index for all countries. However, it is the strength of the relationship that varies between countries. In Australia, the strength of the relationship between ECSC and performance in science literacy is significantly lower than the OCED average. This indicates that the relationship is less deterministic. Relationships between SES background and scientific literacy scores were reported for each of the three testing years. The scientific literacy score of students in the lowest SES quartile was consistently and significantly lower than that of students in the highest SES quartile. As noted by Thomson et al. (2013, p. 147), "this difference was statistically significant and represents over one proficiency level or around two-and-a-half years of schooling." Furthermore, as can be seen in Figure 4.1, consistently larger percentages of low SES status students fell below the internationally accepted standard of Level 2 than did their high SES counterparts. Likewise, greater proportions of high SES students gained a score at Level 5 or higher, than did their low SES counterparts. In other words, while almost 25 per cent of low SES students failed to reach acceptable international benchmarks, approximately 25 per cent of high SES students were in the top two score ranges of the PISA test.

Figure 4.1 Comparison of International PISA benchmark reached by socio-economic status of Australian students, 2006 to 2012



***Note.* Graph generated by thesis author, from data extracted from Thomson & De Bortoli (2008); Thomson et al. (2011) and Thomson et al. (2013).**

Regardless of this apparent differential, the average of the association between SES background and PISA performance for Australian students was found to be similar to the average over OECD countries. Consequently, Australia's higher than OECD average results in scientific literacy coupled with Australia's average strength of relationship between SES background and performance, resulted in Australia's categorisation by the OECD as a high-quality/high-equity country in relation to science literacy performance. This categorisation was called into question by Thomson (2013), who asserted:

> With these results it's hard to see how Australia is high-quality or high-equity. Is "high-equity" a term you would use to describe a country in which the equivalent of around two-and-a-half years of schooling separates the maths, reading and science scores of students in the highest socioeconomic group and students in the lowest socioeconomic group? Or where significant gaps separate the achievement of students based on their gender, location and cultural background? Far from being complacent about being categorised as high quality-high equity, these findings show that Australia has cause for concern. (para. 5)

In order to address this disparity, Thomson (2013) suggests that the efforts already made to improve student outcomes through the Australian Curriculum and the Standards for teachers need to be continued. In particular, states Thomson, emphasis should be placed on professional learning, and skills development in relation to data analysis and assessment techniques "in order to focus on each student's learning" (para. 15). Furthermore Thomson calls for measures to "increase social inclusion – and reduce socioeconomic segregation – in our school system" (para 14.).

Again, teachers — and specifically their qualifications and capacities — are held as central to overcoming issues related to student performance. It is at this point in the argument that it is necessary to restate the findings of Gonski et al.(2011):

> Australian Government funding arrangements for government schools, and for non-government schools under the socioeconomic status funding model, are based on an outdated and opaque average cost measure, the Average Government School Recurrent Costs. As such, the funding that is provided to schools does not directly relate to schooling outcomes, and does not take into account the full costs of educating students to an internationally accepted high standard of schooling. (p. xv)

Gonski's judgement underscores that teachers, particularly those working in schools serving low SES communities, state schools, and rural and regional schools, are working within a system that is chronically under-funded and under-resourced. Therefore, while policy externalisation practices (Sellar & Lingard, 2013) focus on the teaching workforce as the source of weakness in the supply-side of Australia's science system, the political gaze is averted from the larger structural issues that are play. Attempts to render teacher quality as part of the crisis, then, serve to distract the general public from the larger — and less politically desirable — projects required to address the crisis at a systemic level.

PISA and Indigeneity

There is international recognition that, globally, Indigenous peoples are under-represented in cohorts of students who reach or exceed international PISA benchmarks (Marginson et al., 2013). For many Indigenous Australians, these trends are no different. For example, the average difference between the scientific literacy performances of Indigenous Australian students and non-Indigenous Australian students "equates to more than one proficiency level or about two-and-a-half years of schooling" (Thomson et al., 2013, p. 146). Furthermore, Indigenous students were over-represented in the lowest categories of science proficiency and under-represented in the highest category. For instance, in 2012 only two per cent of Indigenous students demonstrated scientific literacy at proficiency Level 5 or higher, compared to 14 per cent of non-Indigenous students. An additional report authored by De Bortoli and Thomson (2010) examined factors that influence Indigenous student performance in PISA. Their study found that home influences and educational resources in the home had a large impact on Indigenous student performance in PISA, as well as lower levels of self-efficacy in relation to mathematics and science, and reportedly lower levels of appreciation in, and instrumental motivation for science, than their non-Indigenous peers. In contrast, Nakata (2007) states that "one knowledge system cannot legitimately verify the claims to truth of the other via its own standards and justifications" (p. 8) and that work at "the cultural interface ... the contested space between the two [Western and Indigenous] knowledge systems" (p. 9) highlights the Indigenous knowledges that are recognised and valued, as well as those that are marginalised and silenced. Further to this, Klenowski (2009) cites the body of literature that recognises the cultural bias inherent in standardised international testing, and as such, she calls into the question the validity and fairness of assessments such as PISA; instead calling for "culture-fair" (p. 78) assessment methods and strategies, because as Nakata (2007) cautions "it is important for those wanting to bring Indigenous knowledge into teaching and learning contexts to understand what happens when Indigenous knowledge is conceptualised simplistically and oppositionally from the standpoint of scientific paradigms as everything that is "not science" (p. 9). Here, Nakata points to the importance of critically considering the purpose and strategic value of isolated, standardised tests such as PISA *for* Indigenous students. Arguably, these tests elucidate little data of value with respect to recognising and valuing local Indigenous knowledges or to reconcile the ontological and epistemological differences between the scientific knowledge of Western knowledge systems and Indigenous Knowledge systems. It is suggested here that, at the current political moment dominated by neoliberal market values, there is, arguably, little propensity for the Federal government to value an alternative approach, despite existing arguments that doing so is likely to be of more value to Indigenous students and communities alike.

PISA and geographical location

As is noted by Thiem (2009), geography is central to "contexualising education" (p. 168). Contextualisation of education "reveals its location 'between' such problematic couplings as production and social reproduction, culture and economy, public and private and political economy and governmentality" (Thiem, 2009, p. 168). An examination of the relationship between geographical location and PISA score, then, offers a contextual background to the STEM crisis; providing an additional framework within which the role of teacher quality in relation to the under-performance of students can be examined.

Since 2006, PISA data show that the geographical location of the school attended by students greatly impacts on the scientific literacy score achieved. For example, over the three year testing cycle, the average scientific literacy score of students attending schools in remote areas was consistently and significantly lower than that of students attending schools in either provincial areas or metropolitan areas. As noted by Thomson et al. (2013), "the difference in mean scores between schools in metropolitan areas and schools in remote areas was around one-and-a-half years of schooling" (p. xvii). Consistently, PISA results also indicate that a greater proportion of students in remote schools fail to reach the minimum Level 2 benchmark as compared with their metropolitan counterparts. In contrast, a greater proportion of metropolitan students attained results at Level 5 or greater, than did their remote counterparts. For example, in 2012 just six per cent of remote students attained a result at Level 5 or higher, compared with 10 and 15 per cent of provincial and metropolitan schools respectively. Conversely, in 2012, remote students comprised 27 per cent of the cohort who did not attain Level 2 benchmark result, as compared with 13 per cent of the metropolitan cohort. These results indicate that the scientific literacy of rural and remote Australian students, as evidenced by PISA, is poorer than the scientific literacy of their metropolitan counterparts. Nevertheless, the extent to which teacher quality is implicated in these results is not directly evident.

Similar trends linking performance and geography were found by Thomson and De Bortoli who state that poor performance in scientific literacy, particularly among Indigenous students, is "inextricably linked to geographic location and to socioeconomic background" (2008, p. 73). However, Lyons et al. (2006) found that student performance was more tightly associated with geographic location than with economic circumstances. As such, the ways in which teacher quality and geography interact requires further consideration. Miles, Marshall, Rolfe and Noonan (2006) noted that attracting and retaining professionals to work in rural and remote areas is an ongoing challenge. It follows that attracting, recruiting and retaining teachers who are 'appropriately trained' to teach in the secondary science fields is also a challenge for schools located in rural and regional settings (Boyd, Terry, & Trinidad, 2013). High rates of staff turnover and limited professional development opportunities are frequently reported in rural and remote school settings, as were limited access to material resources and support personnel. In addition, higher levels of unmet need in providing alternative activities for gifted and talented students, special needs and Indigenous students in rural and remote school settings were also identified (Lyons et al., 2006). These findings speak back to the notion of blaming the under-performance of students on teacher quality by highlighting the structural inequities and material realities of teaching STEM subjects in rural and remote locations. Moreover, Lyons et al. (2006) highlight a number of social and economic factors that could be impacting the teaching and learning experiences of students in rural and remote locations, rather than focusing solely on the qualities and qualifications of individual teachers. Yet these insights are not privileged in reports that call for the need to improve teacher qualifications.

4.3.3 Summary

Sections 4.2 and 4.3, have presented a discussion about the propensity of the Federal Government to construct teacher quality, and by inference, teacher qualifications as a legitimate site of action in efforts to address the STEM crisis, conceptualised as a crisis of supply. While there have been actions taken to increase the regulation of the teaching profession, through newly authored teaching Standards and an associated Professional Development Framework, there appears to be a lack of clarity surrounding what constitutes an ‘appropriately qualified’ STEM teacher. In addition, while there is a focus on strengthening discipline knowledge of all STEM teachers, the literature recognises that senior science teachers are largely well qualified and experienced. Furthermore, there is debate about how much discipline knowledge is enough to define “appropriate qualifications” in particular teaching contexts.

Nevertheless, teacher quality is blamed for student under-performance. To achieve its’ legitimation goal, the Federal government privileges data summarising the performance of students against international benchmarks, particularly Australia’s international PISA ranking. Practices of policy externalisation are deployed to justify calls to improve the performance of Australian students. However, a critical review of the literature has exposed moments where the act of construal has failed, thereby undermining the construction of teacher quality as a key issue in the STEM crisis.

Throughout Section 4.3, data outlining Australia’s performance against international benchmarks from the TIMMS and PISA tests have been presented, and overall, these data show that over the period 2006 to 2012, the performance of Australian students has been largely stable, and on average, they are performing above international benchmarks. Such findings should infer that Australian teachers are doing a good job of teaching science. Instead, Australia's international ranking is used to call for improvements to teacher quality. Moreover, averting the public and political gaze to Australia's aggregated international ranking removes the need to focus on the problems occurring within Australia's education system, masked by the aggregation of national data. Indigenous students, students attending remote and rural schools and state schools, and students from low socio-economic backgrounds consistently underperform in scientific literacy measures, as compared with other Australian students. Yet, this disparity is not the focus of calls to improve teacher quality. Despite reports that clearly state that many of Australia's schools, particularly those serving low socio-economic status communities, are chronically under-funded and under-resourced, teacher quality — regulated through standards — is still regarded as the solution. Debatably, blaming the performance of students on teacher quality, rather than on school resourcing issues, is a politically convenient manoeuvre that allows the Federal government to avoid a much less politically desirable, project; namely, addressing the structural inequalities evident in Australia's schooling system. Yet, this politically convenient approach does little to improve the gap in scientific literacy of Indigenous students, students attending remote and rural schools and state schools, and students from low socio-economic backgrounds.

Despite official knowledge of the persistent under-performance of students from traditional equity groups (James, 2001), this is an issue that is largely under-reported and under-addressed in official renditions of the STEM crisis. Instead, much of the political rhetoric focuses on the aggregate result, and the slippage of students from the higher PISA scores, alongside laments of how such declines detract from Australia's desire to be the best. As individual student scores slide away from the top end of the scale, the aggregate score also slides, making it harder to mask the persistent under-performance of particular groups of students in relation to scientific literacy. Slee (2012) notes that pressures to embrace market ideologies have led to schools whose success is measured by test performance, and to a view of students as “bearers of results, and ultimately, [schools] sponsor those with strong academic prognoses and jettison those who present a risk of failure” (p. 895). It could be argued, then, that calls to improve the content knowledge of teachers are aligned with Australia’s endeavour to be the best at taking tests, rather than the best at developing a world-class education system, based on principles of equity-as-inclusion rather than equity-as-fairness (Marginson, 2011). The notion of equity-as-inclusion is conceptualised here, at the very least, as a proportional increase in the official representation of traditionally under-represented students at Level 5 PISA benchmark of scientific literacy. This kind of ‘official recognition’ would be more demonstrative of reform rather than more rhetoric about the important role that schools play in providing opportunities for students to study high-quality STEM subjects. So far, Chapter 4 has examined teacher qualifications and student performance as sites of blame in framing the STEM crisis. In the following Section (4.4), attention turns to the potential role of teacher influence, including their pedagogical decisions, over students’ decisions to study a STEM subject in their post-compulsory years of schooling, or not.

4.4 Influencing student participation

A myriad of government reports and academic papers regard ineffective pedagogical strategies employed by teachers, particularly during the middle years of schooling, as a primary cause of declining student numbers in the post-compulsory years of schooling. For example, Goodrum, Hackling and Rennie suggested that high school science lessons are “neither relevant nor engaging” (2001, p. viii) and furthermore, that this “disenchantment with science is reflected in the declining numbers of students who take science subjects in the post-compulsory years of schooling" (2001, p. viii). According to the Department of Education, Science and Training (2003), the decline in student participation in the sciences is linked to "too few, well qualified, committed and innovative teachers of mathematics, science and technology in schools" (p. 3). As a consequence of poor teacher quality and practice, "too few, well prepared, confident and interested students [are] entering higher education" (Department of Education Science and Training, 2003, p. 5). Furthermore, the Department of Education, Science and Training (2006), attribute the under-preparedness of students entering STEM courses at university to both teacher quality and the quality of teaching occurring in science classrooms.

In response to the perception that teachers, and teaching, were responsible for declines in student participation, calls were made to "re-imagine" school science (Tytler, 2007, p. 1) such that students would be attracted to science and continue its study into the post-compulsory years of schooling. For teachers, re-imagining science education required reflection on the ways in which science is taught in schools, as well as on how contemporary practice relates to historical practice in science classrooms. According to Tytler (2007), reform in science education is constrained by the views of discipline experts and teachers themselves about the reasons for, and approaches to, teaching science:

> Science education has been trapped in a cycle of practice that relates to its early roots, with its focus on disembedded, abstract knowledge, supported by a largely teacher-centred, transmissive pedagogy. Part of the reason for the largely successful resistance to the many attempts at reform, from progressive educational challenges to process approaches to Science-Technology-Society reforms, has been the commitment of academic scientists, and teachers who have been schooled in these disciplinary traditions to this version of science. Change has been resisted in the name of rigour and standards, but perhaps above all by the silent choice of teachers for the status quo;

> one that supports and reflects their identities as knowledgeable experts. Science teachers tend to teach as they themselves were taught in school and through university, supported by assessment practices which confer status on the ability to manipulate canonical science ideas, and very little else. One of the major issues we face, if we believe in this imperative to re-imagine science education, is how to break into this self-reinforcing cycle. (Tytler, 2007, p. 57)

The Queensland Studies Authority (2011a) found that in order to engage teachers in the lower primary years in more “effective” (p. 33) teaching of science there is a need to reflect on the purposes for science as a discipline. Here, the term “effective” is used as though it is an unproblematic conception. However, the term ‘effective’ is, itself, ambiguous. As alluded to by Tytler (2007) in the extract above, what is regarded as effective teaching of science depends on who is evaluating the teaching, and their view on the primary purpose of STEM education. Teachers are positioned at the centre of this debate, as they enact the curriculum and select and enact pedagogical strategies. Previous research has shown that teachers have their own views about the tensions involved in enacting STEM education, as is exemplified in the following extract:

> Teachers have expressed a clear and coherent view about what sort of science is capable of engaging students. The difficulty, as they perceive it, lies in the influence of the disciplinary guardians on the Science curriculum and assessment, similar commitments to traditional content and pedagogy of many Science teachers, and also a conservative view of parents and the general community as to what school Science should be. These guardians tend to emphasise a narrow, specialist view of the purposes of school science that presumes a main purpose of preparing students for future science studies and careers. (Tytler, 2007, p. 44)

In this extract, Tytler highlights the array of actors who influence the pedagogical decisions made by teachers. Parents, other teachers, university staff and the general community each impress their preferred version of the shape and nature of the teaching and learning experiences they expect students to have in a science classroom. Tytler (2007) argues that these expectations weigh greatly on the enacted science curriculum in Australian classrooms despite teachers' awareness that such decisions may no longer meet the pedagogical demands and expectations of a contemporary science classroom, as defined by academic science educators.

Given this wide array of influences, deciding what constitutes 'effective' STEM education is a complex endeavour. It is argued here that the quality of teachers and of the pedagogical decisions teachers enact, can only be judged in relation to a clearly articulated purpose. As such, tensions in the political efforts to construct the pedagogical decisions of teachers as a legitimate site of action in addressing the STEM crisis arise. From a review of the literature, three such tensions are evident. Firstly, there appears to be no consensus among key stakeholders on the primary purpose of STEM education. Instead, there are conflicting perspectives about whether the goal of STEM education should be about 'education for all' or 'education for some', and whether these goals (should) shift as a student moves through the compulsory years of schooling to the post-compulsory years of schooling and beyond. Secondly, the notion of student interest is conflated with the notion of students' continued participation in STEM education. This conflation aligns with the government's preferred trajectory of human capital production – from school, to university to STEM qualified workforce. Aligning 'student interest in science' with 'ongoing participation' is a superficial treatment of the issue, and doing so affects the identification and interpretation of a range of factors, other than student interest, which may be influencing students' decisions to participate in the study of STEM subjects in the post-compulsory years of schooling. Thirdly, a tension arises for students whose voices are marginalised when the influence of teachers is regarded as a primary contributor to the crisis; such a reading negates the capacity of students to read and to then respond to labour market demands, and to act in what they may regard as their own best interest. As Rose (1990) instructs “the modern self is institutionally required to construct a life through the exercise of choice from among the alternative…. The self is not merely enabled to choose, but obliged to construe a life in terms of its choices, its powers and its values” (p. 226). Given Rose’s perspective, an alternative reading of the participation of students is offered here. Students may, in fact, be astute readers of the market, and are making choices about participation in STEM subjects on grounds other than their interest in science, or teacher influence. It may be the case that these choices made by students contradict with the aspirations of the state, thereby resulting in incommodious outcomes. As such, it is these outcomes, that form the basis of the crisis, and teacher influence may be unjustifiably blamed for declining student participation. Each of these three tensions, outlined above, will now be considered in turn, beginning with an examination of the conflicting views about the purpose of STEM education.

4.4.1 The dual purpose of STEM education: complications for teachers’ work

> *Prof Hogben distinguishes clearly between three factors in the advance of science: the opportunity, the means and the motive. The opportunity lies in the social circumstances of the time, which are propitious or not to the advance of science; the means are those practical and material techniques drawn from industry or from other parts of science, without which research is impossible; the motives determine the setting of the problem and the concentration of the scientist’s attention to it. (excerpt from “Nature” 1938 (3581), p. 1075)*

Attempting to establish an agreed set of motives, or purpose, of STEM education is an exercise in navigating contested terrain. As declared by Apple (2006), “education is a site of struggle and compromise. It serves as a proxy for larger battles over what our institutions should do, whom they should serve, and who should make these decisions” (p. 30). Science education is no exception. In considering the issues and challenges faced by science teachers as they enact versions of STEM education, Dillon and Manning (2010) make the following observation:

> Science teachers are tasked, throughout the world, with a set of almost Herculean challenges; make science lessons interesting, inspire pupils with wonder and excitement; increase the flow of scientists, entrepreneurs and technicians of tomorrow; and ensure that citizens and consumers understand the risks and benefits of modern science. These external demands help make science teaching what it is today. (p. 7)

The drive to develop science curricula that serves this broad range of purposes is not new. The ‘general science movement’ began in the 1930s ("Science in the Service of Man: A review, *Science for The Citizen* by Lancelot Hogben," 1938). Attempts to develop science-for-all curricula surged in the 1950s as countries, at various levels of industrialisation, aimed at providing the perceived benefits of a science education to all learners. By the 1980s, the impetuses for such curriculum development projects were aligned with themes such as “Science and the World of Work” (Fensham, 1985, p. 415). According to Fensham, the success of such projects was mixed:

> We now have much better curricula for education in the sciences of those (about 20% of an age group) from whom the future scientists and science-related professionals will be drawn. We have not achieved an effective science education in schools for the 80% of so who most probably will not continue with any formal education in science after they leave school. (Fensham, 1985, p. 416)

Fensham (1985) goes on to reflect on potential causes for the failure to enact 'science-for-all' which includes a "naivety" (p. 416) about the role of school systems in society and of science education in particular:

> School systems … are expected to produce new sorts of persons with hitherto unavailable skills and knowledge that have become essential to the development of an economy or to the changing needs of the society….Since the 1950s two very distinct societal demands have been place on science education in many countries. The first is the demand for specialist manpower so that societies and economies can keep pace in a world where scientific knowledge and technology is being exploited in a rapidly increasing way. The second is the demand for a more scientifically literate citizenry, ie., science education should produce more members of the society who will be able to benefit from the personal and social applications of science and will be prepared to support the changes of a scientific and technical kids that are needed for a good balance between development and environmental concerns. It is this second demand that now has the slogan 'Science for All'. But these two demands are, I will argue, conflicting and not complementary as was almost universally assumed in the first wave of the science curriculum movement. (pp. 416-417)

Arguably, science education, as enacted contemporaneously in Australian schools, is still attempting to achieve these dual purposes: to prepare students to become scientifically literate citizens, as well as to prepare (some) students for university level science. Throughout the literature, these dual purposes of science education are frequently held in juxtaposition, thereby creating a discursive binary of purpose: 'Science for All' or 'Elite science'. This binary of purpose persists, despite recognition that the outcome of this dualistic approach "is that neither group is served well" (Goodrum & Rennie, 2007, p. 10). This binary of purpose is regarded as a source of concern in the *Health of Australian Science* report (Office of the

Chief Scientist, 2012a), and one that warrants further attention in efforts to address the STEM crisis.

A suite of significant Federal policy documents articulate the official perspective on the nature and purpose of STEM education in Australia. For instance, in the Federal Policy, *Powering Ideas* (Commonwealth of Australia, 2009a, p. 1) the stated goal of the Australian Government is to “make innovation a way of life.” Education, and specifically education that can build the innovative capacity of the citizenry, is heralded as the key to economic security. Moreover, the same Federal policy document claims that the World Economic Forum recognises Australia to be “among those countries that have reached the innovation-driven stage of development” (Commonwealth of Australia, 2009a, p. 22). The concept of Innovation transforms the field of Science, by recontextualising its meaning and purpose. Fuller (2004) names this transformed version of Science as ‘Big Science’, a term which encapsulates the conditions whereby Science, as a field previously upheld for the production of science as a public good, becomes captured by the market. The drive to innovate underpins much of the research that occurs in Big Science. The purpose of Science, in a Big Science paradigm, shifts away from solving problems for the public good and instead focuses on solving problems of economic significance, or on the production of materials that can be used to further leverage investment. Accordingly, in an innovation-led economy, the purpose of science education is also, necessarily, transformed such that it provides the foundational knowledge for ‘innovation’ and for the development of human capital branded with ‘innovative capabilities’. This reading of the transformed purpose of science education is reinforced by the following extract from an OECD report (2009) entitled *Top of the Class: High Performers in Science in PISA 2006:*

> The rapidly growing demand for highly skilled workers has led to a global competition for talent. While basic competencies are important for the absorption of

> new technologies, high-level skills are critical for the creation of new knowledge, technologies and innovation. For countries near the technology frontier, this implies that the share of highly educated workers in the labour force is an important determinant of economic growth and social development. There is also mounting evidence that *individuals with high level skills* generate relatively large externalities in knowledge creation and utilisation, *compared to an "average" individual*, which in turn suggests that *investing in excellence may benefit all*. *Educating for excellence is thus an important policy goal* [emphases added]. (p. 3)

The goal of "educating for excellence" emphasises an approach to STEM education aligned with Fensham's (1985) conception of 'Elite science'; directed at "individuals with high level skills" as opposed to "average individuals". Such an approach is evident in the following extract from the then Department of Education Science and Training:

> perhaps even more importantly the science education system, as it exists, may be *failing to capture the interest of our brightest students* [emphasis added] who would otherwise make enormous intellectual contributions to the future of Australian Science. Declining school student interest in science since the early 1990s — particularly in the study of physics, chemistry and biology subjects at the Year 12 level — is cause for concern and inconsistent with the knowledge needs of an advanced technological and democratic society. (2003, p. 2)

In this extract, the notion of capturing the interest of the 'brightest' students is significant as this political endeavour draws attention to the ways in which the abilities and capacities of students are perceived and then positioned in relation to the Big Science paradigm. There appears to be a clear divide between attracting the 'best and brightest' students into the study of STEM and taking account of the science education system as whole. Here, the inference is that the capacity to innovate is the exclusive domain of the brightest students, and that the focus of STEM education system should be to engage these students so as not to jeopardise the development of their innovative capacities. This position aligns with the view that the primary purpose of STEM education is to provide ‘science for future scientists’ or, ‘science for some’. The sense that STEM education is primarily concerned with ‘science for some’ is also apparent to Lyons & Quinn (2010) who noted that school science has “failed to engage a wider range of students” (p. i) and that this failure may be contributing to the decline in student participation rates. Further to this, DEST (2003) noted that:

> Notwithstanding considerable efforts to *improve curriculum* over recent years, upper secondary curriculum in mathematics and science, particularly *for the ‘more able’*, still tend to be *designed as preparatory for higher education rather than offering knowledge which is significant, applicable and interesting in its own right.* Ironically, too many students do not choose the very ‘futures’ for which these courses are designed to prepare them. We venture to suggest that were school mathematics and science designed to enthuse, inspire and equip students in and for their present lives, more would elect to continue their involvement [emphases added]. (2003, p. 4)

Here, the suggestion is that moves to improve the curriculum are synonymous with an increase in academic rigour, in order to address the needs of the ‘more able’ students. The tension in the purpose of science education is also evident in the construction of curriculum “for preparation to higher education” rather than “knowledge which is significant, applicable and interesting in its own right”. As a result, knowledge for university preparation is positioned as something that is abstracted from everyday life. The discursive binary of ‘abstract’ and ‘relevant’, becomes evident here and this binary, then, underpins the construction of the dual purpose of science education. Furthermore, the language in this extract also implies who each of these versions of STEM education is for; the abstract, canonical version is designed for students seeking to enter university, while the curriculum based on everyday relevance is designed for everyone else. This implication reinforces the sense that there are two purposes of STEM education and they are mutually exclusive. The abstract, canonical curriculum version is restricted to those who wish to go on to further study. In this sense, it is exclusive of those students who do not wish to study further. The everyday relevance curriculum version is for everyone else, and thereby is categorised as 'inclusive'. It is suggested here that the the binary of 'exclusion' and 'inclusion' also underpins views about the dual purpose of science education.

Rather than inclusion-as-fairness (Marginson, 2011), understood here as all student having had the opportunity to learn about science that is relevant to everyday life, taking an inclusive approach to science education requires added considerations. Taking an inclusive approach requires the teacher to focus on the needs of the learner, and to recognise that not all students have had the same educational experiences in their past. This approach to inclusivity is defined further in the following extract:

> Inclusivity means providing all groups of students, irrespective of educational setting, with access to a wide and empowering range of knowledge, skills and values. Such an approach requires recognising and accommodating the different starting points, learning rates and previous experiences of individual students or groups of students. It means valuing and including the understandings and knowledge of all groups. (Curriculum Council, 1998, cited in Goodrum & Rennie, 2007, p.5)

By comparing Goodrum and Rennie's (2007) definition of 'inclusive' with the definition of 'Science for All' provided by Fensham (1985), it is clear that notion of inclusivity need not be synonymous only with developing 'scientifically literate citizens'. Rather, Goodrum and Rennie's (2007) notion of inclusivity can (and should) be applied to all educational experiences, and therefore to any science classroom, irrespective of the contested purpose of STEM education. Enactment of an inclusive approach requires the teacher to engage with a broader range of pedagogical strategies other than traditional, didactic pedagogies. The challenge then, as noted by Thomson (2013), is to draw together the hitherto dual purposes of science education, so that what is enacted is both rigorous and inclusive. What follows from here is the need to examine the nexus between the purpose of science education, particularly in the post-compulsory years of schooling, and the curricula and pedagogical practices that teachers are then encouraged to enact in the classroom.

4.4.2 Teachers enactment of 'preferred' curricula and pedagogy

Moves to implement national, standardised curriculum are taking place in many western developed countries. Apple (2007) would argue that such moves are informed by the alignment of neoconservative forces with neoliberal market ideologies. In Australia, the implementation of the first national science curriculum began in February 2011, after the curriculum development project commenced in July 2008 (Australian Curriculum Assessment and Reporting Authority, 2011). The National Curriculum is designed for students from Foundation Year to Year 10, and as such, it is the mandatory foundation for students entering the sciences in the post-compulsory years of secondary school. According to the Australian Curriculum Assessment and Reporting Authority (ACARA) *Curriculum Design Paper* (Australian Curriculum Assessment and Reporting Authority, 2012a), the development of the Australian Curriculum was shaped by the Melbourne Declaration on Educational Goals for Young Australians (Ministerial Council on Education Employment Training and Youth Affairs, 2008). In particular, the curriculum "will be designed to develop successful learners, confident and creative individuals and active and informed citizens"(Australian Curriculum Assessment and Reporting Authority, 2012a, p. 4). Furthermore two of the key considerations in the design of the curriculum, according to

ACARA, are inclusivity and rigour as is evident in the following extract from the *Curriculum Design Paper*:

> The Australian Curriculum will contribute to achieving the goals of the Melbourne Declaration, including the promotion of equity and excellence in education. *The curriculum must value and build on student's prior learning, experiences and goals* [emphasis added]. Examples used in the curriculum should reflect the diversity of knowledge, experiences and cultural values of students. … Some of the variation among students in their level of development and progress can become the basis for inequities in their educational experiences. *The Australian Curriculum is developed to ensure that curriculum content and achievement standards establish high expectations for all students* [emphasis added]. (Australian Curriculum Assessment and Reporting Authority, 2012a, p. 11)

Here, the added emphases highlight the notion of inclusivity promoted by Goodrum and Rennie (2007) presented earlier; alongside the notion of rigour, imparted through "high expectations for all students". In addition, the *Curriculum Design Paper*, refers to the drive to set high expectations and states "High-performing countries set high expectations. They support the fulfillment of those expectations with high-quality teaching, school and system leadership, and commitment and support from families, communities, business and industry" (Australian Curriculum Assessment and Reporting Authority, 2012a, p. 4). For teachers, such statements imply that through their work they must communicate high expectations and ensure students meet them.

More specific focus on the nature of the ACARA Science Curriculum is given in the document entitled *Shape of the Australian Curriculum* (Australian Curriculum Assessment and Reporting Authority, 2009). This framing paper draws heavily on Goodrum and Rennie

(2007) and Tytler (2007) because they are held to provide "an up-to-date synthesis of national and international research on school science education and bring together the perspectives of a range of science education interest groups with a focus on improving school science learning" (Australian Curriculum Assessment and Reporting Authority, 2009, p. 4) (p. 4). The *Shape of the Australian Curriculum* clearly articulates the purpose of the science curriculum in Australian schools in the following extract:

> For Australian citizens to be sufficiently well-educated for the development of society and to ensure international competitiveness the Australian science curriculum must meet the needs of those students: who, as citizens in a global world, need to make personal decisions on the basis of a scientific view of the world; who will become the future research scientists and engineers; and who will become analysts and entrepreneurs in the diverse fields of business, technology and economics. (ACARA, 2009, p. 4)

In this statement, demand for teachers to enact the dual purposes of the science curriculum is once again evident. The curriculum must serve the purpose of developing a citizenry who can enact a "scientific view of the world" to make personal decisions, but it must also provide 'appropriate' discipline knowledge to prepare students to become scientists and engineers. Furthermore, the curriculum must foster the development of the cognitive skills needed to support entrepreneurial work. From this statement it is clear that the binary of purpose of STEM education persists, despite research by Fensham (1985) and Goodrum and Rennie (2007), stating that framing STEM education in this way results in achieving neither goal well. As such, it is suggested here that constant demands placed on teachers to attempt to achieve both goals from the curriculum may indeed be setting teachers up for further failure.

The nexus of purpose, curriculum and pedagogy — and the subsequent impact on student outcomes and participation — was recently explored in a report commissioned by the Office of the Chief Scientist (2012b); funded by the Australian Government through the Department of Innovation, Industry, Science, Research and Tertiary Education. This report entitled *Mathematics, Engineering & Science in the National Interest*, included a section which focussed on recommendations for "teaching techniques" (p. 9). The claim made by the OCS here is that "science is not taught as it is actually practised: hypothesis, experimentation, observation, interpretation and debate". The report states that teachers and students think that the science being taught is "boring" and irrelevant, and that there is not enough technical support for teachers to offer "interesting practicals" (p.9).

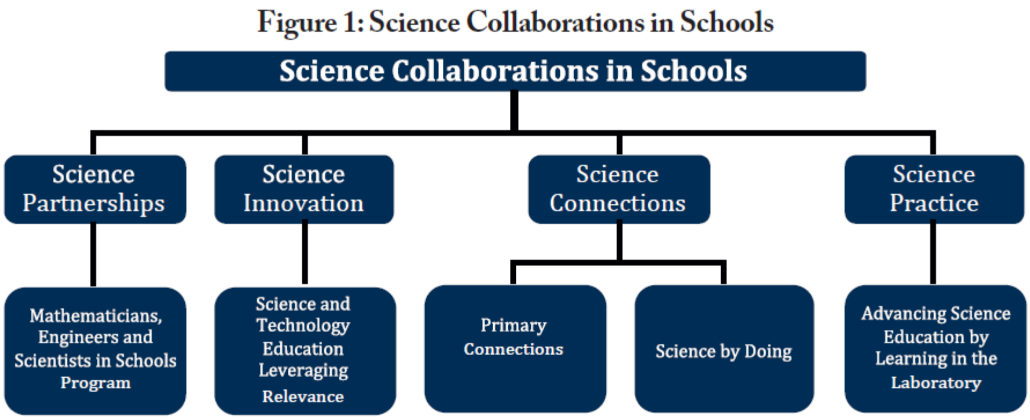
In an attempt to unpack the notion of student boredom, Lyons and Quinn (2010) noted that when asked, students suggested more practical/experimental work would encourage greater interest and participation as would placing more emphasis on applicability of science rather than on theory. The call by students for more laboratory based experiences was considered by the Office of the Chief Scientist (2012b, p. 41) who note that the amount of lab work occurring in science classrooms has decreased as a result of the more stringent occupational health and safety procedures that are required in schools, along with science teachers who lack laboratory experience. In line with the focus to increase the quantity of laboratory experiences offered to STEM students, Goodrum, Druhan and Abbs (2012) recommended an increase in the number of paraprofessionals, particularly laboratory technicians, employed to support STEM teachers. The Office of the Chief Scientist saw that the problems associated with implementing lab work might best be overcome by outsourcing this component of the science education experience, as is evident in the following extract:

> There are novel ways of enhancing the classroom experience of students while supporting teachers and bringing practitioners into the classroom. The best of these

> draw on the expertise and enthusiasm of the mathematics, engineering and science community – the active practitioners. (2012b, p. 9)

This statement refers to calls made by the Office of the Chief Scientist (2012b) to increase funding for an “umbrella program” (p. 40) entitled *Science Collaborations in Schools*. As is illustrated in Figure 4.2 below, this program would involve four components of collaboration with schools - partnerships, innovation, connections and practice. Partnerships are to be brokered by the *Mathematicians, Engineers and Scientists in Schools* program, with funding directed to the CSIRO. Innovation is to be fostered through the *Science and Technology Leveraging Relevance* (STELR Year 7 to 10) program, with funding directed to the Australian Academy of Technological Sciences and Engineering (ATSE). Connections are to be strengthened through two programs developed by the Australian Academy of Science: *Primary Connections* (for the Foundation Year to Year 6) and *Science by Doing* (for students in Years 7 to 12). Finally, Science Practice, related to safe and interesting practical work, will be developed through the program *Advancing Science Education by Learning in the Laboratory* (ASELL) – an initiative to deliver educationally sound and safety-compliant laboratory activities to secondary science teachers teaching students in Years 7 to 10. The Australian Council of Deans of Science (ACDS) will receive the funding to co-ordinate the Science Practice component of the Science Collaborations in Schools project.

Figure 4.2 Overview of the umbrella program "Collaboration in Schools"



Source: Office of the Chief Scientist, 2012b, p. 40.

The Federal Government responded to *Mathematics, Engineering and Science in the National Interest* (Office of the Chief Scientist, 2012b) by allocating what is referred to by Federal Education Minister Peter Garrett as a "$54 million dollar package *for schools* [emphasis added]" (Garrett & Melham, 2012). Of this total, Mr Garrett stated that $16.9 million was "*specifically for schools* because we know that Australia needs more students studying these vital subjects [emphasis added]". In the press release, the package for schools is shown to include the following funding allocations:

- $6.5 million *for the CSIRO* [emphasis added] to expand the Scientists and Mathematicians in Schools' program, taking interesting maths and science lessons to schools across Australia, particularly rural and regional schools
- $5 million *for* Science Connections, to support the 'Science by Doing' and 'Primary Connections' projects, providing extra online teaching resources with leadership from *the Australian Academy of Science* [emphasis added].

- $3 million to fund “National Support and Advice for Teachers” a new service *for maths and science teachers* to help them deliver stimulating and safe lessons [emphasis added].
- $2.4 million to support the participation of Australia’s most talented science and maths secondary students in the International Science and Mathematics Olympiad.

Examining the details of this funding package *for schools*, reveals that schools themselves are set to directly receive very little of the funding. The CSIRO Science Education division stands to gain funding, as does the Australian Academy of Science. Both of these agencies are charged with working *with* schools, but there is no mention about how schools will find the resources to co-ordinate, manage or integrate these collaborations effectively into existing curriculum expectations. It is not clear which agency will deliver the national support and advice service *for teachers,* however, it appears to align with the goals of the ASELL project, as outlined previously, and funded through the ACDS. Furthermore, it is clear that the nature and scope of the service will not be determined *by* teachers. Instead, the service is *for* teachers, presumably with the content determined elsewhere.

In each of these programs, the funding allocations indicate a degree of interaction with teachers that is far removed from that of collaboration. Instead, it appears that at worst, government agencies, with a focus on science education, alongside the Australian Council for Deans of Science from the Higher Education sector will simply arrive at schools and *do* some science *to* the students and staff there. Or, at best, teachers may be ‘supported’ in their work, which may in fact, amount to the regulation and supervision of their work in attempts to ensure that STEM teachers follow the specified ‘appropriate and/or preferred’ techniques. Moreover, Federal Government agencies will receive the funding that could otherwise have been allocated directly to schools, to support the ‘high expectations’ work of teachers in line with the recommendations made by 'The Gonski Review' (Gonski et al., 2011) which states "funding for schooling must not be seen simply as a financial matter. Rather, it is about investing to strengthen and secure Australia's future. Investment and high expectations must go hand in hand" (p. xiv). However, allocating funding directly to schools would contradict government aspirations for a "small, strong state" (Apple, 2006, p. 70) and, as such, the initiatives supported by the Office of the Chief Scientist function precisely as they are intended, that is, as "policies for producers"(Apple, 2006, p. 70). In a policy regime dominated by an alliance of neoconservative and neoliberal forces, there is "deep suspicion of the motives and competence of teachers [as producers in a marketised education system]". Given this position, an alternative reading of the notions of 'support for teachers' and 'collaboration with teachers' is that this support is, in fact, an attempt to exert control over the work of STEM teachers, based on mistrust of their capacity to enact 'preferred' pedagogies and curricula. Such an approach is the neoconservative equivalent of provider capture, a dogma that dominates the neoliberal ideology. Teachers, then, are placed in a position where they must relinquish their professional autonomy, and instead embrace their regulated autonomy — they must enact the preferred and specified curricula and associated pedagogies with the appropriate cohorts of students — or be seen as part of the crisis; contributing to a decline in student interest in STEM subjects.

In summary, while poorly trained teachers and the pedagogical practices they employ are frequently regarded in the literature as key barriers to student participation, such assessments fail to take into account systemic and structural barriers that also contribute to the kinds of STEM education experiences a school can provide. Furthermore, these structural barriers may, in fact, over-rule any attempts made by teachers to enliven or enrich the pedagogical practices deployed in their classroom. In addition, such assessments fail to take into account the agency of students in the STEM crisis. Moreover, student choice — to participate, or not participate — in relation to STEM subjects in the post-compulsory years of schooling, is an under-researched aspect of the STEM crisis.

4.4.3 The conflation of teacher influence, student interest and student participation

Much has been written about the nexus of teachers' work, enacted curriculum and pedagogies, and waning student interest, as is exemplified by this quote by Tytler (2007):

> In tracing the extent and nature of the crisis in science education, we see that there is clear evidence that *the curriculum and classroom practice is failing to excite the interest of many if not most young people* [emphasis added] at a time when science is a driving force behind so many developments and issues in contemporary society. We see also that the main reasons behind this, at least from the students' perspective, are understood. This *decline in interest clearly contributes to a decline in participation in post-compulsory science* [emphasis added], particularly physical science, and this is seen to have considerable implications for the economic well-being of post-industrial societies. (p. 15)

Over the last decade, numerous reports have been compiled, firstly, to establish this nexus between the pedagogical decisions made by teachers, student interest and student participation. Secondly, these reports serve to legitimate teachers and their work as a site of action in addressing the STEM crisis. For example, *The status and quality of teaching and learning of science in Australian schools* was commissioned by the Department of Education, Training and Youth Affairs (DETYA) and authored by Goodrum, Hackling & Rennie (2001). This report notes growing concern about declining student interest in the study of science during the early years of secondary schooling and the flow-on effects for declining participation rates in science in the post-compulsory years of schooling. However, at the time of publishing the report in 2001, state-based student participation data was not collected – a fact “lamented” (Goodrum et al, 2001, p. 38) by the Australian Council of Deans of Science. The Department of Education, Science and Training (2003) also noted the importance of developing interest in science, particularly during the primary school years, in order to boost participation in the post-compulsory years of schooling.

Much of the literature that focuses on science education in the compulsory years of schooling is centred on declines in student interest in science. For example, both Masters (2006) and Osborne (2006) attribute the decline in interest in the post-compulsory years to students’ compulsory school science experiences, and the failure to excite student interest and engagement. Thomson and De Bortoli (2008) refer to the PISA 2006 results which showed that while Australia scored well in scientific literacy, it is ranked 54th out of 57 for students’ general interest in learning science. In 2008, an extensive literature review concerning supports and barriers to STEM engagement at the Primary-Secondary transition entitled *Opening up pathways: Engagement in STEM across the Primary-Secondary school transition* was commissioned by DEEWR and authored by Tytler, Osborne, Williams, Tytler and Cripps Clark. This review summarises a vast body of literature, and it is not the intention to provide an extensive overview here. Instead, some points of salience related to this thesis are highlighted. Firstly, Tytler et al. (2008) note that early experiences, that is those that occur before the age of 14 are the most important in shaping student dispositions towards science.

Lyons and Quinn (2010) in their report entitled *Choosing Science: understanding the declines in senior high school science enrolments* found that 55 per cent of students in Year 11 did not choose a science because they found junior high school science to be uninteresting. As such, the authors recommended that National Curriculum (Australian Curriculum Assessment and Reporting Authority, 2011) should focus on interesting, personally relevant, practical experiences, in line with teacher and student recommendations. These calls were echoed in a report entitled *Starting Out in STEM: Reflections of young men and women in first year university science, engineering, technology and mathematics courses* (Lyons et al., 2012). This report found that 86 per cent of first year university student respondents cited interest as important or very important in their decision to study a STEM course at university.

A similar relationship between student interest and participation was also reported by Goodrum, Druhan and Abbs (2012, p. 34). These authors found that 61 per cent of the students not studying a science subject in their post-compulsory years of schooling stated that they did not do so because they disliked science, or they thought science was boring. However, Goodrum et al. (2012) also found that just under half of the students surveyed were studying a science in their post-compulsory years of schooling; with 47 per cent of students surveyed studying Biology, 44 per cent studying Chemistry and 34 per cent studying Physics. These findings by Goodrum et al. (2012) align with findings of Lyons and Quinn (2010, p. viii) that show 44 per cent of the students surveyed thought that their science subject was their most interesting subject. In addition, 64 per cent of the students surveyed agreed that science helped them to make sense of their world. Lyons et al. (2012) found similar trends, with 77 per cent of students who chose to study science reporting that they did so because they thought it would be interesting.

Other factors, along with student interest, were also found to influence students' decisions about whether or not to participate in STEM subjects in the post-compulsory years of schooling. Lyons and Quinn (2010) in their report entitled *Choosing Science: Understanding the declines in senior high school science enrolments*, used a multiple regression analysis to examine relationships between the decisions made by students about participation in STEM courses in the post-compulsory years of schooling – and particularly at university. The results of the analysis showed that student decisions are most strongly related to three variables: "enjoyment of school science relative to most other subjects; an awareness of new and exciting science related career paths and; to a lesser extent, a relatively high self-rating of academic ability in science" (p. xiii). Previous to this, Lyons and Quinn (2010) reported that:

> the attitudes of today's students towards science and scientists, and their level of enjoyment of school science, are not significantly different to those of students a generation ago. … Overall, these findings challenge assumptions that declines in science enrolments are due to more negative attitudes towards science or science careers among today's Year 10 students. (p. ix)

In general, this body of reports works to legitimate the notion that student interest in science influences student choice. Consequently, the work of teachers is integral to generating and maintaining student interest in science. The role of teachers, and the impact of their pedagogical decisions, are both inferred from student comments about boredom and irrelevance. However, as noted by Lyons and Quinn (2010), while these trends themselves are not in dispute, the magnitude of these trends may be no greater than that observed in previous generations, and as such, these trends may not be a strong factor in declining student participation in post-compulsory STEM subjects.

Declining student participation rates in the sciences is not a phenomenon unique to Australia. In fact, declining participation is a trend that has been observed in most OECD countries over the last two to three decades (Ainley et al., 2008; Office of the Chief Scientist, 2012a). Additionally, these declines are occurring in relation to dramatically increased participation in senior secondary schooling and university education generally. Further review of the literature suggests that various factors, alongside student interest, are contributing to the declines — particularly as students transition from the compulsory to post-compulsory years of schooling. These factors include views about science that are incompatible with students' identities; increased choice in the curriculum marketplace; and a lack of sound career guidance. An additional factor, the selective function of STEM subjects is also found to be contributing to rates of student participation. Each of these factors will now be examined in turn.

A range of issues related to incongruent views between students' perceptions of self and science are reported in the literature. For instance, Department of Education, Science and Training (2003) argued that students who elected not to study a STEM subject in their post-compulsory years of schooling were largely inhibited by their negative experiences in the compulsory years of schooling; gender influences; perceptions that the study of STEM subjects is too difficult, and finally, the lack of opportunity to choose a STEM subject due to timetable conflicts. Tytler, Osborne, Williams, Tytler, Cripps Clark (2008) discussed the relevance of identity theory in the research surrounding the participation of students STEM subjects. The literature summarised by Tytler et al. (2008) indicated that often students will choose not to participate in the study of STEM subjects because the image of being a STEM worker is incongruent with the student's identity. Subsequently, Lyons and Quinn (2010, p. v) called for the need for further research to "determine the influence of students' attitudes to science on their enrolment intentions, and in particular to clarify at what point students' attitudes are most salient to their decisions". Findings of this nature would inform processes of career guidance employed in senior secondary schools.

An increase in the subject choices that are available to students in senior secondary schools is also a commonly cited cause for declining participation rates in traditional STEM subjects. In 2001, Goodrum, Hackling and Rennie noted that increased student retention through the senior years of schooling had produced a wider range of academic abilities in the senior schooling cohort, and that student choices were being made in relation to the "attractiveness" (Goodrum, Hackling & Rennie, 2001, p.40) of STEM subjects in comparison to what the Office of the Chief Scientist (2012a) referred to as more vocational options, for example, Horticulture, Science in Practice and Psychology. These findings were echoed by Venville, (2008) who notes that as students are required to stay at school until they reach 17 years of age, this increased size of cohort may affect the decline in participation rates. Moreover, Venville (2008) suggests that the availability of a wider range of subjects at school may be associated with a decline in traditional sciences, but also an increase in the number of science-related courses (and therefore, she implies, no overall decline, but a shift in focus). Lyons and Quinn (2010) concur, finding that the declining participation patterns observed in the traditional STEM subjects, such as Chemistry and Physics, are part of a broader phenomenon which has seen similar falls in many traditional subject areas. These authors suggest that the principle factor driving these declines is the greater array of subject options available as students transition from Year 10 to Year 11.

In response to the increase in student choices, many authors suggest the need to increase the resources available for subject selection and career guidance, particularly with students prior to the age of 14, so that more students can be encouraged into the study of STEM subjects in their post-compulsory years of schooling. For example, Goodrum, Druhan and Abbs (2012) recommend “a set of guidelines be developed to provide quality advice to Year 10 students considering selecting Year 11 and 12 subjects” (p. iii). This recommendation aligns with the findings of Lyons et al (2012) who recommended the establishment of a comprehensive online resource for careers advisors, parents, and students providing useful, reliable, and current advice on STEM courses and careers. Tytler et al. (2008) suggest that the early years of high school and late primary school were of prime importance to shaping career aspirations and that, as such, government expenditure directed towards working with people aged 14 years and under should be given priority. Lyons and Quinn (2010) cautioned the Australian government, and recommended that it should carefully consider which year level is the most efficient in delivering change: “Around 80% of the Year 10 students surveyed found that their most recent experiences (Years 9 & 10) had the greatest influence on their decisions about taking senior science classes" (p. iv). While it is established that science teachers themselves appreciate the influence they have on students' career paths (Lyons et al, 2012), the Department of Science, Education and Training (2003; 2006) note the lack of career and course information integrated in STEM subjects and further to this, many teachers, parents and careers counsellors may actively discourage students from the study of STEM subjects because "their knowledge of SET career opportunities is limited" (DEST, 2006, p. 28). Meanwhile, other authors also suggest science teachers should allocate greater priority to discussing and promoting careers in science with their students (Tytler et al., 2008).

As students move from lower secondary school to upper secondary school, student 'interest' in science is then construed, so that students are encouraged to 'value' a science-related career. For example, the Office of the Chief Scientist discusses the "strategic value" (2012b, p. 9) of Physics and Chemistry as university pre-requisites, then the "value in MES career pathways" (2012b, p. 28). In addition, the "perceived value of science" is discussed (Office of the Chief Scientist, 2012a, p. 43), along with the "utility value" (Office of the Chief Scientist, 2012a, p. 53) of science subjects. In this way, the qualitative dimension of the crisis hitherto concerned with student 'interest in' or 'enjoyment of' science shifts towards the need to develop an appreciation of the value of science subjects as ways to move into STEM careers. Unpacking this discursive shift requires an examination of the notion of value.

To Marginson (1997), value is a characteristic assigned to a commodity. An economic commodity is "at one and the same time a 'useful thing' and 'a thing possessing value' that may be exchanged against a given quantity of money." (p. 13). Usefulness is more appropriately defined in terms of a "use-value… derived from the 'natural form' of the commodity, its physical properties" (p. 13). Since there are many ways in which a commodity may be used, there is no single system of measurement that can be used to quantify use-value. In contrast, exchange-value is “abstract and social, and is universally signified by money” (p. 13). Educational commodities, then, constitute both use-values for the consumer, and exchange-values for the producer. Marginson (1997) recognises “self-goods — purchased by the students, or their family, to enhance the attributes of that student” (p. 38) as one type of educational commodity. Self-goods can then be further divided into two categories, one of which is “positional goods — places in which education which provide students with relative advantage in the competition for jobs, income, social standing and prestige” (p. 38). Positional goods can be produced under non-market conditions, and they are “often signified by credentials, used in the transition to labour markets and further education” (p. 39). Furthermore, positional goods are “scarce in absolute terms…there is a fixed limit to total supply” (p. 39). Given these definitions, the ‘value’ of STEM education described in the literature can be further interrogated.

The strategic nature of school subjects is not an issue that is commonly raised in the science education literature. Choice to participate (or not) in science subjects in particular is considered to be due, largely, to the broadening of the curriculum marketplace alongside the retention of more students through the post-compulsory years of schooling (Lyons & Quinn, 2010). According to Marginson (1997), education, from the point of view of the student, is best considered as either a form of “consumptive production … or … as an investment, or both” (p. 27). It is suggested here that the motives of students — making choices under market conditions — reflect Marginson’s view. That is to say, students recognise that the commodities they gain from their educational experiences must have both ‘use-values’ and ‘exchange-values’ in order for the commodity to be regarded as broadly ‘valuable’. This argument is supported by DEST (2003), who acknowledged that students were recognising and responding to the ‘value’ of STEM subjects, for example, choosing STEM subjects to broaden options for tertiary study, or to meet pre-requisite requirements. Furthermore, DEST expressed concern that many of the students who did elect to study a STEM subject did so largely for strategic reasons. Again, in 2006, DEST found that patterns of subject participation differed depending on university career destinations. For example, for Year 11 and 12 students, "participation in science and mathematics subjects was higher than technology subjects for students hoping to pursue a health career. There was relatively even participation in science, mathematics and technology subjects for students hoping to pursue a SET career" (p. 18). Both of these reports indicate that the Australian Government is aware of the significant influence that perceived 'use-value' and 'exchange-value' of STEM subjects has on patterns of student participation, particularly in the post-compulsory years.

Student choice is significantly influenced by the ways in which traditional STEM subjects, in the post-compulsory years of schooling, function as positional goods in the overall commodification of a STEM education. In addition to the reports by DEST (2003; 2006) cited above, this argument is supported by the work of Lyons and Quinn (2010) who found that 60 per cent of students who selected a science subject in Year 11 did so to facilitate their university or career aspirations. Similarly, of those students who did not elect to study a science, 63 per cent stated that doing so was not necessary for university or for their career. In this way, student choice is mediated by an understanding of both the use-value and exchange-value of science subjects, functioning as commodities in a marketised education system. Such a reading is further supported by Venville's (2008) suggestion that the current enrolments in Year 11 and 12 science subjects are actually being maintained at an artificially high level because "students select subjects like Physics and Chemistry because they perceive that these subjects will contribute to a higher tertiary entrance rank" (p. 44). In her conclusion, Venville (2008) states that given PISA results rank Australian 15 year olds as 4th lowest in the world in terms of wanting to learn science, "practical factors such as perceived advantage in taking science subjects for tertiary entrance and job prospects, rather than affective factors such as enjoyment of the subject, are maintaining high school enrolment levels at the current levels" (p. 46). Furthermore, Venville (2008) suggests that, increasingly, students in the cohort "who are not tertiary bound may select subjects that they perceive to be less difficult so they have a better chance of success" (p. 45). These strategic choices would also impact on the percentage of students selecting a traditional 'enabling' science, and therefore to the declining rates of student participation in traditional STEM subjects in the post-compulsory years of schooling. In other words, as stated by Lyons and Quinn (2010, p. 1), there has been a "decrease in the utility value of key science subjects relative to their difficulty". Taken together, these findings support the claim that students choices are, in fact, responses to the transformation of STEM subjects into positional goods in the commodification of a STEM education. This claim has implications for the ways in which teachers, and the work of teachers, can be blamed for the supply crisis. In addition, it indicates the need to explore the extent to which the readings of 'use-value' and 'exchange-value' made by students reflect current labour market demands.

Addressing the decline in the perceived 'value' of science subjects requires systemic intervention. In this regard, Lyons and Quinn (2010) recommend recognising the value of academically challenging subjects in the calculation of university entrance scores/rankings:

> Around 67 per cent of science teachers believe that declines in science are due to students' tendency to choose less academically challenging subjects from the broad curriculum available. Implicit in this view is the belief that students weigh up the anticipated benefits and costs of taking subjects. In the context of the 'curriculum marketplace', one salient cost of taking physics and chemistry is their difficulty relative to many other subjects. Adequate and explicit recognition of this difficulty in

> university entrance calculations and requirements would go some way towards making these science subjects more attractive to students (p. iv).

In addition, Lyons and Quinn (2010) state:

> because the declines have been strongly influenced by students' responses to systemic curriculum changes, it cannot be expected that interventions targeting teacher education, science syllabus development or better promotion of science courses and careers will result in these subjects attaining the same levels of curriculum market share they realised in the early 1990s. The more competitive curriculum environment makes it critical that steps are taken to ensure school science is more engaging, inclusive and valued by students. (p. ii)

Taking heed of these recommendations, the Office of the Chief Scientist (2012b, p. 9) urged universities to "send accurate signals about the value of mathematics, engineering and science to schools, students, teachers and careers advisors" implying that universities could reinstate the strategic value of these subjects by broadly reinstating their function as pre-requisites to university entry. These findings call into question the extent to which reforms to pedagogy and curriculum alone can impact on the supply crisis. It is clear that while the quality of learning and teaching occurring in classrooms is significant, this consideration should not be the focus of attempts to address the STEM crisis, conceptualised as a crisis of supply. Instead, the interplay of individuals, schools, and the curricula, read here as an assemblage of positional goods, requires further examination.

It is not only students that are recognising and responding to the 'value' of STEM subjects. One study has found that schools, as providers in the educational marketplace also recognise and respond to the STEM subjects as positional goods. Venville, Oliver, Longnecker, and

Rennie (2010) conducted a study where the subject selection patterns of Year 10 students transitioning to Year 11 were interrogated. Venville et al.’s (2010) study revealed that while many students expressed a desire to study a science, and particularly an enabling science in Year 11, enrolment in these science subjects did not eventuate for many of the students sampled. For instance, 47% of the Year 10 students interviewed expressed a desire to study Chemistry, while only 34% of the cohort enrolled in Chemistry. Similarly, 46% of students expressed a desire to study Physics, however, only 29% of the cohort enrolled in this subject. In relation to these findings, Venville et al. (2010) noted:

> This school has a clear and publicised policy of restricting student enrolment in Year 11 subjects based on their performance in Year 10. Other schools have similar policies because students who do not perform well drag the school rank in the published league tables down. The data indicate that there is a serious tension around the issue of subject selection. There is a possibility that considerably more students would study science subjects if given a true choice, however, a number of factors seem to have restricted science subject selection, including the schools need to perform well in published league tables.

The findings of Venville et al. (2010) emphasise another facet of the supply crisis evident in the post-compulsory years of schooling. That is, not all students who voice an interest in science are encouraged to participate. Venville et al.’s findings agree with those of Goodrum, Druhan and Abbs (2012, p. 55) who state “some students, including interested and able students, were actively discouraged from selecting science courses because of the perception that science subjects were difficult and time demanding.” A pattern of exclusion emerges and while Goodrum et al. (2012) and Venville et al. (2010) both acknowledge that some students are actively discouraged from participating in STEM subjects, what differs is the inferred reasoning for this exclusion; Goodrum et al. (2012) places the locus of misunderstanding with the students, and they are blamed for having a poor perception about undertaking study in the STEM field. Meanwhile, Venville et al. (2010) makes it clear that schools are responding to market pressure, and are seeking to gain positional advantage in the marketplace. This pattern of exclusion corresponds with the “selection task” fulfilled by science education, which involves asking a question of the education system; that is, “who shall be permitted to enter the training group?” (Fensham, 1985, p. 418). As noted earlier, a positional good must be scarce in absolute terms. As such, in order for traditional STEM subjects to be transformed into positional goods, they must abide by this law of the market. This transformation aligns with an elite or exclusionary purpose for STEM education, however it directly contradicts the aspirational purpose of ‘Science for All’. According to Fensham (1985), the selection task frequently operates in the curricula of the physical sciences. Consequently, “if a science education at school could be devised that most children were able to learn with substantial success, it would not suit the selection task as we now understand it” (Fensham, 1985, p. 418). Taken together, these findings underscore the nexus between student interest, student participation and the perceived purpose of STEM education. More broadly, a paradox becomes evident in the construction of the STEM crisis. Declining participation is a central concern of the STEM crisis, yet there is some evidence to suggest that some students who express an interest in studying science are not enrolled, as a function of schools competing for positional advantage in a marketised education system. Rather than examining these dynamics, attempts to legitimate teacher quality as a primary issue in the STEM crisis, and therefore a legitimate site of action to address the crisis persists. Furthermore, it is argued here that while the pedagogical decisions of teachers are important to the teaching and learning experiences occurring in classrooms, they are not the only — or the primary factor — influencing student choices in their post-compulsory years of schooling. As such, political decisions to outsource the task of ‘engagement’ to government agencies, rather than invest in the infrastructure of schools themselves, is likely to have little impact on the STEM crisis, as a crisis of supply, particularly if schools continue to be required to facilitate the task of 'selection' as students enter their post-compulsory STEM studies.

Section 2 Conclusions and Implications

This part of the thesis, Section 2, has focused on the policy production phase of this research, offering a critique of the STEM crisis as it appears in policy discourse. In particular, the 'official knowledge' that is used to construct the crisis has been interrogated. The analysis presented in this part work towards answering the first guiding research question of this phase: *How is the 'crisis' in STEM education framed in policy discourse?*

A critical review of the literature was the first step in answering this question. Chapters 3 and 4 have presented the results of a critical literature review. Primarily, the findings of the literature review undertaken in this part of the thesis have been related to drawing out the key issues, and therefore key sites of action, in the STEM crisis. The work of Tytler (2007) was presented to illuminate four key aspects of the crisis. One of these aspects, "decreasing participation in post-compulsory Science subjects, especially the enabling sciences of Physics, Chemistry and higher Mathematics" (p. 7) was interrogated throughout this part of the thesis. One focus of Chapter 3 was to examine the notion of "decreasing participation" . Data related to participation in secondary schools as well as in STEM courses offered by universities was presented and considered.

Numerous reports have been published in attempts to quantify the "decrease in participation", however, Ainley, Kos and Nicholas (2008) were the first to report declines against specified definitions of participation. Data presented in this report show that a decrease in participation is not evident in terms of raw numbers, with enrolments in science subjects increasing over the last two decades. Decreasing participation is evident in participation rates, that is, the proportion of Year 12 students studying a STEM subject has decreased. Moreover, the proportion studying two or more STEM subjects has decreased to an even greater extent. Further evidence suggests that low socioeconomic status students, rural and regional students and students who attend state schools are among the groups of students least likely to study Chemistry in the post-compulsory years of schooling. Contemporary reports by the Office of the Chief Scientist (2012a, b) fail to take these findings into account, and it is argued here that doing so is an attempt to strengthen legitimation for further strategic action. Aggregating the data in this way universalises the crisis, making it seem as though it is a problem affecting all Australian students. However, failure to account for differential patterns of participation significantly undermines attempts to legitimate the STEM crisis in two key ways. Firstly, particular needs and experiences of traditional equity groups are fused with a broader political agenda and this is counterproductive to the calls made by the widening participation agenda which seeks to increase participation of low SES Australians in higher education. Efforts to increase participation could be well informed by better understanding the differential patterns of participation. Secondly, these trends of participation are particularly relevant for the enrolment of students in STEM courses at university.

After having examined “decreasing participation” (Tytler, 2007, p. 7) in the secondary school sector, patterns of participation in higher education sector were examined. Reports commissioned by either the Australian Council of Deans of Science, or the Federal Government show that in the years prior to 2020, there have been numerous data collection, collation and enumeration methodologies employed, thus making the process of generating and comparing enrolment trends difficult. During the period 2002 – 2009/10, data handling was consistent across jurisdictions, and as such some trends for this period were able to be reported. These data showed that the proportion of enrolments in STEM courses had actually remained relatively stable over time. Moreover, growth in enrolments in the Natural and

Physical sciences were comparable to system-wide results. “Decreasing participation” (Tytler, 2007, p. 7) was very evident at the narrow field of study. For example, enrolments in a Chemistry degree declined by 23.6 per cent. Course completion data was of more concern to “decreasing participation” (Tytler, 2007, p. 7), with completion rates in Chemistry among the lowest reported rates of course completion. It is suggested here that these findings are indicative of students ‘playing the market’ and using a participation in a Bachelor of Science to leverage access to a more vocational pathway in the Health fields. An additional feature of “decreasing participation” (Tytler, 2007, p. 7) was also evident in relation to quality of students enrolling in the higher education sector. In this case, quality was expressed in terms of students entering with lower ATAR scores, and general under-preparedness for university study. It is this qualitative feature of “decreasing participation” (Tytler, 2007, p. 7) along with declining enrolments and rates of course completions that are used in attempts to construct the work of teachers and schools as central to the supply crisis.

Chapter Four explored the role of teachers, and teacher quality in relation to declining student participation in STEM subjects during the post-compulsory years of schooling as well as in relation to the perception of student under-performance against internationally benchmarked assessments of scientific literacy including TIMMS and PISA. ‘Quality’ of teachers was deployed to construct teachers and their work as legitimate issues for the STEM crisis, and therefore as legitimate sites of action to address declines in both students participation and performance. However, analyses presented in the chapter revealed moments where attempts to blame the role of teachers in the crisis fail, thereby undermining attempts at legitimation. For instance, the notion of “appropriate” (Australian Institute for Teaching and School Leadership, 2014a) qualifications was identified as a point of contention amongst stakeholders in the field of education. Debate over the depth and breadth of necessary teacher qualifications persists, despite newly authored Professional Standards for teachers, and an associated framework for Professional Development. Furthermore, research has shown that secondary school Chemistry teachers are largely qualified and experienced, while teachers working in rural and remote schools, or schools servicing low socio-economic status communities were likely to be teaching ‘out-of-field’. Some studies offered cautions about reducing quality teaching to disciplinary expertise as, in doing so, opportunities to develop pedagogical approaches and strategies in STEM education are limited.

Teacher quality is also implicated in the apparent decline in student performance against international benchmarks. Further analysis revealed that the performance of Australian students has remained relatively stable over the last three testing cycles, and it is the ascendance of the students from China (represented through results from Shanghai and Hong-Kong) that have meant Australia’s international ranking has slipped. Studies have argued that this leap to a public discourse of decline may be the result of PISA envy, or the practice of policy externalisation, whereby the success of China is used to justify calls for education reform in Australia. What is of more concern to this study, herein, are the disparities in performance between Australia’s high SES students, and students from low SES backgrounds, state school, and remote and rural geographies and Indigenous students. While these disparities have been clearly and predominantly discussed in PISA reports, the official renditions of the STEM crisis, as reported by the Office of the Chief Scientist, do not focus on this aspect of the crisis. Instead, Australia’s aggregated international ranking is used to justify calls to improve teacher quality. It is argued here that these practices of policy externalisation work to avert the public gaze from less politically desirable projects such as addressing issues of structural inequity facing Australian schooling system.

Chapter Four also examined the ways in which teachers are positioned to influence student choice over whether to participate in STEM subjects in their post-compulsory years of schooling. The work of teachers, and specifically, their enactment of ‘ineffective’ pedagogies that lead to student boredom and disengagement is much discussed in the literature. Moreover, a nexus between teacher quality, student interest and student participation has developed. However, it was argued that the notion of ‘effective’ or ‘ineffective’ is ambiguous, and it can only be evaluated in relation to a clearly articulate purpose for science education. Critical review of literature revealed that there has been, and continues to be, debate around the purpose of STEM education. STEM education is charged with a dual purpose – developing a scientifically literature citizenry as well as preparing future scientists for university study. Despite previous research that has shown that framing STEM education in this way results in neither purpose being achieved well, the new ACARA national curriculum mandates the same approach. As such, it is argued here that the official view of effective science teaching is setting teachers and students up to fail from the beginning. Since teachers are regarded as not providing effective teaching, the Office of the Chief Scientist recommended a program of ‘collaboration with schools’, which, when the funding allocations are examined in detail, reveals that schools do not directly receive any of the funding. It was argued that this amounts to a mistrust of teachers on the part of the Federal government, and it forces teachers to embrace regulated autonomy or be perceived to be contributing to the crisis. While notions of poor pedagogy were noted to be frequently cited as reasons for declining participation, three studies suggested that the strategic value of STEM subjects may significantly impact on students decisions to study them, or not. Moreover, one study noted that schools, too, were found to recognise the strategic value of STEM subjects, and were reported to discourage interested students from studying STEM subjects in order to avoid their place in league tables slipping and to maintain their positional advantage in the marketised education sector. This finding highlights a paradox within the construction of the STEM crisis, and works to undermine attempts to legitimate teacher quality as a key issue in the STEM crisis. While on the one hand, decreasing student participation is central to the

STEM crisis, student quality and positional advantage may work to limit student participation. This finding highlights a gap in the research related to student participation in science subjects in the post-compulsory years of schooling, and that is, the potential influence of systemic factors that may be contributing to patterns of student participation. This study seeks to contribute in relation to this paucity of research.

Finally, in answering the first guiding research question of the policy production phase of this research, it is suggested here the crisis is framed as a crisis of supply. The supply-side of Australia's science system — schools and universities — are charged with increasing the supply of Australian graduates who are STEM qualified. Such a human capital profile is regarded as essential for Australia, as a nation-state, to realised a complete transition to an innovation-led economy. However, attempts to legitimate the crisis as one of supply are undermined by moments where attempts to construe under-performance of students and declining student participation as issues related to teacher quality, qualifications and teaching quality and effective fail. These failed attempts at construal are exposed through the critical analyses presented herein, which highlight the need to acknowledge that a range of social, economic and political factors, other than those related to the work of teachers, significantly impact on students' participation in the study of STEM subjects during the post-compulsory years of schooling. Moreover, the analysis herein has revealed many moments where there is lack of consensus on a range of concepts essential to efforts to legitimate the crisis as one supply. For example, there were issues reported around consistent data collection methodologies in attempts to quantify declines in student participation. International benchmarking data showed that performance of Australian students against international benchmarks has been relatively stable, it is the improvement of Australia's economic competitors that has seen Australia's international rank position drop. There is a lack of agreement on the primary purpose of STEM education, and the most effective way to frame the STEM curricula to be enacted by teachers, and finally, student interest in science was shown to not always be enough for students to enrol in science at secondary school. Schools respond to market demand by strategic enrolling students in subjects so as not affect their positional advantage. Given these conclusions, it is suggested here that rather than "re-imaging science education" (Tytler, 2007) it may, indeed, be necessary to re-think the way the crisis itself has been framed. It may be more fruitful to change tack, and to investigate the crisis as one of 'demand' rather than as a crisis of supply. This endeavour, then, is the focus of Section 3 of this thesis.

Section 3: Critiquing the Crisis: Demand

Introduction

While Section 2 of this thesis focussed on the 'official knowledge' used to frame the STEM crisis as a crisis of supply, Section 3 of this thesis re-directs the gaze of inquiry and, instead, examines the crisis from the perspective of demand. The analyses presented herein aim to address the overarching research question from the policy production phase of the research methodology: *What is the official rendition of the STEM crisis?* Earlier, in Section 2, the paradigm of 'Big Science' was introduced. The Big Science paradigm views the transformed purpose of the field of science to be aligned with Innovation, therefore, simultaneously transforming the purpose of science education. Section 3 of this thesis, then, aims to explore this nexus of Innovation and the STEM crisis in more detail. These goals are informed, methodologically, by Critical Discourse Analysis (CDA) (Fairclough, 2010). The broad objective of CDA is to "develop ways of analysing language which address its involvement in the workings of contemporary capitalist societies" (Fairclough, 2010, p. 1). Fairclough (2010) advocates for a focus on the economic, not because of a "mechanical economic determinism", but because "of the dominance of the economy in contemporary societies" (p.1). As Fairclough notes, the 'neo-liberal' version of capitalism, "which has been dominant for the past thirty years is widely recognised to have entailed major changes in politics, the nature of work, education, and healthcare, in social and moral values, in lifestyles and so forth" (Fairclough, 2010, p. 1). CDA is premised upon the existence of a dialectical relationship between structure and strategy, such that effects of structures give rise to strategies oriented to changing structures. Given this dialectical relationship between strategies and structures, Fairclough suggests that an approach to researching a 'crisis' could be exploring:

> … the emergence of different and competing strategies for overcoming the crisis, and the processes through which and the conditions under which certain strategies can be implemented and can transform existing systems and structures. This formulation is based upon a theory of crisis which among other things sees crises as events which arise from the character of structures, and sees strategies and structures as in a relationship such that the effects of structures gives rise to strategies oriented to changing structures. If it also sees strategies as having a partly discursive character, one 'point of entry' for research could be focussed on discursive formations of strategies and how they may contribute to their success or failure. This might include for instance analysis of *explanations of* the crisis and *attributions of blame, justifications for* and *legitimations of* particular lines of action and policy, and *value claims and assumptions in explanations, justifications and legitimations* [emphases added]. (2010, p. 5)

Section 2 of this thesis examined the explanation of the STEM crisis from a supply perspective, including an examination of the attribution of blame for the decline in students participating the study of STEM subjects, particularly in the post-compulsory years of schooling. Further to Fairclough's (2010) suggestion, Section 3 of this thesis examines the explanation of the 'STEM crisis' from a demand perspective.

In particular, Chapter 5 examines the extent to which Innovation, as a globalised and globalising policy imperative steered by the OECD, works to *justify* particular lines of Australian Federal action and policy. In addition, Chapter 5 examines the *assumptions* evident in the re-structuring of ministerial responsibility for the portfolios of Science, Education and Innovation, through time.

Chapter 6, then, follows on to examine the efforts made in policy discourse to construct Innovation as an order of discourse. It is posited that two dominant discourses are evident: the discourse of security and the discourse of opportunity. Both these discursive categories work to legitimate the Innovation agenda, thereby legitimating actions that aim to increase the number of students studying STEM subjects, particularly in the post-compulsory years of schooling.

Chapter 7 presents a range of tensions that become evident when the STEM crisis is analysed from a perspective of demand rather than supply. This chapter presents the argument that the lack of clarity surrounding the domestic labour market demand for STEM graduates, and the relationship between Innovation, STEM-skills, and the enabling sciences, contributes to the STEM crisis and should be considered alongside the explanation of the STEM crisis from a supply perspective.

Finally, Section 3 concludes with a consideration of the implications of these legitimation tensions for a reconceptualisation of the crisis from one of quantity, to one of quality. Furthermore, the implications for students seeking to navigate access to the Innovation agenda are also discussed.

The analyses presented in Chapters 5, 6 and 7 address the following guiding research questions:

1. How did Chemistry come to be regarded as an ‘enabling science’?
2. What is being ‘enabled’ by calls for increased participation in the ‘enabling sciences’?
3. Who is being ‘enabled’?

Attention will now turn to an examination of the extent to which Innovation, as a globalised and globalising policy imperative, works to *justify* particular lines of Australian Federal policy and associated initiatives, followed by an analysis of the *assumptions* evident in the process of re-structuring the Australian Federal ministerial responsibility for the portfolios of Science, Education and Innovation, through time.

Chapter 5 Justification of the STEM crisis as a site of legitimate action for the Innovation Agenda

5.1 Justification through the forces of 'Globalisation' and globalism

The notion of globalisation is highly contested throughout the education policy literature. The term is used here with full recognition of the difficulty in providing a singular definition. In attempting to define the sense of globalisation pertinent to this thesis, herein, a description by Rizvi and Lingard is offered. They state that the term globalisation "refers not only to shifts in patterns of transnational economic activities, especially with respect to the movement of capital and finance, but also to the ways in which contemporary political and cultural configurations have been reshaped by major advances in information technologies" (Rizvi & Lingard, 2010, p. 22). They go on to describe three different ways in which globalisation can be understood: firstly, "as an empirical fact that describes the profound shifts that are currently taking place in the world"; secondly, "as an ideology that masks various expression of power and a range of political interests"; and finally, "as a social imaginary that expresses the sense people have of their own identity and how it relates to the rest of the world, and how it implicitly shapes aspirations and expectations" (Rizvi & Lingard, 2010, p. 24). Elements of each these understandings of 'globalisation', as described by Rizvi and Lingard (2010), contribute to the contextualisation for the policy analysis presented in Section 3 of this thesis.

Empirical definitions of globalisation provide a necessary historical drive to the force of globalisation, without which the term globalisation may become a weakened "catch-all phrase" (Robertson, 2006, p. 3). Without an empirical perspective, it is possible to lose sight of the fact that globalisation was, and continues to be, "the outcome of processes that involved real actors—economic and political—with real interests" (Robertson, Bonal & Dale, 2002, cited in Robertson, 2006, p. 4). The work of Dale (1999), Dale and Robertson (2002), Robertson (2006), and Robertson, Bonal and Dale (2002), present the historical and empirical evolution of notions of globalisation. This body of work highlights the agency of players such as transnational corporations (TNCs), alongside various international and regional organisations including The World Bank, The International Monetary Fund (IMF), the European Union (EU), the Asia Pacific Economic Cooperation (APEC) and the Organisation for Economic Cooperation and Development (OECD) in the transition to a particular form of globalisation, now dominating education policy discourse. Framing globalisation as a political imperative, without calling attention to the work of these international organisations, is problematic:

> Globalization discourses 'ontologize' the global market logic, creating global subjects who are asked to consider policy options through its presupposed conceptual prism, which revolves around such market principles as free trade; the production of profits through greater productivity; a minimalist role for the state; a deregulated labour market; and flexible forms of governance. In this way, the term 'globalization' is deeply ideological, implying certain power relations, practices and technologies. This way of using 'globalization' Bourdieu (2003) refers to a performative usage - one taken to mean neoliberal globalization. (Rizvi & Lingard, 2010, p. 33)

The dominant ideological form of globalisation deployed in the policy analysis presented herein, is 'neo-liberal' globalisation, in accordance with the description provided by Rizvi and Lingard (2010) above. These authors assert that neo-liberal globalisation is an ideology that is inevitable, irreversible and without social actors at its helm. Furthermore, this ideology relegates issues of social justice to the market, with full faith that the market, with minimal state interference, can reconcile issues of social justice (Rizvi & Lingard, 2010).

Working with this neo-liberal conceptualisation of globalisation, an exploration of the ways in which neo-liberal globalisation works to shape ‘social imaginaries’— a term originating from Appadurai (2001) — is undertaken. This exploration draws out the ways in which the shaping process is scaled from the nation-state to the individual (Robertson, 2006). Individuals, as global subjects, are required to respond to the demands of neo-liberal globalisation — as both an ideological and contextual force — by imagining and aspiring in ways relative to this force. It is in this light, that the term ‘globalism’, in contrast to ‘globalisation’, is considered:

> Globalization refers mainly to a series of objective changes in the world that are partly outside us. Globalism on other hand, suggests a set of value preferences – changes associated with globalization so that they are now incorporated into our emotions and our ways of thinking about everyday life. (Cohen & Kennedy, 2000, cited in Rizvi & Lingard, 2000, p. 32)

It is argued here that globalism is the force that the Australian Federal policy assemblage under study seeks to harness. Globalism, driven by the ideology of neo-liberal globalisation, transforms the notion of security such that economic security, rather than physical or geographical security, becomes the myopic focus of nation-states and individuals alike. Osborne (1996) noted that ensuring the integrity of economic processes of the population was a primary function of liberal mechanisms of security. Given this, both nation-states and individuals alike, responding to neo-liberal globalisation, seek to attain and retain economic security by pursuing relevant forms of intervention, resulting in a shift in value preferences. One such form of intervention is to attempt to establish a dominant social imaginary:

> Governments secure their authority by allocating values through attempts to forge people’s subjectivities in terms of a dominant social imaginary. One the one hand, the

> neoliberal social imaginary of globalization is designed to forge a shared implicit understanding of the problems to which policies are presented as solutions, seeking a sense of political legitimacy. On the other hand, it is designed to discipline people and is aimed at guiding and shaping their conduct. (Rizvi & Lingard, 2010, p. 36)

According to Appadurai (2001, p. 8), imagination has become “a critical part of collective, social, everyday life and is a form of labour” in the formation of global subjects and subjectivities. Also, in his paper entitled *Imagination and the globalisation of educational policy research,* Rizvi (2006, p. 195) highlights that “any treatment of how imagination comes to be socially constituted and politically utilised” is missing from the body of work concerning the role of imagination in social life. It is argued here that much of the policy discourse evident in the Australian Federal policy assemblage under study, works to promote Innovation as a new social imaginary or, as Fairclough (2010) would describe it, an order of discourse. Furthermore, political efforts to justify and legitimate Innovation as an order of discourse are underpinned by the deployment of the discourses of opportunity and security, both of which are evident in numerous Australian Federal policy documents. In particular, it is through the deployment of the discourse of opportunity, evident in the policies under analysis herein, that imagination is used politically in an attempt to mobilise innovation-led globalism. Moreover, it is through the hegemony of neo-liberal globalisation that the notion of ‘security’ has been transformed in Australian Federal policy discourse. Alongside this transformation is the emergence of the discursive binary of security – ‘risk’. The discourse of security calls into question Australia’s ability to respond to neo-liberal globalisation – unless individuals are willing to accept the ‘opportunities’ cultivated for them by the market. It is this globalised discursive imperative that underwrites efforts to legitimate Australia’s Innovation policy agenda.

5.2 Establishing the link between Science and Innovation: The role of the OECD as a globalising force.

For over a decade, Innovation has been positioned by the OECD as essential to economic prosperity (OECD, 1999, 2000a, b, 2001, 2004a, b, 2007, 2011; OECD Centre for Educational Research Innovation, 2008). In addition, this historical trajectory of OECD policy frameworks makes apparent the links between Innovation, Science and Technology. For example, a policy brief entitled *Science, Technology and Innovation in the New Economy* (OECD, 2000a) states that both human capital and scientific progress are integral to the innovation process, with scientific progress in particular acting as a “more direct driver of the innovation process” and, as such, “science, technology and innovation are now key to improving economic performance and social well-being” (p. 4). The OECD policy brief (2000a) then recommended that in order for a government to benefit from the transformation to a “new economy”, they must work to put “the right policies in place” (p. 1). The OCED (2000a) also lists some key structural reforms that, from its perspective, constitute policy settings that enable a new economy to flourish. These structural reforms include the liberalisation of telecommunications markets; limiting publicly funded research to that which is strategically aligned with governmental goals; creating ‘centres of excellence’ in order to target co-operation between industry and university; and, finally, generating education reform that results in the production of human capital with particular qualities: creative, critical thinkers who are life-long learners. Despite noting Australia’s previous lack of attention to these areas of policy reform, the OECD (2000b), at the time, regarded Australia’s policy manoeuvres – particularly those related to increasing the role that science played in economic growth – to be closely aligned with those made by other OECD member nations.

The OECD is a key policy actor in Australia's Innovation agenda. Reports and frameworks published by the OECD define the innovation agenda; identify areas of growth in, and challenges to, the Innovation Agenda; and record the international 'scoreboard' of success in relation to the implementation of an innovation-led economy. For example, every two years, since 1999 the OECD's Directorate of Science Technology and Industry has published a report entitled the *Science, Technology and Industry Scoreboard* (STIS) that compares the performance of OECD countries against a broad array of performance indicators pertaining to science, technology, industrial performance and globalisation (OECD, 1999). Since 2007, these biennial reports have also included comparisons between OECD countries and major non-OECD countries, including China, India and Indonesia (OECD, 2007). One such indicator of success is the supply of "Human Resources in Science and Technology (HRST)" (OECD, 2011, p. 72).

HRST human capital is defined by the OECD in accordance with the *Canberra Manual* as "persons having graduated at the tertiary level of education or employed in a science and technology occupation for which a high qualification is normally required and the innovation potential is high" (OECD, 2011, p. 72). In the latest STIS report released in 2011, the OECD states that, in most OECD countries, growth in the demand for HRST is outstripping total overall growth, with most of the HRST labour force employed in the personal and health services sector rather than in the manufacturing sector (OECD Centre for Educational Research Innovation, 2011). Furthermore, the OECD ranks Australia's supply of HRST human capital ninth in the world; Australia is outranked by Luxemborg (ranked first in the world), Sweden, Denmark, Switzerland, Norway, The Netherlands, Iceland, and Germany (ranked eighth). In addition, Australia was found to be contributing above the OECD average to the non-patent literature, but was not progressing in relation to the quintessential indicator of Innovation – entrepreneurialism; as measured by the issuance of patents.

Australia's national response to the OECD's coalition of scientific progress, human capital development and innovation is reflected in the re-structures of ministerial responsibility for the portfolios of Science, Education and Innovation over the last decade. As such, it could be argued that Australia, as a nation-state, has made a shift in the way these responsibilities need to be considered from both an operational and ideological perspective. Such shifts correspond with the notion of globalism defined in Section 5.1 (Rizvi & Lingard, 2010), and lend weight to the argument that the OECD plays a significant role as a globalising force in the Australian Federal Innovation policy agenda. Attention will now turn to the structural responses made by consecutive Australian Federal governments in response to Innovation as a globalised policy imperative.

5.3 Shaping the Australian Innovation agenda: An intersection of Science, Innovation and Education Policies through time

Since 1996, Australian policy, at the Federal level, has prioritised education, science and innovation as strategies of economic transformation. However, through time, the order, relative positions, and ministerial responsibility of the Australian Federal government portfolios of Science, Innovation and Education have undergone significant re-shaping. Table 5.1 summarises the shifts in ministerial responsibility for science in the Australian Federal parliament from 1996 to 2013. This summary reveals that Science, as a ministerial portfolio, has been variously located and collocated over the last 20 years, with Science's proximity to other portfolios such as Education and Industry underlying broader governmental objectives associated with the development of 'Innovation' as a field. More specifically, the alignment and re-alignment of portfolio responsibility for Science, Education and Industry reflect governmental aspirations to leverage a transition to an innovation-led economy, in which "techno-scientific knowledge is understood as a central driver of economic growth" (Bullen et al., 2006, p. 56). The following section (5.3.1) examines the structural re-alignments associated with the development of the Federal Innovation agenda in Australia from 1996 to the present. It is argued here that these points of re-structure reflect the national response to Innovation as a globalised policy imperative.

Table 5.1

Ministerial responsibility for Science in the Australian Federal Parliament, 2013 - 1996

Era	Prime Minister	Political Party	Cabinet Dates	Federal Department overseeing Science	Federal Cabinet Minister overseeing Science	Key Policy Documents
present	Abbott	LIB	18th September, 2013 to present	Department of Industry	Ian MacFarlane: Minister for Industry	
2013	Rudd	ALP	27th June, 2013 to 18th September, 2013	Department of Industry, Innovation, Climate Change, Science, Research & Tertiary Education	Kim Carr: Minister for Innovation, Industry, Science and Research; and the Minister for Higher Education.	Health of Australian Science (2012) Mathematics, Engineering & Science in the National Interest (2012) Research Workforce Strategy – Research Skills for an Innovative Future (2011)
2010 to 2013	Gillard	ALP	14th September, 2010 to 27th June, 2013	Department of Industry, Innovation, Climate Change, Science, Research, & Tertiary Education (from 26th March, 2013)	Craig Emerson: Minister for Tertiary Education, Science, and Research; Trade and Competitiveness; and the Minister assisting the Prime Minister on Asian Century Policy.	
				Department of Innovation, Industry, Science, Research & Tertiary Education (from 15th December, 2011)	Christopher Evans: Minister for Tertiary Education, Skills, Science & Research Greg Combet: Minister for Industry and Innovation	Inspiring Australia (2010)
			24th June, 2010 to 14th September, 2010	Department of Innovation, Industry, Science and Research	Kim Carr: Minister for Innovation, Industry, Science and Research	
2007 to 2010	Rudd	ALP	3rd December, 2007 to 24th June, 2010	Department of Innovation, Industry, Science and Research	Kim Carr: Minister for Innovation, Industry, Science and Research	Transforming Australia's Higher Education System (2009) Powering Ideas - An Innovation Agenda for the 21st Century (2009)
1996 to 2007	Howard	LIB	22nd October, 2004 to 3rd December, 2007	Department of Education, Science & Training (2007 – 2001)	Julie Bishop: Minister for Education, Science and Training (27th January, 2006 – 3rd December, 2007) Brendan Nelson: Minister for Education, Science and Training (until 27th January, 2006)	Backing Australia's Ability (2001)
			26th November, 2001 to 22nd October, 2004		Brendan Nelson: Minister for Education, Science and Training	
			21st October, 1998	Department of Industry, Science & Resources	Nick Minchin: Minister for Industry, Science and Resources	

to 26th November, 2001	(2001 – 1998)	
11th March, 1996 to 21st October, 1998	Department of Industry, Science and Tourism (1998 – 1996)	John Moore: Minister for Industry, Science and Tourism Peter McGauran (Junior) Minister for Science & Technology

5.3.1 Re-structures through time: Shaping up the Innovation agenda

In 2001, under a Liberal Howard Government, a policy entitled *Backing Australia's Ability (BAA): An Innovation Action Plan for the Future* was authored. According to DEST (2006, p. ix), BAA was funded in two rounds. In the first funding round, \$3 billion was allocated over the five years 2001–02 to 2005–06; then, in 2004, the second funding round entitled *Backing Australia's Ability (BAA2) – Building our Future through Science and Innovation* was announced. BAA2 was worth \$5.3 billion and was funded to 2010-11. The *Backing Australia's Ability* Innovation agenda was launched on the premise that "more needs to be done in response to an increasingly competitive world environment and the recognition that success in the 21st century will depend predominantly on the innovative capacity of nations, their industries and their research and educational structures" (Commonwealth of Australia, 2001, p. 4).

Alongside the BAA funding in 2001, came shifts in key Federal government portfolios. In particular, the responsibility for Science was removed from the *Department of Industry, Science and Resources* and was, instead, allocated to the *Department of Education, Science and Training* (see Table 5.2). This shift in responsibility for science flagged a significant intersection of Australian Federal policy, resulting in the interlacing of policy objectives concerning science, education and training, with a sharp focus on auditing and building Australia's stock of HRST human capital (Department of Education Science and Training, 2003, 2006). Arguably, the BAA policy moment was significantly steered by the globalising innovation policy frameworks of the OECD and, as such, "developing and retaining skills" (DEST, 2006, p. ix) became a central tenet of this Innovation agenda. However, the Liberal government response to the Innovation agenda was limited to auditing the supply of HRST human capital and recommending structural reforms to the education sector in order to leverage the transition to an innovation-led economy. The structural reforms themselves — also a strategy suggested by the OECD as essential to transition to the new economy — were predominantly enacted by the Australian Labor Party (ALP) Rudd/Gillard government following its election to Federal office on the 3rd of December, 2007.

Following the election of a Labor government, major re-structures in many of the Australian Federal Government departments were once again enacted and, as before, ministerial responsibility, for Science was shifted. The *Department of Innovation, Industry, Science and Research* (DIISR), led by Minister Kim Carr was established — inclusive of responsibility for the Science portfolio. Simultaneously, the *Department of Education, Employment and Workplace Relations* (DEEWR) was formed. Under the new portfolio arrangements, DEEWR was responsible for all education from early childhood to undergraduate university education, while DIISR was responsible for research, including research that occurred in university settings. As a result of the 2007 re-structure, the portfolios of Science and Education were once again separated, as was the case prior to the Howard era. In contrast, during the Howard era, the portfolios were positioned together in the Department of Education, Science and Training. The contrast in alignment of portfolios between Labor and Liberal governments speaks to the purpose of education in relation to the economic project (Cranston, Kimber, Mulford, Reid, & Keating, 2010); the binary of education as a public good versus education as a private good.

In relation to the 2007 re-structure, Julia Gillard, the then minister for Education, is quoted as stating: “we created, deliberately, a human capital portfolio, the Department of Employment, Education and Workplace Relations” ("Julia Gillard Joins Insiders," 2010). However, following the change in ALP leadership to Gillard, on the 15th of December, 2011, the *Department of Innovation, Industry, Science and Research* added *Tertiary Education* to its portfolio responsibilities, forming the *Department of Innovation, Industry, Science and Research, and Tertiary Education*. The inclusion of Tertiary Education in the ‘Innovation’ portfolio — and its exclusion from the ‘human capital’ portfolio — constitutes a significant re-structure; reorganising the ways in which the portfolios of science, education and innovation were now ordered in relation to one another, such that education became a divided portfolio. Firstly, the excision of Tertiary Education from DEWEER and its insertion into

DIISRTE resulted in the flow of a previously 'human capital' portfolio responsibility into DIISRTE – further tightening the nexus between 'innovation' and 'education' and emphasising the role that both portfolios will play in producing the human capital needed in an innovation-led economy. Secondly, the decision to excise *only* Tertiary Education from DIISRTE, reduced proximity for both the compulsory and the post-compulsory years of schooling from the Innovation agenda. Instead, the compulsory years of schooling, inclusive of the Australian Curriculum for Science (Foundation to Year 10) (Australian Curriculum Assessment and Reporting Authority, 2011), and the draft science curricula for Years 11 and 12, remained the responsibility of DEEWR — the 'human capital' portfolio.

The implementation of the national Australian Curriculum, including Science and Mathematics, is currently underway in the compulsory years of schooling around Australia. However, neither DEEWR nor DIISRTE are currently responsible for the implementation of the curricula of the post-compulsory years of schooling. While ACARA has written the 15 senior secondary subjects (including the sciences of Biology, Chemistry, Earth and Environmental Sciences, and Physics), that were endorsed in December 2012, ACARA notes that:

> State and territory curriculum, assessment and certification authorities are responsible for determining how the Australian Curriculum content and achievement standards are to be integrated into their courses. Some states and territories commenced implementation of integrated courses in 2014, while others are still determining integration timelines (Australian Curriculum Assessment and Reporting Authority, 2013b, "Senior Secondary Overview", para. 3).

At present, each State and Territory in Australia retains the authority to implement the curriculum of their choosing in the post-compulsory years of schooling. As such, despite attempts to move responsibility for school (including post-compulsory school STEM) education to the Federal level by authoring a National Curriculum, both the curricula pertaining to, and therefore policies directed at, increasing participation in STEM subjects in the post-compulsory years of schooling remain beyond the jurisdiction of the Federal Government.

Along with the separation of school science education from the Innovation agenda, the 2011 re-structure also positioned Australia's universities as key actors in the Innovation agenda. Under the re-structure, the responsibility for implementing *Transforming Australia's Higher Education System* (Department of Education Employment and Workplace Relations, 2009), the Federal Government's response to the *Review of Higher Education* (Bradley et al., 2008), also shifted to DIISRTE. Further reforms to Tertiary Education, in particular those concerning a new quality assurance and regulatory framework formalised in the *Tertiary Education Quality and Standards Agency Act (2011)*, were to, then, be overseen by an independent government agency — the *Tertiary Education Quality and Standards Agency* (TEQSA) — rather than DIISRTE. This separation of strategic and regulatory power marked a new era of accountability in Australia's Higher Education Sector. At the same time, additional structural agencies were also established within DIISRTE, namely the *Office of the Chief Scientist* (OCS) and the *Prime Minister's Science, Engineering and Innovation Council* (PMSEIC).

The OCS, as a newly established structural agency, plays a significant role in responding to the STEM crisis, and in (re-)shaping Australia's Innovation agenda accordingly. Reports recently published by the OCS, in particular, *Health of Australian Science* (Office of the Chief Scientist, 2012a) and *Maths, Engineering and Science in the National Interest* (Office of the Chief Scientist, 2012b), present a range of data, definitions and descriptions that constitute the official rendition of the nature and scope of the STEM crisis, along with descriptions of the sites of the STEM crisis. These sites include schools, universities and students themselves. These official representations of the sites of the STEM crisis allow the government to justify a range of globalised policy intent and actions (Fairclough, 2010). Once the crisis has been explained and justified, particularly in relation to the globalised policy imperative that is Innovation, the Federal Government seeks to legitimate these policy actions in relation to the STEM crisis. An examination of these discursive attempts to legitimate the sites of action for the STEM crisis will now be presented in Chapter 6.

Chapter 6 Legitimation of the Innovation Agenda

6.1 Introduction

Legitimation can be defined as the processes by which a political action is deemed legitimate. The processes by which legitimation is achieved are fundamental to both the power relations in a society, and to the relations of production. According to Habermas (1973), legitimation is not easily achieved – at best, it is gained temporarily, and usually only under extraordinary circumstances. In order for a government to achieve legitimation, neither values held by the administration nor the private form of acquiring those same values can be explicated. In addition, legitimation can only be achieved when private citizens have the freedom to choose whether or not to participate in, or align with, a particular political standpoint. These conditions for policy legitimation, as described by Habermas (1973), highlight the tensions faced by the Australian Federal Government in their attempts to garner political will for both the deterministic and beneficial nature of the Innovation Agenda. Such legitimation efforts require shifts — not only in the means and methods by which ideas are represented through discourses, but also in the manner by which individuals are compelled to develop new ways of acting, interacting and being; considering new identities and new subjectivities in response to the legitimation efforts made by the government. As is suggested by Habermas (1973), legitimation of a political agenda is achieved by assuming "the task of ideology planning" (p. 657), a process akin to globalism as described by Rizvi and Lingard (2010) and which is reflected in Fairclough's (2010) notion of an order of discourse. An order of discourse is defined as "the discourse aspect of a social order … a particular social ordering of relationships between different ways of making meaning … a particular social structuring may become hegemonic, become part of the legitimising common sense which sustains relations of domination" (Fairclough, 2010, p. 265).

Policy, then, as a tool of the political system, works to create an order of discourse that mediates the process of legitimation. It is argued here that Innovation should be regarded as an order of discourse. According to Gee (2011):

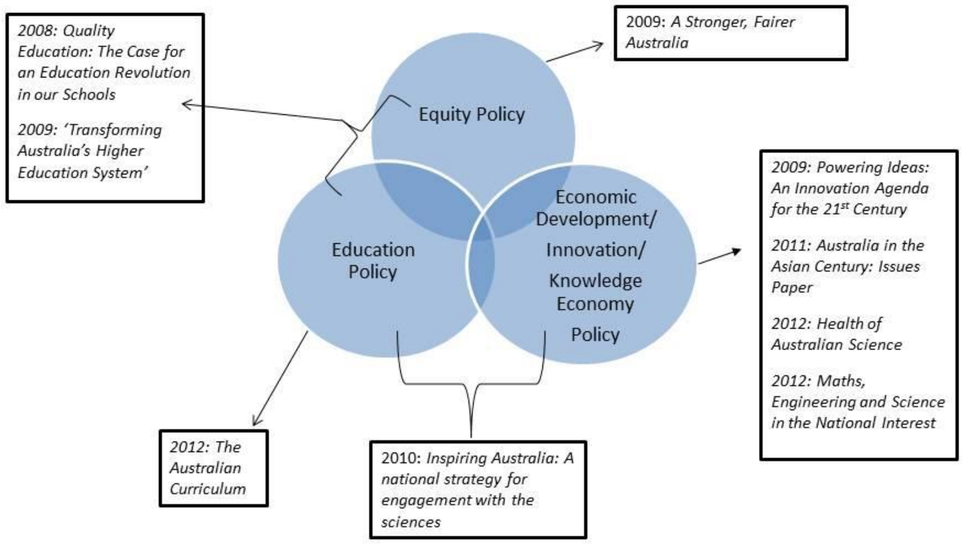
> A Discourse with a capital "D" … is composed of distinctive ways of speaking/listening and/or reading/writing … coupled with distinctive ways of acting, interacting, valuing, feeling, dressing, thinking and believing … Discourses are … ways of recognizing (sic) and being recognized (sic) as certain sorts of whos doing certain sorts of whats …. Discourses are matters of enactment and recognition.

In the same way, innovation, as a political discourse and agenda, requires Australians to subscribe to, act as and then to become, particular types of citizens – a population of innovators. As such, the term *innovation* will be stylistically presented in the capitalised form; as in *Innovation*, to signify to the reader the distinction between the notion of innovation and Innovation working as an order of discourse. As will be demonstrated through the policy analysis to follow, the Australian Federal Innovation agenda seeks to embed Innovation as a "way of life for all Australians" (Commonwealth of Australia, 2009a, p. 1). In light of these ideological goals, it is clear that the Innovation agenda requires Australians to re-imagine their way of life, and, as is suggested by Appadurai (2001), this re-imaging has in itself become a form of labour in the formation of global subjects and subjectivities. It is argued here that the legitimation efforts of the Innovation agenda, work to leverage ideological reform. Such reform requires policy from a range of spheres to intersect, in order to confront citizens at various moments of their public life, and to require them to reflect upon their own position in relation to the Innovation Agenda. Establishing Innovation as an order of discourse is significant to this thesis herein as doing so describes the ideological conditions under which the call for increased participation in STEM exists. Following on, establishing Innovation as an order of discourse also describes the ideological conditions under which secondary school students may or may not respond to the call for increased participation in the study of STEM subjects.

In an attempt to evidence the argument that Innovation should be read as an order of discourse, selected Australian Federal policy documents from the spheres of Education, Equity and Economic Development were interrogated in the analysis presented here. Figure 6.1, provides a summary of the policy documents examined. The policy actors who authored each of these policies is provided in Table 5.1, in the previous chapter. The method of analysis, and justification for both the selection of these documents and the methodological approach undertaken was presented in detail in Chapter 2 of this thesis.

Overall, it is argued here that four dominant discourse categories are deployed in the policy assemblage under study in order to legitimate the Innovation agenda. These are the discourses of (i) security, and its binary (ii) risk; and (iii) opportunity and its binary, (iv) quality. In addition, these discursive categories are ordered relative to one another (Fairclough, 2010) so as to both justify and legitimate particular policy lines and actions within the Innovation agenda. Furthermore, these discourses are scaled, such that they work to leverage ideological transformation for both the nation-state and individuals simultaneously. An overview of the interactions between these discourse categories, as they work to underpin the Innovation agenda, is represented in Table 6.1. The following sections (6.2 and 6.3) will provide examples from the policy assemblage of these categories of discourse working to legitimate the Innovation agenda.

Figure 6.1 A graphical representation of the intersection of Australian Federal policy under analysis



Note. **The blue circles indicate fields of policy concern: Education, Equity and Economic Development. The rectangles contain the names of policy documents, and their year of authorship, analysed herein. Analysis of this suite of policy documents revelated that policy imperatives and strategies concerned with science education and the STEM crisis emerge from each of these three fields.**

Table 6.1
Matrix of discourse categories underpinning efforts to legitimate the Innovation agenda

Scale	**Discourse**	**Security**	**Quality**
Individual	Risk	Loss of traditional social contracts means that individuals must be responsible for their own security and prosperity	Failure to attain the necessary qualities to secure prosperity places the individual at risk of social dislocation and/or disadvantage
Nation-State		Time of global uncertainty and transformation. Australia is at risk of losing its competitive edge and therefore its capacity to provide opportunities for its	As the innovation qualities of Australia's human capital declines, the economy faces risk of loss of productivity

		citizens to work in meaningful employment.	
Individual	Opportunity	Taking up opportunities will secure place in a global labour market	Australians have the opportunity, through education and training to develop desirable innovation qualities to secure their future in a transformed economy.
Nation-State		Taking up opportunities will secure a competitive edge in securing economic investment and in transforming traditional manufacturing industries.	Australia, as a nation-state, has the opportunity to invest in the transition to an Innovation-led economy, and to secure quality work opportunities for its citizens.

6.2 The discourse of security

6.2.1 Introduction

Along with the conceptualisation of neo-liberal globalisation (as discussed in Section 5.1), there has been a turn from away from traditional liberal democracy toward a neo-liberal version of democracy, and a concurrent transformation of the notion of 'security'. Traditional notions of security, concerned with physical security or geographical security, have given way to economic security. The field of Economics, as a technology of security (Osborne, 1996), has come to represent the concerns for security more broadly within the Australian policy discourse. It is argued here that significant discursive work must be done in order to maintain the hegemonic representation of 'security' as 'economic security'. The policy discourse establishes the need for policy action; then, it generates political will for the project at hand (Fairclough, 2010).

In light of this, Section 6.2 of this thesis presents an examination of the scaled deployment (Robertson, 2006) of security as a discursive category — that is, from the individual to the nation-state — in the Federal policy assemblage under study here. Further to this, an examination of the ways in which 'security' then works to construct the notion of risk is made. As will be exemplified by the policy extracts that follow, both risk and discursively moderated forms of risk are frequently co-located with notions of security in the policy assemblage, in order to legitimate government action directed at realising the Innovation agenda, including increased participation in students studying the enabling sciences, such as Chemistry, in the post-compulsory years of schooling.

Moreover, it is argued here that the assemblage of Federal Australian policy under study works to legitimate assertions made within it that there are significant implications for both individuals and Australian as a nation-state, should the Innovation agenda fail to be realised. This discursive work, then, constitutes the premise upon which strategies to counteract the risk can be suggested. In other words, the discourse evident in the policy assemblage leverages the transformation of 'innovation' from a concept to an order of discourse, which then legitimates the call for an increased supply of for STEM-qualified human capital.

6.2.2 Evidence from the policy assemblage

In 2009, the Australian Federal Government, through the Department of the Prime Minister and Cabinet authored its social inclusion strategy entitled *A Stronger, Fairer Australia* (Commonwealth of Australia, 2009b). This document outlines an "agenda for change" (p. iii), and aims to "make sure every Australian has the capability, opportunity and resources to participate in the economy and their community, taking responsibility for shaping their own lives" (p. iii). Here, emphasis is placed on Australians being responsible for their own futures, particularly in relation to participation in the economy. Further to this, the policy states "Australia is changing" (p. 5) bringing with it a redistribution of employment opportunities:

> Australia's economy *has changed* in recent decades, with greater demand for skilled workers, *shrinking opportunities* for people with limited training or education and a geographical redistribution of job opportunities as some sectors contract and others expand. Our economy continues to *change*, more and more *work opportunities will be available only to those with*

qualifications and higher level skills [emphases added]. (Commonwealth of Australia, 2009b, p. 5)

Habermas (1973) argues that during the process of legitimation, meaning cannot be created through supplanting the values held by the administration. Instead "at best [there can only be] an ideological erosion of cultural values" (p. 657). In the policy excerpt presented above, the changed (and changing) nature of Australia's economy and labour market is emphasised. Here, security is scaled to the individual – where opportunities to gain employment are limited to those individuals who hold "higher level skills". The specific nature of these higher level skills remains unspecified, and yet those individuals who do not hold such skills are regarded as at risk of losing their livelihoods. In addition, the notion of change becomes synonymous with uncertainty, and constitutes a moderated form of the discursive category of risk. This excerpt implies that without individuals taking active responsibility for their own futures, their security can no longer be taken for granted. In this way, traditional representations of security are eroded, to make way for new conceptions of security, underpinned by globalised neo-liberal ideologies, and an individual's position in relation to a globalised labour market. This transformed notion of security — read as economic security — is also scaled to that of the nation-state in the following quote from the same document: "A strong economy is essential for Australia's future" (Commonwealth of Australia, 2009b, p. 9). Overall, *A Stronger, Fairer Australia* requires Australians to reconsider the ways in which they interact with a changed, and changing, labour market and to accept that their future security, as well as the future security of the nation-state, is tied to their capacity to use the resources and 'opportunities' made available to them, such that they are positioned to participate in a labour market which will demand "higher level skills".

The discourse of security, co-located with the discourse of risk, was also activated in policy from the sphere of Innovation. For example, in the policy document *Powering Ideas* (Commonwealth of Australia, 2009a):

> Innovation is the key to making Australia more productive and more competitive. It is the key to answering the c*hallenge* of climate change, the *challenge* of national security, the age-old *challenges* of disease and want. It is the key to creating a future that is better than the past [emphases added]. (p. 1)

In the excerpt above, it is asserted that the "challenges" facing Australia can be overcome by Innovation. Similarly, the strategy, *Inspiring Australia* (Commonwealth of Australia, 2010) states that:

> In order to meet the *challenges* [emphasis added] of the government's Innovation Agenda, Australia needs a greater proportion of the student population undertaking science and advanced mathematics courses through high school, as well as gaining higher level and higher quality science, mathematics and engineering qualifications at university. (p. 39)

It is argued here that this assemblage of policy, from Equity, Economy and Education spheres, works to underwrite the call for increased participation in STEM subjects, and in turn, this action aims to realise the Innovation agenda. In addition, Innovation is significant to both the individuals who secure "higher level skills"; thereby enabling participation in the Innovation agenda, and simultaneously, to the productivity of the nation-state.

However, the Australian government also noted that " *urgent action* was needed to *boost* Australia's *innovation capacity* and *performance* [emphases added]" (Commonwealth of Australia, 2009a, p. 2). In this preceding extract, the notion of Innovation working as an order of discourse becomes more apparent. For instance, Innovation is used to describe a particular capacity and style of performance, both of which require "boosting" in order to realise a more secure future. The need to boost, or improve, the nation-state's performance originates from Australia's relative Innovation performance as compared to that of its global competitors. For example, the government expressed concern that "Australia's recent innovation *performance has been uneven*, and we have *failed to keep pace* with the rest of the world [emphases added]" (Commonwealth of Australia, 2009a, p. 3). Further to this, the policy described how Australia's rank in the Word Economic Forum's Global Competitiveness Index had "slipped" (2009a, p. 3) and that "a decade of policy *neglect* has *hurt* Australia's innovation *performance*, making us *less productive and competitive*, and reducing our ability to meet the needs and aspirations of Australian families and communities [emphases added]" (Commonwealth of Australia, 2009a, p. 3). In the above extract, words such as "failed", "slipped", "declined", "neglect" and "hurt", used in relation to Australia's Innovation "performance", all point to a 'fear of falling' (Ehrenreich, 1989) — which underpins the co-location of the discourses of security and risk. The fear of falling is further exemplified in the following extract:

> Innovation activity is increasing rapidly across the globe. *Australia must redouble its innovation efforts or risk falling behind its competitors and seeing its living standards decline*. Precisely because we are an advanced country, we have to work harder to maintain our position [emphases added]"(Commonwealth of Australia, 2009a, p. 21).

Here, the reference to "Australia must ..." followed by "or risk … seeing its living standards decline" simultaneously scales the discourses of risk and security from that of the nation-state to that of the individual, and with that scaling, the implications of failing to mitigate this risk falls back to the livelihoods of individuals. Individuals are positioned as 'at risk' unless, as a nation, Australia increases its efforts toward realising an Innovative way of life for all its citizens. Read in this way, "Innovation activity" is represented as a mode of production which is critical to Australia's economic security and, therefore, by default, an activity that is critical to the livelihoods of individual Australians.

The extracts from the policies analysed herein demonstrate that the policy discourse works to legitimate the need for the nation-state to reframe its response to Innovation across political, social and economic fields. In addition, the policy discourse works to suggest that individuals may need to reconsider their ways of being, acting and interacting in relation to the field of Innovation, in order to mitigate the risk of being excluded from the new order of logic that this field represents. In other words, the assumption that is evident here is that individuals who fail to participate in the Innovation agenda are at risk of being left behind.

It is at this point in the argument, as presented here, that an interrogation of the ways in which individuals are discursively constructed as sites of political action, becomes relevant. Section 6.3 below discusses the work that the discourse categories of opportunity and quality perform in the government's effort to construct individuals as legitimate sites for action in efforts to construct the Innovation Agenda as a set of stable practices, institutions or fields (Fairclough, 2010). In turn, the need for individuals to respond to calls for increased STEM participation is also examined as a site of legitimate action in relation to the STEM crisis.

6.3 The discourse of opportunity

The Federal policy assemblage under study includes numerous references to opportunity. In these instances, the term 'opportunity' is usually used to describe the provision of opportunity by the Federal government. In contrast, the term is also used to refer to the imperative for individuals to take up opportunities presented to them in order to gain security in uncertain times. For example, the policy *A Stronger, Fairer Australia* (Commonwealth of Australia, 2009) states that:

> Social inclusion means building a nation in which all Australians have the *opportunity* and support they need to participate fully in the nation's economic and community life, develop their own potential and be treated with dignity and respect. (p.2)

This policy aspiration sits as a point of tension with the following excerpt from the *Australia in the Asian Century* Issues paper (Commonwealth of Australia, 2011, p. 3) which states: "ensuring access to opportunity for all Australians is also becoming more complex". In neo-liberal times, the role of government becomes one of providing opportunities to enhance 'employability' in an innovation-led economy (Brown, Hesketh, & Williams, 2002). The complexities faced by governments are no longer limited to equalising opportunities within domestic labour markets for education and jobs. The goal is for the government to construct a national education system that allows the nation-state to compete for positionality in a global marketplace in an attempt to attract the greatest share of high-skilled, high-waged jobs for the nation, while at the same time, providing the opportunity for each individual to enhance their own employability (Brown, 2003). In light of the loss of traditional social contracts of security that are accompanied by neoliberal policy ideologies, the provision of 'opportunities' can be regarded as a transformed version of social inclusion, one whereby social inclusion is read as 'inclusion in the market' – the ability to compete for jobs and employment in the 'knowledge economy' (Kenway, Bullen, Fahey, & Robb, 2006).

Inspiring Australia: A national strategy for engagement with the sciences (Department of Innovation Industry Science and Research, 2010), is located at the intersection of the spheres of education and innovation policies (see Figure 6.1). This strategy states that "Australia aspires to an innovative society with a technologically skilled workforce, a scientifically literate community and well informed decision makers" (Commonwealth of Australia, 2010, p. xiii). So, too, it notes that "this Inspiring Australia report ... will help realise the goals articulated in *Powering Ideas: An Innovation Agenda for the 21st Century*" (Department of Innovation Industry Science and Research, 2010, p. xiii). The *Inspiring Australia* strategy, then, serves to operationalise the Innovation agenda. As Habermas (1973) instructs, legitimation requires engineering of the public and, as such, "the political system takes over the tasks of ideology planning" (p. 657). In light of Habermas' (1973) conceptualisation of legitimation, it is argued here that the *Inspiring Australia* strategy lays out a new ideological plan with particular significance for Australia's young people. That is, an ideological position that constructs Science as both an opportunity and as a means of gaining security, as is exemplified by the following quotation:

> Now is the time to motivate and inspire young Australians to get involved with science and science-related issues … Inspiration is simply too important to leave to chance … The aspirational goal is for a scientifically engaged Australia—a society that is inspired by and values scientific endeavour, that attracts increasing national and international interest in its science, that critically engages with key scientific issues and that encourages young people to

pursue scientific studies and careers. (Department of Innovation Industry Science and Research, 2010, p. 1)

In the above excerpt, the discursive category of 'security' is entangled with the notion of 'opportunity', with particular emphasis on Australia's young people. The use of rhetorical devices such as "now is the time" and "too important to leave to chance" impart a sense of urgency and the need for young Australians to engage strategically with the field of Science. This argument is further exemplified in the following excerpt from the 'Recommendations' section of the *Inspiring Australia* strategy. Overall, the strategy made 15 recommendations, two of which are of most significance to this thesis:

> A FOCUS ON YOUTH AND THE FUTURE [capitalisation in original]
>
> It is imperative for Australia to *address identified skills shortages in the sciences* by *encouraging* young Australian scientists to communicate science and young *Australian students to further their studies and take up careers in the sciences*. [emphases added]
>
> Recommendation 11
>
> That a key focus of the national initiative should be raising awareness among young people of *opportunities in science and research* [emphasis added]. The Australian Government's investment in schools, higher education and research should be harnessed to achieve this.
>
> UNLOCKING AUSTRALIA'S FULL POTENTIAL [capitalisation in original]
>
> *To ensure a more equitable Australia*, a special focus is required to *maximise the potential of people who may not previously have had interest in or access to science engagement activities* [emphasis added].
>
> Recommendation 12
>
> That the national initiative support science communication exhibitions and programs that target *under-served groups* [emphasis added], such as those living in outer metropolitan,

regional and remote areas; Indigenous communities; people for whom English is a second language; and people who are disabled or have limited mobility. (Commonwealth of Australia, 2010, p. xix)

Recommendations 11 and 12 interweave notions of security and opportunity. In particular, Recommendation 11 states that it is "imperative" that in order to address the skill shortages in STEM fields, high schools and universities need to promote the "opportunities in science and research" to their students and to encourage students to "take up careers in science". However, while delegating the task of promoting the opportunities in science to schools and universities, the strategy fails to problematise the notion of "opportunities" in "science and research". Instead, *Inspiring Australia* — a strategy aimed at operationalising the Innovation Agenda — simply declares that opportunities to participate in an innovation-led economy by training in a STEM-related field exist, and that more young people need to be encouraged to recognise such opportunities.

As a result of the unproblematised notion of 'opportunity' presented in *Inspiring Australia*, the capacity of 'opportunity', as a category of discourse, to legitimate the Innovation Agenda is weakened. As demonstrated in the extract above, the strategy does not quantify the contemporary labour market demand for graduates of STEM-related fields. Rather, the strategy simply asserts that there *are* opportunities within these fields. Furthermore, this assertion implies that 'opportunities' in the Sciences are ubiquitous, irrespective of geographical locality. Moreover, this discursive construction of 'opportunity as ubiquitous' occurs despite the Commonwealth recognising, in the very next recommendation, that there are groups of people who are "under-served" by the Sciences, including those who live in regional and remote areas and Indigenous communities.

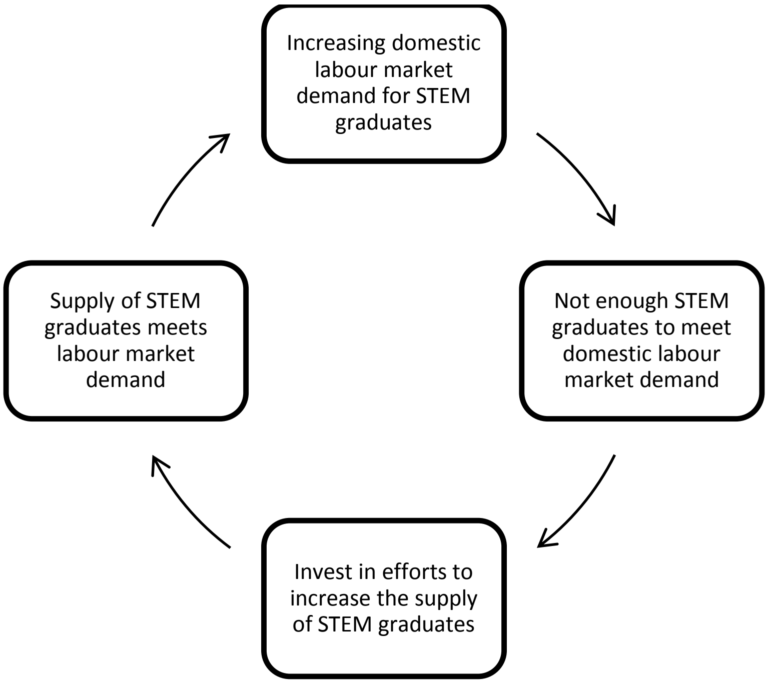
Taken together, it is clear that through their policy assemblage, the Labor Government seeks to encourage young Australians to regard participation in Science and Science-related fields as "opportunities" that will leverage employability and therefore, security, in an innovation-led economy. In this way, the discourses of ‘opportunity’ and ‘security’, are deployed in policy to construct Innovation as an order of discourse, and, thereby, steering subjects and subjectivities in particular ways in relation to the Innovation Agenda. More specifically, the categories of discourse evident in the policy assemblage under study seek to encourage young people to secure their inclusion in the knowledge economy. Be that as it may, it is argued here that the capacities of these discourses to legitimate the Innovation agenda are weakened by two significant tensions that become evident when the STEM crisis is interrogated from a demand perspective. Firstly, there is a lack of clearly articulated labour market demand for Bachelor degree graduates with STEM skills. Secondly, this lack of clearly articulated labour market demand is linked to the unstable representation of STEM-skills in policy discourse through time. It is argued here that each of these tensions mediate the extent to which young people respond to the Innovation agenda as an ideological proposition. An analysis of these tensions will now be presented in detail in Chapter 7.

Chapter 7 Tensions in efforts to legitimate the Innovation Agenda

7.1 Introduction

The dwindling number of students participating in STEM in the post-compulsory years of schooling, leading to further declines in the number of STEM qualified university graduates, is a central tenet of the conceptualisation of crisis in science education (Tytler, 2007). The declining number of students is referred to as a "lack of supply" (see for example Dobson, 2007, 2012; Office of the Chief Scientist, 2012a, b; Tytler, 2007; Tytler et al., 2008). The term "lack of supply" frames an apparent demand for human capital imbued with STEM-skills. The circular argument (illustrated in Figure 7.1 below) that follows from here proceeds as follows: There is labour market demand for STEM qualified graduates in order to leverage the aspirations of the Innovation agenda. However, there are not enough STEM graduates to meet this demand. Therefore, we must invest in efforts to boost the supply of STEM graduates, such that the labour market demand can be met.

Figure 7.1 Representation of the circular argument of supply and demand in the conceptualisation of the STEM crisis



What is clear here is that the argument to increase the supply of STEM graduates is predicated upon an unproblematised notion of 'labour market demand' for 'STEM' graduates. However, the analyses presented in this chapter suggest that failure to problematise the notions of 'demand' and 'STEM' results in two significant tensions for the Australian government in its attempts to legitimate the Innovation agenda as an order of discourse. Firstly, despite consistent calls from a range of stakeholders for improved student participation in STEM studies, (as was discussed in Section 2 of this thesis), and claims that there is increasing employer demand for employees with STEM skills, evidence presented in this chapter demonstrates facts to the contrary; there has been an increase in the proportion of Bachelor degree graduates majoring in each of the fields of Biology, Chemistry, Physics and Mathematics who are seeking full-time employment. As such, it is argued here that the scope and nature of the labour market demand for STEM graduates is, at best, unclear. Secondly, while the terms ‘STEM’ ‘Innovation’ and ‘enabling’ appear with high frequency throughout the Innovation policy assemblage under study herein, the policy discourse practices evident in the same assemblage fail to establish coherent links between the ideational meanings of these three terms. These ‘weak’ discursive practices lead to a hollow conceptualisation of ‘STEM’ which, in turn, makes defining the nature and scope of the labour market demand difficult.

Chapter 7 argues that, taken together, these two tensions strongly contribute to the reduced number of students choosing to study STEM subjects in the post-compulsory years of schooling. Furthermore, these tensions need to be considered alongside the notional issues related to pedagogy and engagement that underpin the attribution of blame for the supply side of the crisis. These two tensions — as apparent via an examination of the Australian Government’s articulation of current labour market demands and an examination of the coherence of ‘STEM’ through the policy trajectory under study here — will now each be presented in turn.

7.2 Failure to explicate current domestic labour market demand for STEM graduates

Tytler’s (2007) *Reimagining Science Education* report used the language of ‘crisis’ to describe the ramifications of the decline in student participation in STEM education in Australia:

> Science education in Australia, as in other post-industrial countries, is in a state of crisis. The language of crisis is used by government, industry and educators alike to describe the diminishing proportion of students in the post-compulsory years who are undertaking science-related studies, particularly in the physical sciences. In itself this might not be such an issue, except that this flight from science is occurring in societies that are in increasing need of science and technology-based professionals to carry the nation into a technologically driven future. It is the pipeline into this pool of expertise that seems in danger of drying up. The concern is thus largely economic, but as this review will point out, the issue is wider than this, and encompasses the need to maintain a citizenry that is literate in and well disposed towards science. The crisis has other dimensions, namely the shortage of skilled science professionals in the workplace in Australia and the shift in momentum of science-based development to developing countries…. (p.1)

In the above excerpt, Tytler states that "there is an increasing need of science and technology–based professionals" and, in a complementary statement, refers to "the shortage of skilled professionals in the workplace in Australia" alongside the loss of "science-based development to developing countries". However, what is not apparent is the extent to which these reported labour market shortages have been quantified. The language used by Tytler implies that there is a current shortage of what is referred to as Human Resources in Science and Technology (HRST) human capital (OECD, 2011) which is impeding the capacity of Australian industry to proceed with Research and Development. Tytler's position is echoed by the Australian Industry Group (AIG) (Australian Industry Group, 2013) which claims: "our relative decline of STEM skills is holding back our economy and causing real frustrations for employers" (p. 1). However, reports published since 2006 have found that while the extent of immediate labour market demand for STEM skills in Australia is unclear, the global demand for STEM skills is on the rise, and in fact the crisis in supply and demand of HRST human capital may be less about absolute supply and more about a mismatch between STEM skills and geographical location (Craig, Thomas, Hou, & Mather, 2011, 2012).

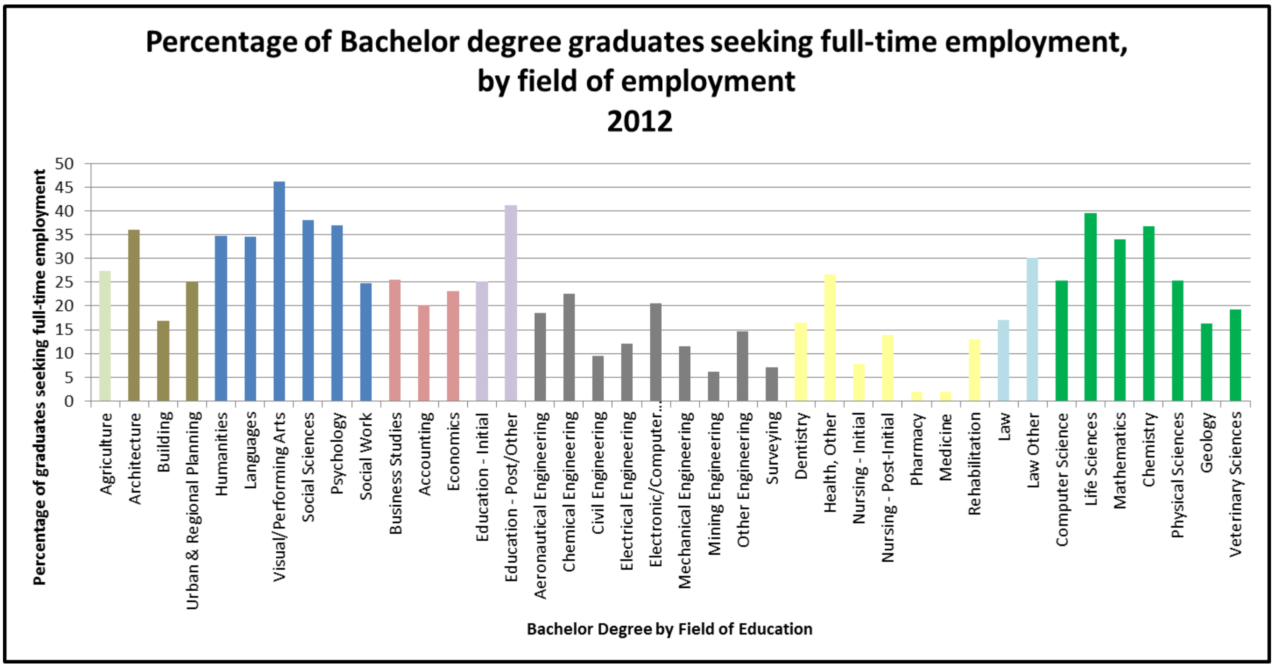
In 2006, the then Department of Education, Science and Training (DEST) conducted an audit of Australia's Science, Technology and Engineering skills to support the aspirations of the Howard Liberal Government's Innovation agenda. In this audit, DEST found that Australia's supply of HRST human capital, relative to total employment (13.5%), was comparable to that of many OECD countries (15% to 20%) (DEST, 2006, p.3). In addition, the DEST report found that "patterns of demand and supply will vary markedly for particular occupations, especially with respect to higher level science qualifications where labour markets are smaller and employers' skill needs are more specialised" (2006, p. 33). The reported projections indicated domestic demand for SET skills over the decade 2003-4 to 2011-12 were likely to be met by graduates from both the domestic education sector and the planned levels of skilled migration and, together, these actions would "largely be able to meet industry and the research community's SET skill needs".
While the DEST report (2006) indicated projected labour market growth was likely in some specific STEM occupations including engineers, mathematicians, statisticians and actuaries, and environmental and agricultural scientists, demand was more closely aligned with the need to replace staff as they retired or emigrated, rather than demand generated from domestic job growth in the STEM sector. Finally, the DEST report noted that factors including globalisation and technological change were likely to be the most significant drivers of demand for HRST human capital, resulting in the demand for "enabling capabilities among SET personnel" and (2006, p. 8) and enhanced "entrepreneurial skills" (2006, p.9). Overall, the findings of the DEST report indicate that, in 2006, there was "marked variation" in projected patterns of supply and demand for HRST human resources. At the time, there were calls in policy to develop HRST human capital with both enabling and entrepreneurial capabilities in order to meet the needs of emerging industries.

The unclear labour market demand, as evidence in the DEST (2006) report, was further discussed by Anlezark, Lim, Semo, Nguyen (2008, p. 5), who found that the "greatest leakage" in the STEM pipeline occurs as students move from commencing post-school STEM study into a STEM occupation; indicating that not all STEM graduates are employed in the STEM field. More specifically, they noted that: “two-thirds of students who undertook post-school STEM study, as well as studying a STEM subject in Year 12, do not go on to work in a STEM career” (p.5). Anlezark et al. (2008) suggest that specific areas of post-school STEM study fail to result in employment in a STEM occupation. Furthermore, Anlezark et al. (2008) report that while there was a decline in the uptake of STEM subjects at school, and in students undertaking post-school STEM study, “the proportion of all students moving into a STEM career is holding steady at about 12%” (p. 29). In fact, the stable proportion of students entering STEM careers suggests that “there may be no shortage of supply of people with the potential to undertake STEM occupations” (p. 5). Conversely, this stability could be “related to a shortage of skilled labour, with employers more prepared to employ individuals in a STEM career with non-STEM qualifications” (p. 17). The findings of Anlezark et al. (2008) as cited above, show that for the young people who did undertake STEM study, there was no guarantee of employment in their chosen field and that employers are willing to employ personnel without STEM qualifications in STEM occupations. These findings indicate that the STEM skills and/or qualifications that *are* ‘in demand’ are not being clearly articulated to students who are faced with making career choices, which may result in a “location mismatch” (Craig et al., 2012), whereby the STEM skills held by individuals are not required domestically, but may be in demand in other locations globally. Failure by government and industry to clearly articulate specific domestic demand may result in more STEM qualified Australians responding to the global auction for labour and thereby withdrawing their talent from the domestic labour market (Brown & Lauder, 2009; Brown & Tannock, 2009).

The argument here, which challenges the notion of strong domestic labour market demand for HRST human capital, is further evidenced by data reported in the Graduate Destinations Survey (Graduate Careers Australia, 2010, 2013). Data related to the proportion of the 2012 Bachelor degree graduates available for full-time employment was extracted from Table 4a of the Survey report (Graduate

Careers Australia, 2013, p. 12) and was represented graphically. The result is illustrated in Figure 7.2 below.

Figure 7.2 The proportion of the 2012 Bachelor degree graduates available for full-time employment.



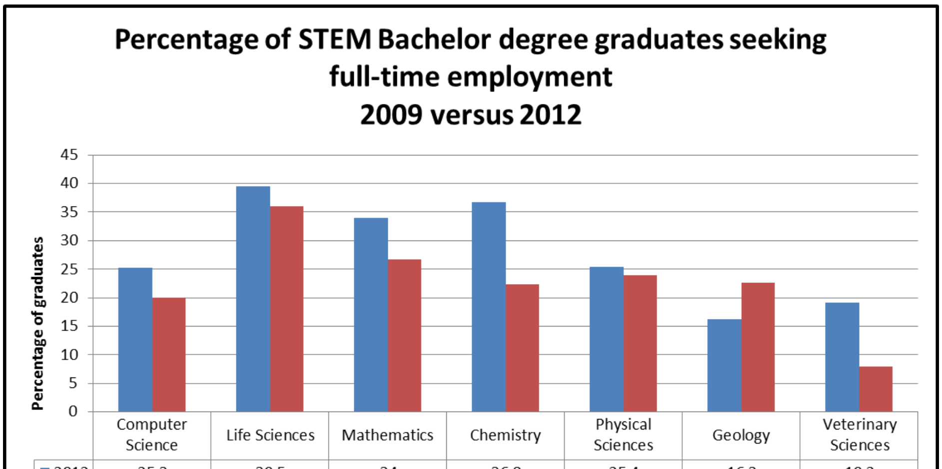
***Note.* Graph generated from data sourced from Graduate Careers Australia, 2013, Table 4a, p. 12**

As is evident in Figure 7.2, graduates from the Humanities and the Natural and Physical Sciences are among the student groups most likely to be seeking full-time employment at the completion of their degree. This trend is elaborated upon in the following extract from the 2012 Graduate Destinations Survey report:

> *Respondents in* visual arts, education – post/other, life sciences, social sciences, psychology, *chemistry,* architecture, humanities, languages and mathematics *were the most likely to have been seeking full-time employment at the time of the AGS (all with more than one-in-three doing so)* [emphases added]. It is worth noting however, that the graduates of some fields of education can always take longer to find full-time employment than those from other fields, and this slower labour market uptake of graduates of such fields reflects more on the state of the labour market and not on the quality of the graduates or their study choices. (Graduate Careers Australia, 2013, p. 14)

Such evidence lends weight to the argument presented here — such that challenges the notion of strong labour market demand for HRST human capital in Australia. Furthermore, this lack of demand appears to be increasing with time. Figure 7.3 was generated to compare the data for the proportion of the 2012 Bachelor degree graduates, from the field of Natural and Physical Sciences, available for full-time employment, to those in 2009. Figure 7.3 clearly shows that the percentage of students seeking full-time employment has increased for all of the Natural and Physical Science fields, except for Geology (which has decreased by 6.4 per cent). In particular, the proportion of graduates from Chemistry degrees seeking full-time employment has increased from 22.3 per cent in 2009 to 36.8 per cent in 2012. Similarly, the proportion of Mathematics graduates seeking full-time work has also increased – from 26.7 per cent in 2009 to 34 per cent in 2012. If these findings are considered from a prospective student's perspective, with regard to deciding whether or not to participate in a course in the Natural and Physical Sciences, it would be reasonable to anticipate that one would be less likely to gain full-time employment in such fields as compared with the fields of Health, Engineering or Economics. The choice to study in the Natural and Physical Sciences, then, may be regarded as risky. These data undermine political efforts to construct Innovation as an order of discourse (as discussed in Chapters 5 and 6 of this thesis) – the discourse of security is once again weakened by evidence weighted towards its binary; risk.

Figure 7.3 The proportion of the 2012 Bachelor degree graduates, from the field of Natural and Physical Sciences, available for full-time employment in 2009 and in 2012



	Computer Science	Life Sciences	Mathematics	Chemistry	Physical Sciences	Geology	Veterinary Sciences
2012	25.3	39.5	34	36.8	25.4	16.3	19.2
2009	20	36	26.7	22.3	23.9	22.7	7.9

In addition to the findings of the GDS (Graduate Careers Australia, 2010, 2013), two reports produced by the Office of the Chief Scientist (OCS), namely *Health of Australian Science* (2012a) and *Maths, Engineering and Science in National Interest* (2012b) also draw conclusions that highlight the lack of clarity around contemporary domestic labour market demand for STEM graduates. Both of these OCS reports focus sharply on elucidating the key factors that 'cause' the STEM crisis. Arguably, these reports apportion much of the blame to the quality of teaching and learning occurring in schools as the prime reason for the STEM crisis. However, neither report attempts to draw out the complexities of the demand for STEM skills. In *Maths, Engineering and Science and National Interest* (Office of the Chief Scientist, 2012b), Professor Chubb argues that for industry to grow, there must be a steady supply of graduates. However, on page 20, the report notes that one barrier to studying science is "career opportunities". Professor Chubb then links this barrier back to the need to improve teaching, teacher qualifications and collaborations between schools, universities and industry. Meanwhile, on page 23, while discussing trends in under-graduate enrolments in STEM courses, Chubb notes that:

> Enrolments in MES as a percentage of all enrolments in university generally fell in the 1990s and were flat between 2002 and 2008. There was a small increase in both 2009 and 2010. …. There are differences between men and women—both in enrolments and in graduations. Doubtless there are multiple reasons for these differences and attempts to change the pattern have been many, though clearly with limited impact. One possible reason, with all its complexity, is employment. Admittedly, this is chicken and eggish — if the women are not graduating they can't be employed, but if employment numbers are low, why would they enrol in the first place? (Office of the Chief Scientist, 2012b, p. 23)

Indeed, this 'chicken and eggish' characteristic may be at the heart of the decline in participation in STEM subjects in the post-compulsory years of schooling for many students, including women and students who live in rural and regional Australia where opportunities for employment in these fields are unclear or, at best, may be highly competitive. It is argued here that failure to explicate the characteristics of the STEM skills that are in demand contributes to the decline in student participation in STEM courses, particularly in the post-compulsory years of schooling, and serves to undermine political efforts to construct Innovation as an order of discourse.

With further consideration of the labour market demand, statements presented in *Health of Australian Science* (OCS, 2012a) note that the ways in which STEM-graduates are trained to think adds valuable skills in the workforce broadly, not just in specific STEM occupations, as is exemplified by the following quotation:

> The decade from 2006 to 2016 will see about 7000 Natural and Physical Sciences professionals retiring while (on current completion rates) about 120 000 Natural and Physical Sciences graduates will enter the workforce. Once in the workforce, many science graduates at the Bachelor's level work in government, education, commerce and industry in roles classified as something other than a Natural and Physical Sciences professional … scientific thinking promotes innovative inquiry which is central to the creation of new and more efficient industries and business models. This is a workforce characteristic that will lead Australia to success in building an innovative economy. (Office of the Chief Scientist, 2012a, p. 10)

So, while it is recognised that many Australian STEM qualified graduates will not work directly in the STEM field for which they trained, their skills are regarded as highly valuable to the overall human capital profile of the nation-state. Furthermore, Professor Chubb alludes to the potential for the *supply* of graduates to move *beyond* replacement — an issue predicted some six years earlier (Department of Education Science and Training, 2006). On this issue of supply and demand, the OCS notes:

> It is impossible to gain an accurate picture of the size and diversity of the science workforce from the current data sources. Inflexible access to some government databases also limits our ability to compile sound evidence for policy development. An overarching challenge for the

> Commonwealth at present is that there are insufficient measures that would allow for confident identification of existing and emerging vulnerabilities. (Office of the Chief Scientist, 2012a, p. 11)

In the above excerpt, the inability of the Federal Government to clearly articulate the specificity of demand for STEM skills is highlighted. Indeed, the complexities of STEM demand are framed as "vulnerabilities", indicating that there is both strategic concern about, and consequences for, failure to account for the STEM skills that are 'in demand'. Similar concerns were raised in much earlier international accounts. In 2004, the European Commission (EC), on reflection of their STEM crisis, identified "the need to better define the skill shortage … and sell the opportunities" (European Commission, 2004, p. 182). Arguably, the European Commission's finding, made almost a decade ago, represents a strategic approach that the Federal Government of Australia should have noted and responded to when the notion of the 'STEM crisis' was first articulated, rather than attributing much of the blame to teacher quality and inferior pedagogical approaches alike.

The above analysis has attempted to challenge the notion of a strong domestic labour market demand for human capital with STEM-skills. Despite both an apparent increase in the number of Australian STEM graduates seeking full-time employment, and insufficient data related to the specifics of the STEM-attributes that are in demand, the Australian Industry Group (AIG) (2013), in their recent report entitled *Lifting our Science, Technology, Engineering and Maths (STEM) Skills*, described the difficulty that large Australian enterprises face in recruiting STEM-qualified employees. According to this report, recruitment was particularly difficult for the manufacturing sector seeking technicians and trade workers with STEM skills. For example, 24.9 per cent of the AIG survey respondents stated that there was a lack of applicants with STEM skills; 24.4 per cent of applicants lacked workplace experience; and 18.3 per cent of applicants possessed qualifications with STEM content that were not relevant to business needs. Despite these findings, the AIG report was not able to articulate, with any specificity, the nature of STEM-skills that *were* in demand. Instead, the AIG cited recommendations made by the OCS and concurred that there is a need to increase the number of students participating in STEM study at school along with a focus on programs to improve teacher quality and pedagogy which, the AIG suggests, should include the introduction of semester-long work placements for STEM undergraduates and the development of a national framework to promote and implement school-industry STEM-skill initiatives. It is argued here that despite calls from Industry for an increase in STEM graduates, what they are actually seeking is the development of a human capital profile imbued with STEM-skills that can be used to leverage economic transitions in traditional manufacturing. In other words, the AIG is seeking to leverage the development of human capital with specific *qualities,* rather than an increase in the *quantity* of STEM-graduates.

Given this proposition, it is advocated that attempts to address the STEM crisis requires a shift in emphasis —moving from a focus on quantity of STEM graduates to carefully considering the quality or qualities of STEM graduates. In their recently released report *STEM: Country Comparisons: International comparisons of science, technology, engineering and mathematics (STEM) education*, the authors, Marginson, Tytler, Freeman and Roberts (2013) explicate their interpretation of such a shift in emphasis with regards to the nature of the STEM crisis:

> STEM is a central preoccupation of policy makers across the world. In many countries discussion about STEM is advanced in terms of claims about shortages of high skill labour. However, the consultants' reports make it clear that nowhere are there conditions of general shortage. Though in many countries there are episodic shortages in particular fields, such as engineering and computing in Australia, in reality the STEM economic policy agenda is largely driven by the need to lift the general *quality* [emphasis added] of the supply of human capital as well as enlarge the high-skill group capable in research, commercialisable innovation and effective response to technological change … The STEM disciplines are seen as essential for work and citizenship, while providing the cut through in global economic competition and social creativity. (p. 13)

Furthermore, Marginson, Tytler, Freeman & Roberts also note: "there is a lack of clear data in Australia concerning destinations of STEM graduates and the role of STEM training in a variety of professions. There is also lack of data on qualifications of teachers of STEM" (2013, p. 24). These findings support the argument made herein that there is both a poor understanding of the domestic labour market demand for STEM-skills and a lack of clarity surrounding the role that STEM-education plays in graduates gaining a STEM-occupation. Taken from a student's perspective, choosing to participate in STEM study could be considered risky — and this conclusion contradicts the rhetoric of security espoused in the Innovation policy assemblage presented in Chapter 6 of this thesis. Consequently, the government's inability to legitimate a strong labour market demand for STEM-skills undermines any policy efforts to construct Innovation as an order of discourse. Moreover, the lack of clear evidence for strong labour market demand is a weakness in the government's legitimation efforts and is, in itself, contributing to the STEM crisis. As such, a critical explication of 'demand' must be included alongside other measures in any future policy attempts to address the 'STEM crisis'.

Having challenged the hollow notion of domestic labour market demand for STEM-skills and the attenuating impact of the this weak version of 'demand' on political efforts to construct Innovation as an order of discourse, Section 7.2 will now draw attention to the link between the failed articulation of labour market demand and the weak policy discourse practices that fail to cohere the ideational meaning of STEM. In particular, Section 7.2 argues that governmental efforts to legitimate Innovation as an order of discourse are undermined as a corollary of these weak discursive practices.

7.3 STEM as a pre-fix

As outlined in Chapter 5 of this thesis, the ministerial responsibilities and structural alignments for Science, Education and Innovation in the Australian Federal political landscape have shifted over the last two decades. While Science has been, and continues to be, a named portfolio responsibility in Australian Federal policy, only rarely has either 'Science' as a field or any specific scientific discipline name rarely appeared in its isolated form in the literature or in policy discourse. Instead, the notion of 'Science' is, and has been, variously represented in both Australian and International policy over the last decade. In many recent publications, 'Science' — read here as a discipline of knowledge traditionally containing the sub-disciplines of Chemistry, Physics, and Biology — has come to be represented by the acronym 'STEM', which itself represents a complex matrix of ideas. STEM stands for Science, Technology, Engineering and Mathematics. These four fields are also complex, multi-dimensional fields, and yet they are discursively deployed in both policy and in the literature without problematisation. Moreover, 'STEM' has not always been a readily identifiable discursive category. Rather, the fields that constitute 'STEM' have shifted through time, as well as changing with the stakeholder deploying the acronym.

Throughout the literature, including policy documents, 'STEM' or one of its reconstituted ideological synonyms (for example, SET or STM) is frequently deployed as a prefix to mark out distinctive elements of a given discursive category. In doing so, what was previously a generic concept, then becomes specific to 'STEM'. For example, Anlezark et al (2008) in attempting to understand barriers to STEM-participation in the post-compulsory years of schooling, presented a range of definitions that were essential to describing the pathways taken by Australia's STEM students. These definitions include: STEM post-school qualifications, STEM school subjects, STEM university courses and STEM occupations. Similarly, in a report authored by the Office of the Chief Scientist (2012b), a range of STEM concepts are represented, for example, STEM-fields and the STEM-workforce (p. 6) as well as STEM graduates, STEM teachers, STEM-capable students, STEM competencies, STEM-related fields (p. 13) and STEM curricula (p. 20). Likewise, in the *Inspiring Australia* strategy (Department of Innovation Industry Science and Research, 2010), STEM education and STEM awareness programs are also constructed as categories of sites of action relevant to STEM. Craig, Thomas, Hou & Mather (2012) and the Australian Industry Group (2013) also discuss the importance of STEM-skills. In each of these examples taken from a range of contemporary sources, the STEM prefix has been coupled with terms that point to the role(s) individuals play as social agents in relation to institutions, for example, teachers, students, and graduates. In addition, the STEM-prefix has been coupled with a range of practices enacted by these social agents on behalf of institutions — for example, university courses, school subjects, curricula and awareness programs. In this way, social agents, their representative institutions and a range of institutional practices are constructed as sites of action in relation to addressing the STEM-crisis. Along with social agents, institutions and institutional practices, the STEM prefix is coupled with an array of attributes that individuals, as social agents, would come to embody and to represent as part of their subjective identities. These attributes include “qualifications”, “competencies” and, in particular, “skills”. And, it is the case that these attributes or terms, emerge from the discourse of human capital theory.

Much of the contemporary literature underpinned by Human Capital Theory stems from the landmark work of economists including Mincer (1962), Schultz (1963), Becker (1975). While the field of human capital theory was not officially established until 1960 (Sweetland, 1996), human capital theory emerged as a dominant ideology in Australian education policy in the late 1950s during a time of economic transition underpinned by political shifts away from Post World War II optimism to cold war era anxieties (Schwab, 1996). Furthermore, human capital theory underpinned debate related to market-based reforms of the higher education sector during the Dawkins era. At its core, human capital theory suggests that “individuals and society derive economic benefits from investment in people” (Sweetland, 1996, p. 341). Education was, and is, considered to be a primary site of investment. Arguably, the most significant benefits of investment in education are best measured qualitatively. For example, making a quantitative measurement of the benefits of producing “an enlightened citizenry able to participate in democratic and legal due processes” (Sweetland, 1996, p. 341) would be quite challenging. Given this, new ways to quantify the benefits of education were sought. Economic growth emerged as one such quantitative measure and, thus, the development of human capital theory progressed primarily through the work of economists. Overall, an empirical goal of human capital theory is to provide a framework within which the costs and benefits of education, to both individuals and society, can be evaluated. Benson (1978, as cited in Sweetland, 1996) is attributed with stating two basic assumptions on which human capital theory rest. One of these assumptions is particularly relevant to the analysis herein, that is: “Education helps develop *skills* of work, that is improves the *capacity* of the worker to be productive [emphases added]” (p. 354). In this excerpt, “skills” are presented as subordinate to “capacity”. The term capacity, by definition, implies being able to contain or receive something; or being susceptible to a particular treatment. In this way, then, the development of STEM-skills relies on workers who utilise ‘STEM’ to become more productive workers.

Intellectual capital is a concept that encompasses human capital, and it is reported to be significant in measuring the extent of the “capacity” within a given human capital profile. According to Alcaniz, Gomez-Bezares and Roslender (2011), intellectual capital is a conceptual development to human capital theory and while “there is no globally accepted definition or taxonomy of intellectual capital” (2011, p. 110), “the intellectual capital of a nation includes the hidden values of individuals, enterprises, institutions, communities and regions that are current and potential sources for wealth creation. That is, to create wealth it is necessary that people possess intellectual capital” (2011, p.106). Alcaniz et al (2011) also recognise that intellectual capital can be divided into human capital and structural capital, with human capital encompassing “the knowledge, *skills*, *abilities etc*. [emphasis added] of the employees” (p. 109). Here, the term “skills” appears again, indicating the notion of a human capital profile containing or receiving particular treatments to which it has been exposed. Additionally, the term “abilities” appears. Ability, by definition, is more aligned with the notion of ‘capability’; a characteristic that can be developed, or a potential aptitude. Here, work by Sen (1997) becomes relevant, as he highlights the need to distinguish between “human capital” and “human capabilities”:

> Human capital … concentrates on the agency of human beings - through skill and knowledge as well as effort - in augmenting production possibilities…. Human capability … focuses on the ability of human beings to lead lives they have reason to value and to enhance the substantive choices they have. The two perspectives cannot but be related since both are concerned with the role of human beings, and in particular with the actual abilities that they achieve and acquire. (p. 1959)

Similarly, from the field of human capital theory, it is stated that "education increases or improves the economic *capabilities* [emphasis added] of people" (Sweetland, 1996, p. 341), however, these capabilities are more difficult to account for empirically, and perhaps this explains why reference to "STEM-capabilities" are less frequently cited in the literature. For example, in only one instance did the Office of the Chief Scientist describe "STEM-capable students" (OCS, 2012b, p. 13). It is argued here that the deployment of STEM as prefix in relation to terms that originate from the discourse of human capital theory is skewed; emphasis is placed on the development of "skills" as a subordinate of a capacity — as a feature of an industrial requirement — rather than on the development of "capabilities", conceptualised as aptitudes that can be developed and valued by human beings leading their lives. Furthermore, slippages in the deployment of key terms that have emerged from the discourse of human capital theory work to undermine the clarity with which sites of action are defined.

Despite these weak discursive practices, the co-location of 'STEM' with terminology that has emerged from the discourse of human capital theory is indicative of a hybridisation of discourses (Fairclough, 2010) which serves to establish shifts in the boundaries between what were previously separate fields. The hybridisation of discourses, then, allows for the construction of a series of categories that can then be conflated as sites of action in efforts to address the 'STEM crisis'. These sites of action are used in policy discourse to narrate, and subsequently justify, the actions deemed necessary to achieve the aspiration of an Innovation-led economy. The emergence of these discursive practices allows the Federal government to inculcate “changed ways of being” and “changed practices” (Fairclough, 2010, p. 20), thereby establishing the conditions needed to operationalise a discourse of the Innovation agenda. Once operationalised, governments are enabled to justify actions taken in relation to the specified social agents, institutions and systems in order to shape a particular type of human capital, that is, STEM-ready human capital. Discursive hybridisation, then, establishes the conditions required to deploy the term ‘STEM-skills’ and to then narrate the role of ‘STEM-skills’ in relation to the Innovation agenda. However, it is argued here that the government’s capacity to legitimate the relationship between ‘STEM-skills’ and the Innovation agenda is undermined by weak discursive practices that fail to cohere the ideational meanings of both ‘STEM’ and ‘skills’. Section 7.3 presents an analysis of these weak discursive practices and the implications of such with regards to legitimating Innovation as an order of discourse.

7.3.1 What is ‘STEM’ in relation to the Innovation agenda?

The notion of ‘STEM-skills’ has been, and continues to be, an ill-defined concept. While over the last decade there have been numerous and persistent calls in the literature to increase the supply of human capital with ‘STEM-skills’, locating a clearly articulated description of the precise nature of the STEM in STEM-skills that is to be developed is more difficult. For example, the *Backing Australia’s Ability* (BAA) policy (2001) sought to “foster *scientific, mathematical and technological (SMT) skills* [emphasis added] and innovation” (p. 5) and to produce “enhanced science and technology literacy” (p.20). These aspirations were no further defined in the policy, instead the categories of “skills” and “literacy” serve as sites of action in the development of human capital to feed the Innovation agenda. Furthermore, *BAA* sought “to develop the community’s understanding of, and support for, *innovation* [emphasis added] to bring it in line with our competitor countries” (p. 23). Here, the emphasis is on the field of “innovation” and “competition” rather than STEM skills or literacy. Two themes emerge from these *BAA* quotations. Firstly, STEM, as a category, was not conceptualised. Instead, the policy referred to “SMT skills and innovation” — with Scientific (S), Mathematical (M) and Technological (T) deployed in their adjectival forms; indicating that the aim of the policy is for people to develop a specific set of skills. Secondly, emphasis is placed on developing an appreciation of Innovation; its connection to the fields of science, mathematics and engineering, and the role of Innovation in strengthening future economic productivity. However, while these strategies are co-located in the policy statement, developing an appreciation for innovation, particularly as an economic driver, is quite a different proposition to developing scientific literacy — particularly given that the policy fails to define the version of scientific literacy it is aiming to enhance. In the above example, the 'STEM' skills that are to be developed and their alignment with "innovation" are presented as little more than vagaries.

Further legitimation of *Backing Australia's Ability* was offered in reports compiled by the Department of Education Science and Training (2003). These reports tie the scientific literacy of all Australians to the security of the nation and to the work of science teachers, as is exemplified by the following quote:

> For Australia to achieve its full potential as a highly successful knowledge-based economy and society, it will be necessary to raise the scientific literacy of Australians, to strengthen the foundations for world class scientists and innovators to emerge, and to support the development of a new generation of excellent teachers of science, technology and mathematics. Especially valuable will be the role played by high calibre teachers of science, technology and mathematics in developing the sound knowledge bases, competencies and capacities for creative and innovative thinking needed to secure our future well-being as individuals and as a nation. (Department of Education Science and Training, 2003, p. ix)

In the above excerpt, the components of 'STEM' are reduced to Science, Technology and Mathematics. Aspects of the demand for increased participation in 'STEM' also begin to gain clarity; sound knowledge bases in STM and well-developed creative and innovative thinking are explicitly stated as "valuable" and "needed". Teachers, and specifically STM teachers, are positioned as central in developing these attributes of Australians. The nexus between science, science education and innovation is further established in the following excerpt:

> Australia, like many nations seeking to position its citizens to participate in the emerging global economy, is increasingly having to base its future on the emerging new *science and industry fields* [emphasis added] such as bioinformatics, biotechnology, genomics, laser science, nanotechnology, micro-electronics—which derive from the *enabling sciences of physics, chemistry and mathematics* [emphasis added]. The way this happens will in turn depend on the way in which research, development and innovation are supported. (DEST, 2003, p. 1)

Here, the category of 'enabling sciences' appears for the first time. In addition, the notion of 'enabling sciences' begins to place conceptual boundaries around what the 'S' in the 'STM' complex might represent. However, the notion of an enabling science is not clearly defined, and it calls into question what is, in fact, being enabled by these sciences.

Following on from the 2003 report, and still against the backdrop of the *Backing Australia's Ability, Our Universities – Backing Australia's* initiative, DEST commissioned a SET skills audit (Department of Education Science and Training, 2006, p. ix) aimed at supporting the development of Science, Engineering and Technology (SET) skills and abilities in Australia's population. In the audit report, SET skills were regarded as integral to the development of an "innovative and globally competitive workforce" (Department of Education Science and Training, 2006). Such a workforce was seen as "vital" to the growth of industry and economic productivity (Department of Education Science and Training, 2006, p. ix). In this 2006 audit report, it is clear that the concept of 'STEM' has once again shifted; the category of Mathematics is absent and, in its place, Engineering appears as a new field in demand. This re-constitution of STEM, as SET, suggests a move on the part of the government to define the 'STEM-skills' to be embodied by a HRST-ready workforce. In this re-constitution, the skills 'in demand' are, by default, articulated.

In the same audit (DEST, 2006), some definitional limitations of the 'T for technology' component of the acronym were also provided. For example, neither ICT skills nor health skills were examined as part of the Technology category. Instead "trends in the demand and supply" (DEST, 2006, p. iii) of technology skills relevant to emerging Australian industries were examined and, as such, the T-for-Technology category was constituted by new science and technology fields — as first identified in *Interim Report: Attracting and Retaining Teachers of Science, Technology and Mathematics* (Department of Education Science and Training, 2003) — including biotechnology, bioinformatics, and laser technology. In addition to providing some limitations to the definition of technology that constitutes the T in 'STEM', DEST also offered some elaboration on generic skills that were desirable attributes of HRST-ready human-capital, including "enabling capabilities" (2006, p. 8). Here, the quality of "enabling capabilities" emerges as a critical attribute of HRST-ready human-capital, however, no further elaboration of what constitutes an enabling capability is offered, nor is the precise nature of what is enabled discussed. What is implied is that the development of human capital in possession of "enabling SET skills" will facilitate growth in industry, research and productivity for the nation. In other words, 'enabling SET skills' are held to underpin the transition to an innovation-led economy. Despite the transitory use of STEM/SET, and the lack of clarity about how the STEM category (and its synonyms) articulate with the notion of Innovation, this nexus between broadly stated 'STEM/SET' skills, education and economic transformation continued to be deployed in the effort to legitimate the Innovation agenda. These legitimation efforts were assisted by continual steerage from the OECD (OECD, 2000a, b, 2004a, 2011) and continued in the same vein after the demise of the Howard government.

In 2009, the Rudd/Gillard government's Innovation agenda, *Powering Ideas* (Commonwealth of Australia, 2009a), was launched with the goal to "make innovation a way of life for all Australians" (Commonwealth of Australia, 2009, p. 1). Rather than describing the need for the development of broad SET/STM/STEM skills, Chapter Four of *Powering Ideas* presented strategies to develop "Research Skills" and "Innovation Skills", both of which were regarded as essential to the progression of the Innovation agenda. In *Powering Ideas*, realising the goal of an 'innovation-led economy' is, once again, linked to the development of human capital with particular (and yet broadly defined) skills:

> Innovation takes many forms, but it still relies heavily on formal research and development. This is obviously true of technological innovation, but it is also true of innovation in other spheres — whether it be in social policy, business management, or the creative arts. *Australia's capacity for paradigm-shifting, new-to-the-world innovation still depends very much on how many researchers we have, how good they are* [emphasis added], what research equipment and facilities they have access to, and how well connected they are to industry and the wider world. *It also depends on the availability of innovation skills more broadly defined in the general workforce* [emphasis added], and on the quality of management (Commonwealth of Australia, 2009a, p. 31).

In the above extract, both the number and the quality of researchers are held as central to the achievement of "paradigm-shifting" innovation. What becomes clear here, is that the role of human capital in the realisation of the "new-economy" project, as described by the Commonwealth of Australia (2009), continued to be steered and shaped by frameworks and reports authored by the OECD. Moreover, as the OECD definition and measurement of Innovation shifted through time, so, too, the STEM skill set 'in-demand' shifted. For example, in the excerpt presented above (Commonwealth of Australia, 2009a, p. 31), emphasis was placed on "innovation skills", representing a move away from the discipline-bound categories of STEM toward skills that, by definition, cohere with entrepreneurialism. In this way, the instability between the notions of STEM/SET/enabling sciences/ and Innovation, and the associated weak discursive practices, begins to emerge.

In 2012, DIISRTE released a report entitled *Enabling technology futures*: *a survey of the Australian technology landscape* (Department of Industry Innovation Science Research and Tertiary Education, 2012). In this report, a new category, “enabling technologies”, emerges in the official discourse. The report defines the category of enabling technologies, such that the fields of nanotechnology, biotechnology and synthetic biology are central to the category. These new fields of innovation are heralded as ways forward for Australia in an innovation-led economy:

> Australia possesses world-class enabling technology strengths—including world leading research organisations—with the prospect to lead future developments and market applications. For Australia to remain globally competitive against advanced and emerging economies in research, *scientific know-how* and *product innovation,* it will need to capitalise on its existing comparative advantages in these domains. The development of new enabling technology applications, their translation into valuable outcomes for business and society, and their subsequent adoption will require close collaboration between government, industry and the broader community. In this respect, it must be noted that underlying skills in *enabling sciences* such as physics, chemistry and mathematics *are vital for the development of enabling technologies and their applications* [emphases added]. (Department of Industry Innovation Science Research and Tertiary Education, 2012, p. 2)

In this excerpt, there is the notable return to the category of ‘enabling sciences’ which was first categorised by DEST in 2003. However, in the 2012 publication, ‘enabling sciences’ is explicitly linked to enabling technologies and the need to “capitalise” on existing strengths in this field in order to remain globally competitive in an innovation-led economy. Furthermore, the intersection of ‘skills’, ‘enabling sciences’, and ‘innovation’ as discursive categories, working to legitimate the Innovation agenda, becomes apparent. That is, the notion of ‘enabling technologies’ is reliant upon the development of human capital with enabling capacities (DEST, 2006) and “scientific know-how” (DIISRTE, 2012, p.2) which is grounded in the ‘enabling sciences’ of Physics, Chemistry and Mathematics (DEST, 2003, DIISTRE, 2012). In combination, these three discursive elements (enabling technologies, enabling capacities and enabling sciences) – which, herein, are categorised as ‘enabling elements’ – constitute sites of legitimated action for the Federal government, such that the policy goals of the Innovation agenda, as articulated in *Powering Ideas* (2009), can be enacted.

In addition, *Enabling technology futures*: *a survey of the Australian technology landscape* (DIISRTE, 2012) explicates the lack of clarity surrounding the scale of the demand for these ‘enabling elements’, as is exemplified in the following excerpt:

> The effects of globalisation play an important role in the formulation of policies to support industry sectors such as those discussed in this report. Globalisation means that Australian policy strategies cannot be developed in isolation of the global economy. *Insights* [emphasis added] into where Australia fits into the overall enabling technologies value chain *must be gained* [emphasis added] to better understand where Australian industry can leverage its expertise to maximise value for the nation. In this respect, the creation of high-tech labour forces *may* [emphasis added] be advantageous to Australia’s position in the global economy. (Department of Industry Innovation Science Research and Tertiary Education, 2012, p. 8)

Here, globalisation, underpinned by a post-Fordist mode of production, is named as a driving force in Australia’s innovation agenda. However, DIISRTE also call for greater clarity around the elements of an innovation-led economy in which Australian industry “can leverage its expertise”. There is an apparent uncertainty about the extent to which enabling capacities can facilitate a transition to an innovation-led economy— as is evidenced in the statement that “high-tech labour forces *may* be advantageous” to Australia’s position under competitive global market conditions. Given this lack of certainty, it could be argued that the drive, in the current policy moment, to increase the number of students studying an enabling science in both the post-compulsory years of schooling and in higher education is underpinned by governmental aspirations informed by globalised policy discourse steered by the OECD. In other words, the call for an increased supply for human capital that possesses ‘enabling capacities’ grounded in the ‘enabling sciences’ persists despite a lack of clarity surrounding the extent of the contemporary labour market demand for these capacities. In the policy excerpts presented previously — from 2001 to 2012 — the role of enabling sciences in the STEM crisis is framed: participation in the enabling sciences, which includes Chemistry, is seen to position Australian citizens so as to facilitate their participation in a global knowledge economy. The enabling sciences underpin the development of a high-tech labour force, imbued with enabling capacities, thereby enabling Australians to participate in a partially realised innovation-led economy in which enabling technologies lead the transition to a post-Fordist mode of production.

There is also a challenge in creating human capital that meets the demands of the innovation agenda. These challenges include the global division of labour. The Innovation agenda requires human capital that can operate in two HRST categories: professional and technical. The professional HRST category is set to produce the innovators of the future – a new class of social elite; while the technical HRST categories are positioned to become the new version of the working class – based on new-Taylorism – reduced to high skill, low wage work (Brown & Lauder, 2009; Brown & Tannock, 2009). The discourse of 'skills' dominates the construction of the technical HRST category. Meanwhile, the professionals need to demonstrate specialist, discipline based expertise along with attributes that enable collaboration with entrepreneurs such that there is an ascendency in the commodity value of non-tangible knowledge assets such as intellectual property and patent applications.

It is argued here that the various, and sometimes ill-defined, notions of 'STEM' as evident in the examples from policy and government reports presented above have contributed to the 'crisis' itself. As these variously defined notions of STEM have been steered and shifted by globalised(/ing) imperatives, they have come to be co-located with categories such as innovation, skills and enabling sciences, all of which play a role in constituting the Innovation agenda. While STEM has been deployed as a powerful prefix to legitimate action to address the 'STEM crisis' across spheres of intersecting Federal policy, the range of broadly stated definitions active in policy discourse since 2001 have made it difficult to articulate, and indeed, then, to measure, the extent of Australia's demand for the STEM attributes in its citizens. Furthermore, it is clear that there is a range of STEM skills that are relevant to employers and government in terms of the realisation of the Innovation agenda. Of interest in this thesis is the way in which STEM education, and in particular education in the enabling sciences such as Chemistry, acts as a mechanism by which some students gain access to the Innovation agenda; and moreover, the role Chemistry plays in mediating pathways to professional versus technical occupations in the Innovation agenda.

Section 3 Conclusions

Critiquing the crisis: Quality rather than Quantity

There is a lack of clarity around domestic labour market demand for graduates with STEM-skills. Similarly, a series of weak discursive practices evident in the literature fail to cohere the ideational meaning of either 'STEM' or 'skills'. Consequently, calls to increase the number of students participating in STEM study, particularly in the post-compulsory years of schooling are undermined by this lack of clarity. Instead, analysis from a demand-centred perspective has revealed that it may be more accurate to regard the crisis as, primarily, a crisis of 'demand'. More specifically, from the perspective of industry, the STEM crisis is a crisis borne of 'demand for specific qualities', which is exacerbated by a global mismatch of STEM-skills. Compounding this mismatch is the inability of consecutive Federal Governments to clearly articulate the specific relationships between enabling sciences and the realisation of an innovation-led economy. As stated by Habermas (1973, p. 660), "legitimation difficulties lead to a legitimation crisis as a result of a motivation crisis". In this case, difficulties in legitimating the STEM crisis arise from a discrepancy between the motives of both the state and industry and of the motives of students in response to the globalised/ing labour markets. Efforts to increase the quantity of STEM graduates being produced by the supply-side of Australia's science system are undermined by a lack of clarity in the domestic labour market regarding both the quality and qualities of STEM graduates that are in demand. This lack of clarity works to undermine both the discourses of security and opportunity that have been operationalised in Federal Policy discourse.

Marking out some graduates, and not other graduates, with the right 'qualities' requires criteria for distinction (Bourdieu, 1984). In particular, considering which definition of quality or qualities — authored by which social actor — should be privileged is important to reconceptualising the crisis in terms of quality rather than quantity. Furthermore, it is important to consider how, and by whom, a sense of 'quality' might be attributed to individual students and finally, whether or not these attributed qualities would ensure access to the Innovation agenda. Based on the analyses presented in Chapters 5, 6 and 7 of this thesis, it is argued here that credentials in an 'enabling science' such as Chemistry underscore the profile of professional HRST human capital. Credentials in the enabling sciences are conflated as developing a "scientific know-how" (Department of Industry Innovation Science Research and Tertiary Education, 2012, p. 2) which marks out an individual as one of the elite — one of the professional innovators, as opposed to a technical innovator.

Tensions arise between providing the 'opportunity' to acquire STEM skills as a means of guaranteeing 'security' for all while also needing to ensure the development of the distinctive qualities of at least some, that is, 'the professional innovators' – those individuals, and/or institutions that seek demarcation on the basis of distinction, on both a domestic and global scale. This move to use enabling sciences to mark out sites or practices of distinction is a complexity that arises from conceptualising the crisis as one of quality. This complexity, it is noted here, sits at odds with the current widening participation goal of the Australian Federal Government.

Quality as a barrier to navigating access to the Innovation Agenda

The Australian Higher Education widening participation agenda, driven by the Federal Government's commitment to respond to the Bradley targets (Bradley et al., 2008; Department of Education Employment and Workplace Relations, 2009), aims to increase the participation of non-traditional students and students from low socio-economic backgrounds in study at university. The widening participation agenda is positioned in the policy assemblage under study here as vital to providing more students, particularly those traditionally under-represented in higher education, with the 'opportunity' to develop highly employable attributes (including STEM skills) in an innovation-led economy. However, as is noted by the Australian Industry Group (2013), the opportunity to develop STEM-skills is achieved by participation in STEM subjects at school and at university. For students, the completion of particular pre-requisite subjects, such as Chemistry, is central to participation in STEM courses in many higher education settings. So, a nexus exists between an agenda to increase participation of low SES students in university; students' participation in Chemistry in their post-compulsory years of schooling; and access to many STEM courses in higher education. These intersections are exemplified and problematised in the following quote:

> A further critical juncture for students is at the transition from compulsory to post-compulsory schooling, particularly when making choices for Year 11 and 12 subjects preceding tertiary studies or entering the workforce. The Non-Ministerial members of the Victorian Council for Knowledge, Innovation, Science and Engineering argued that student enrolments still include a core group who are *passionate* about science but there are many *there just to meet pre-requisite requirements*, keep options open or improve tertiary entry scores [emphases added]. (DEST, 2003, p. 5)

Here, the idea that students who are at a junction in their educational career — moving from compulsory to post-compulsory years of schooling, and planning their pathway beyond school — would choose to study a science subject in order to meet the pre-requisite requirements for university entry is positioned as a deficit decision. The language used in the extract implies that such choices are shallow, "*just* there to meet pre-requisite requirements", as opposed to the students who are "passionate" about science. From this depiction, it is possible to make an account of representations of the categories of students considering whether or not to study science in their post-compulsory years of schooling. Some students are constructed as 'strategists' – students who understand the strategic value of a subject to attaining access to their preferred university course. Other students are constructed as 'junior scientists' – those students who are perceived by government representatives to be passionate about the study of science. Here, passion is positioned as a valuable quality of students seeking to study in STEM subjects in the post-compulsory years of schooling. Passion is treated as though it is synonymous with quality and, likewise, quality is synonymous with capacity, in the human capital theory sense of the term. However, this representative binary fails to account for a third category – 'the aspirationals' – students who have expressed an interest in studying science in their post-compulsory years of schooling, but who have been perceived by government officials to lack the *qualities* to participate in the study of STEM subjects. The choices of these aspirational students are mediated by official systems and structures, often resulting in their exclusion from the 'opportunity' to study in the enabling sciences in their post-compulsory years of schooling. It is argued here that this systemic removal of 'opportunity' denies students the possibility accessing a stream of professional innovator occupations in the Innovation agenda. Tensions, then, arise as students attempt to navigate the importance of STEM-skills to the globalised policy discourses of 'opportunity' and 'security' as they are deployed in the Innovation agenda. These attempts are mediated by teachers, working as social actors in secondary schools, and by institutions that, if implementing the agenda of the Federal Policy assemblage under study here, are working to address the STEM crisis by increasing the quantity of participants from low socio-economic backgrounds. In contradiction to this work, teachers also identify "the strategists", "the junior scientists' and the "aspirationals" and determine which students embody the right qualities to participate in the study of STEM subjects. As such, the ways in which Chemistry, as a secondary school subject, is used to mark out sites of distinction is explored in Chapter 8. In addition, the ways in which Year 10 students, and their teachers, navigate the process of 'choosing' Chemistry is the focus of Chapter 9 of this thesis. Both of these chapters are presented in the next section of the thesis – Section 4 – which attends to both the policy articulation and policy reception phases of the research methodology.

Section 4: Navigating access to the Innovation agenda

The final section of this thesis, Section 4, contains three chapters. Chapter 8 attends to the policy articulation phase of the research and examines the role of Chemistry – as an enabling science – in relation to university entrance, and the production of skills and capacities that are considered valuable in the Innovation agenda. Chapter 9 attends to the policy reception phase of the research and includes data from document analyses as well as interview data from students and teachers from three secondary schools, categorised as low socio-economic status schools based on their ICSEA ranking, in remote, rural and urban settings in North Queensland. As such, two of the three overarching research questions are addressed in this part of the thesis: *How is Chemistry positioned in the field of Education?* and *How do secondary school students navigate the process of 'choosing' Chemistry?* The analyses in both Chapters 8 and 9 are drawn from examples from the State of Queensland. In both cases, students, teachers, schools and universities bound by the jurisdiction of State authored policy are positioned to respond to the Federal policy imperatives made evident in Section 3 of this thesis. As such, considering policy as practice (Blackmore, 2010), the cases presented make evident some practices of policy articulation and policy reception in this particular context. Finally, Chapter 10 summarises the key findings of the research, addresses each of the three overarching research questions, discusses the limitations of the research and offers some suggestions for future research arising from this study.

Chapter 8 Chemistry in Queensland: A case study

8.1 Introduction

Chemistry, as a secondary school subject, is frequently named as a pre-requisite for entry into many university courses. As will be demonstrated in the analysis that follows, ‘Chemistry’ is a term that requires definition and, as such, the term Chemistry used throughout Section 4 of this thesis, refers to the Queensland Studies Authority (2007) Chemistry syllabus. As is noted by Denscombe (2007), theory building can be achieved through the use of an illustrative case-study. This chapter, Chapter 8, seeks to make evident the process of policy articulation by examining the case of Chemistry and its articulation with tertiary entrance procedures in Queensland universities. In particular, this Chapter seeks to draw attention to “the contradiction between widening participation and the consolidation of social positions” (Clegg, 2011, p. 93) evident in the Higher Education system in the State of Queensland.

Chemistry, as a form of academic capital, plays a significant role in the STEM crisis and to the re-fashioned equity agenda, as framed by current Higher Education policy. Transitions between school and university can be made more complex “because of the intersection of vertical stratification created by institutional and sectoral status hierarchies and segmentation … and the horizontal stratification of regional, rural, and remote locations in which students live” (Abbott-Chapman, 2011, p. 57). This chapter, then, attempts to highlight the role Chemistry plays in this stratification and in sustaining “Bourdieuan polarity in the Field of Education” (Marginson, 2008, p. 305). This chapter also attempts to address calls made by Gale (2011) for future research to shift the focus from “access to what is a way of framing up a new understanding of, and approach to, equity” (p. 19).

8.2 Official versions of Chemistry curriculum in Queensland, 1992-2011

The practices and policies of Education are the result of struggles between numerous stakeholders. Rather than these struggles serving only the interests of the dominant social class, the State as the mediator of Education policies and practices, "is a site of interclass struggle and negotiation … where the interests of dominant classes can be partially institutionalised and realised" (Apple, 2000, p. 64). During these negotiations the State attempts to balance intraclass interests and, as a result, there will always be pressure for the State to compromise. According to Apple (2000), the goal of these negotiations "is to form an accord that acts as an umbrella under which many groups can stand but which is basically still under the guiding principles of dominant groups" (p.64). Authoring school curricula is predicated on striking an accord between the stakeholders. Deciding what counts as 'official' curricula must be advanced through negotiation and, as a consequence, "the cultural capital declared to be official knowledge, then, is compromised knowledge" (Apple, 2000, p. 64), since its legitimacy must first be authorised by numerous political actors and agencies. In this statement, Apple is drawing on Bourdieu's (2004) notion of cultural capital, which as a form of capital, can exist in an institutionalised state. Institutionalising a body of knowledge legitimises it as 'official knowledge'. Academic qualifications, interred through curricula, exemplify institutionalised cultural capital and, as such, allow for an official recognition of the competence of the person bearing the credentials, as well as the competence of the institution recognising the credentials (Bourdieu, 2004). Curricula, then, defined through syllabus documents that mandate both educational policy and practice, can be regarded as the product of struggles, for the purpose of providing a framework against which knowledge and credentials can be legitimated.

The scope and nature of curricula, conceptualised as compromised knowledge, shift and transform as new accordances are struck. Bernstein (1999) would see these accordances being struck in an "official re-contextualising field which is responsible for creating, maintaining, and changing official pedagogic discourse" (p. 215). Government officials and advisers drawn from fields of education and economy are the actors that commonly occupy the official re-contextualising field. The product of such accordances is “the production and reproduction of official pedagogic discourse” (Bernstein, 1999, p. 215) in which the contents and categories of the pedagogic discourse are determined, alongside preferred manners of transmission. In both cases, discourse is removed from its primary sites of production, and re-contextualised as a school subject. As a consequence of this recontextualisation, curricular content is:

> … re-located, re-focussed….The rules of selection, sequence, and pacing cannot themselves be derived from some logic internal to the [primary site of production]…the rules of reproduction…are social, not logical facts. (Bernstein, 1999, p. 215)

The curriculum that regulates what constitutes Chemistry in secondary schools throughout Australia exemplifies Bernstein’s recontextualising principle. Currently, there are political moves to enact a national science curriculum for the senior science subjects of Chemistry, Biology, Physics and Earth and Environmental Science. According to ACARA (2013b), the final revised and quality assured curriculum documents were approved by the Standing Council of Ministers in December 2012, however the timeline and processes for implementation of these curricula will be determined by state and territory curriculum, assessment and certification authorities. Currently, each state and territory in Australia delivers and accredits different Chemistry curricula, as is summarised in Table 8.1. This table shows that across Australia, Chemistry curricula have been frequently modified, with periods of accreditation varying from as little as 12 months (as is the case in Tasmania) to as long as eight years (as is the case in the Australian Capital Territory). It is to be noted here that the Chemistry curriculum delivered in the Northern Territory “is based on” (Northern Territory Government, 2013, "Related Links", para. 5) the South Australian curriculum. However, the extent to which these documents are similar could not be ascertained as the Northern Territory curriculum documents are available only through a secure website (password access required).

Table 8.1
Summary of Chemistry curricula delivered across Australia, as at January 2014

State/Territory	Curriculum Name	Year of Publication	Reference
Queensland	Senior Syllabus: Chemistry	Accredited from 2007 to 2014	Queensland Studies Authority (2007)
New South Wales	Chemistry: Stage 6 Syllabus	First published 2001; amended 2002, updated 2009	Board of Studies New South Wales (2009)
Victoria	Chemistry: Accreditation period 2013-2016	2012; Accredited 2013 to 2016	Victorian Curriculum and Assessment Authority (2012)
Australian Capital Territory	Chemistry T course Type 2	2006 Accredited from 2007 – extended to 2015	Board of Senior Secondary Studies ACT (2006)
	Chemistry integrating Australian Curriculum Type 2	2013 Accredited from 2014	Board of Senior Secondary Studies ACT (2013)
Tasmania	Chemistry TQA Level 3	Accredited from 1 Jan 2014 to 31 Dec 2014	Tasmanian Qualifications Authority (2014)
South Australia	Chemistry 2014 Subject Outline Stage 1 and Stage 2	First published 2010 Reissued for 2011, 2012, 2013, 2014 Accredited from 2010 Stage 1 & 2011 Stage 2	South Australian Certificate of Education (2014)
Western Australia	Chemistry	Accredited from March 2008, Updated October 2013	Curriculum Council of Western Australia (2009)

Northern Territory	1CME10 Chemistry 1CME20 Chemistry 2CME20 Chemistry	The NTCET is based upon the South Australian Certification of Education (SACE) which is administered by the SACE Board of South Australia.	Northern Territory Government (2013)

From this table it is clear that a variety of accordances have been struck within and across each State and Territory agency, resulting in nine official versions of Chemistry being delivered nationally. In this way, Table 8.1 summarises the "distributive rules" (Bernstein, 1986) of Chemistry — that is, the ways in which the various curricula "mark out and distribute who may transmit what to whom and under what conditions, and in so doing attempt to set the outer and inner limits of legitimate discourse" (p. 209).

Young (2013) has advanced the notion of distribution of curriculum, noting that "there are massive political factors shaping the distribution of opportunities" around curriculum choices and, moreover, "a major task of curriculum theory is to identify the constraints that limit curriculum choices and to explore the pedagogic implications that follow" (p. 103). Young also (2013) recognises STEM subjects, such as Chemistry as bodies of "powerful knowledge" (p. 108) which is both specialised and differentiated from the kinds of experiences that a student might bring with them to school. Bodies of powerful knowledge can be organised into subjects and then recontextualised into curriculum through a knowledge-based approach, which aims to ensure "epistemic access" (p. 115) to the knowledge of the fields that they study in. Young also argues that subjects, as bodies of knowledge recontextualised from disciplines, are "sources of stability for schools, students and teachers … sources of national coherence [and] … sources of identity for both teachers and students".

While it is clear the official curriculum in Queensland is strongly organised around a knowledge-based approach, whether or not the subject of Chemistry is currently acting as a source of stability, and national coherence is questionable. In Queensland, the notion of various official forms of Chemistry is particularly evident. In the period from 1992 to 2011, there have been five versions of the Chemistry syllabus used in Queensland (see Table 8.2). At some points in time, more than one official version was simultaneously in use in secondary schools throughout the state. For example, in 2004 and 2005, and again in 2008, three different versions of the Chemistry syllabus, all authored by the Queensland Studies Authority, mandated the teaching, learning and assessment work to be undertaken by Chemistry teachers in Queensland secondary schools. The current syllabus (QSA, 2007) was first introduced to schools in 2007. This syllabus followed the 'extended trial pilot' syllabus of 2004, which was introduced in 2005, once its accreditation lapsed in 2008. Given the diverse array of Chemistry curricula over this period, for some students — the cohort who began Year 8 in 2006 and completed Year 12 in 2010 — there were as many as four different versions of the senior secondary Chemistry syllabus being enacted throughout Queensland. Students from this cohort are the subject of the research undertaken to inform this thesis.

Table 8.2
Versions of a Chemistry syllabus employed in Queensland secondary schools, 1992 to 2012

Year	Chemistry 1987	Chemistry 1995	Chemistry 2001	Chemistry 2004	Chemistry 2007
1992	✓				
1993	✓				
1994	✓				
1995	✓				
1996	✓	✓			
1997		✓			
1998		✓			
1999		✓			
2000		✓			

2001	✓			
2002	✓	✓		
2003	✓	✓		
2004	✓	✓	✓	
2005	✓	✓	✓	
2006	✓		✓	
2007	✓		✓	
2008	✓		✓	✓
2009	✓			✓
2010				✓
2011				✓
2012				✓

A major transformation of the Chemistry syllabus occurred in 2002 when context-based approaches to teaching and learning were introduced to the senior sciences. Previously, and as was evident in the 1995 Chemistry syllabus, the mandated pedagogical approach could best be described as abstract and canonical, with little concern for the relevance of the content to everyday experiences (Goodrum & Rennie, 2007). Bernstein (1999) argues that these shifts in mandated pedagogical approaches are reflective of a shift from “vertical discourse” to “horizontal discourse” (p. 159). According to Bernstein:

> A horizontal discourse entails a set of strategies which are local, segmentally organised, context specific and dependent, for maximizing encounters with persons and habitats. … Because the discourse is horizontal it does not mean that all segments have equal importance, clearly some will be more important than others. (1999, p. 159)

Whereas:

> A vertical discourse takes the form of a coherent, explicit, and systematically principled structure, hierarchically organised, as in the science. … In the case of a vertical discourse,

> there are strong distributive rules regulating access, regulating transmission and regulating evaluation. (1999, p. 159)

Based on Bernstein's definitions, it is clear that the Chemistry curriculum in Queensland over the last two decades has been transformed, or "recontextualised" (Bernstein, 1986, p. 210). Furthermore, it could be argued that the Chemistry curricula, post-2001, aimed to engage a more horizontal pedagogic discourse as opposed to the vertical pedagogic discourse strongly evident in earlier curricula. Bernstein (1999) argues that such re-contextualisation is usually undertaken in order to "facilitate access to a vertical discourse" (p. 169), or to make the content more relevant to the lived experiences of the student. In addition, the horizontal discourse embedded is usually segmental in nature, or is considered to constitute low order procedural or operational knowledge. Using segments of horizontal discourse as resources to facilitate access to vertical discourse is linked to attempts to increase the utility of the vertical discourse, highlighting its relevance to the students' lived experiences. As noted by Bernstein (1999), "here, access and recontextualised relevance meet, restricted to the level of strategy or operations derived from horizontal discourse" (p. 169). This reading, of the re-contextualisation of horizontal discourse into the Chemistry curriculum, is exemplified by the following extract from the Queensland Studies Authority:

> The study of Chemistry provides students with a means of enhancing their understanding of the world around them, a way of achieving useful knowledge and skills and a stepping stone for further study. It adds to and refines the development of students' scientific literacy. An understanding of Chemistry is essential for many vocations. (p. 2)

The intimated purpose of Chemistry education is evident. The Chemistry curriculum of Queensland means to facilitate teaching and learning experiences that illustrate everyday relevance and that endeavour to develop scientific literacy and 'useful' knowledge. Such goals are indicative of a move to use segmented horizontal knowledge from the primary field of Chemistry knowledge production in order to bridge access for students to the field. Additional extracts of the syllabus reveal the goal for students to develop what Bernstein refers to as a “gaze” (1999, p. 170) toward Chemistry; “by means of which the acquirer learns how to recognise, regard, realise and evaluate legitimately the phenomena of concern” (Bernstein, 1999, p. 170). Such a gaze is demonstrated in the following Chemistry syllabus extract:

> This syllabus presents a framework to guide teachers as they construct context-based units of work. Courses will develop students’ understanding and appreciation of Chemistry in real-world, relevant contexts. It will encourage students to think creatively and rationally about Chemistry. Students will be challenged to understand and act responsibly on Chemistry-related problems and issues and to communicate effectively in a range of modes. (Queensland Studies Authority, 2007, p. 2)

Bernstein (1999) suggests that the move to embed horizontal discourse into vertical discourse signifies a shift in equity – “from equality of opportunity to recognition of diversity” (p. 169). Furthermore, Bernstein (1999) warns, in the process of re-contextualising horizontal discourse and embedding it into vertical discourse that “vertical discourses are reduced to a set of strategies to become resources for allegedly improving the effectiveness of the repertoires made available in horizontal discourse” (p. 169). He goes on to suggest that vertical discourses have been “colonised” (p. 169) by horizontal discourses, and students may not, necessarily, acquire vertical discourse more effectively as a result of such an approach. Here, Bernstein illuminates the very tensions in pedagogical discourse that underpin the contested purpose of STEM education. Moreover, his work highlights the struggles over not only what constitutes an ‘official’ version of Chemistry but also, and just as significantly, the preferred way in which to transmit an ‘official’ version of Chemistry and whose principles become dominant in the process of re-contextualisation.

8.3 Chemistry and tertiary entrance

Despite the struggle over a single official version of Chemistry, the Queensland Studies Authority arrived at one official version of the Chemistry curriculum (Queensland Studies Authority, 2007) to be implemented in secondary schools throughout Queensland. For students, this Chemistry syllabus functions as “a stepping stone for further study” (Queensland Studies Authority, 2007, p. 2). The way in which Chemistry contributes to tertiary access is two-fold. Firstly, Chemistry (along with other QSA subjects) is assigned an official field position in the calculation of Overall Position scores (OPs) which are used to rank students for access to university. Secondly, Chemistry is frequently named as a pre-requisite for courses offered at universities throughout Queensland. The details of Chemistry’s field position, along with its deployment as a pre-requisite will be the focus of the following two subsections.

8.3.1 Chemistry’s official field position

The suggestion that Chemistry holds an ‘official’ field position requires elaboration. While Apple (2000) has offered a definition of official, a field can be considered as a “structured space of positions in which the positions and their interrelations are determined by the distribution of different kinds of resources or capital”. Moreover, as Bourdieu notes:

> A field is always the site of struggles in which individuals seek to maintain or alter the distribution of the forms of capital specific to it. The individuals who participate in these struggles will have differing aims — some will seek to preserve the status quo, other to change it — and differing chances of winning or losing, depending on where they are located in the structured space of positions. But all individuals, whatever their aims and chances of success, will share in common certain fundamental presuppositions. All participants must believe in the game they are playing, and in the value of what is at stake in the struggles they are waging. The very existence and persistence of the game or field presupposes a total and unconditional ‘investment’, a practical and unquestioning belief, in the game and its stakes. (1992, p. 14)

In this sense, Bourdieu theorises the choices that individuals make in relation to a field. The choices students make in relation to the field of education and in relation to the sub-fields of school education and Higher Education exemplify instances of struggle over positions that specific forms of academic capital hold within these fields. As Gale (2011) notes, the field of education “is defined by its field-specific resources, specifically its academic capital” (p. 12). Chemistry, then, can be regarded as a field-specific resource to the field of education, and as will be demonstrated below, Chemistry holds a dominant position within the field.

One of the primary functions of the Queensland Studies Authority is to facilitate students’ entry into university. Through a complex procedure, the QSA ranks eligible Year 12 students and issues Tertiary Entrance Statements (Queensland Studies Authority, 2012d). The process for gaining entry to the pathway to tertiary study is described by the QSA (2014) as follows:

> Obtaining an Overall Position (OP) is the usual pathway for Year 12 students to gain tertiary entrance, but other options are available to those wishing to pursue further studies. Students can seek tertiary entrance by obtaining an OP rank. To be eligible, they must study 20 semester units of Authority subjects, including at least three subjects for four semesters each, and sit the Queensland Core Skills (QCS) Test. Students must also choose courses that meet the subject prerequisites for their tertiary preferences. Students who satisfy the prerequisites are then selected for particular courses based on their OP. Students with the best OPs are offered places first. In some cases institutions need to differentiate between students with the same OP by using Field Positions (FP)s. In cases where it has not been possible to separate applicants for the same course by using the OP followed by the FPs as the primary means of selection, QTAC will use the Australian Tertiary Admission Rank as a final discriminator.

According to the Queensland Studies Authority(2012a), FPs are used to separate students applying for a place in the same course, who have the same OP. Overall position scores are ranked from one (the highest score) to 25 (the lowest score). Field positions are only used when students have an equivalent OP rank score and places in a course are capped. A “field” is an area of emphasis in the senior curriculum. A student may receive up to five FPs, as shown in Table 8.3:

Table 8.3
Summary of Field Positions evident in Queensland Studies Authority senior curriculum subjects

Field	Area of emphasis in the senior curriculum
Field A	Extended written expression involving complex analysis and synthesis of ideas
Field B	Short written communication involving reading, comprehension and expression in English or a foreign language
Field C	Basic numeracy involving simple calculations and graphical and tabular interpretation
Field D	Solving complex problems involving mathematical symbols and abstractions
Field E	Substantial practical performance involving physical or creative arts or expressive skills

A student's eligibility for a FP depends on the combination of Authority subjects studied and the number of weighted semesters completed. The number of weighted semesters is calculated by multiplying the number of semesters by the subject weight. As is evident in Table 8.4, not every subject is weighted equally, and weightings vary between field positions. Chemistry has strong field rankings in relation to both quantitative and qualitative domains across the fields. In comparison, many of the humanities subjects, including English, does not have a rank in relation to Field D. As such, if a student's result in Chemistry, is compared to a student with an equivalent grade in Biology (eg. High Achievement), the student with Chemistry will receive a higher FP, simply by the weighting of this subject in each of the field positions. In Bourdieuan terms, it is clear that Chemistry can be construed as a valuable field-specific resource within the field of education.

Table 8.4
Chemistry's field positions relative to selected QSA senior subjects

Syllabus	Field A	Field B	Field C	Field D	Field E	Year
Chemistry	4	3	5	5	2	2007
Biology	5	4	4	3	2	2004
	4	3	5	5	2	2007

Physics						
Earth Science	3	3	4	3	2	2000
Mathematics A	1	2	5	4	N/A	2008
Mathematics B	1	2	5	5	N/A	2008
English	5	4	1	N/A	3	2010
Geography	4	5	4	3	2	2007
Information Processing and Technology	3	2	4	4	2	2010
Information Technology Systems	3	2	3	3	3	2006

***Note.* Source: Subject Weights table for use in Year 12 in 2013(Queensland Studies Authority, 2012c).**

While there is variation in weighting between subjects, there is also variation within a subject; subject weights are not fixed through time — they change as new syllabi are implemented and old syllabi become redundant. Therefore, the subject weights used to calculate a field position correspond with the year that the student is expected to exit Year 12. Table 8.5 provides a summary of the shifting field positions of Chemistry from 2009 to 2014. From this table, the shift in emphasis between the

1995 Chemistry syllabus and 2007 Chemistry syllabus is evident. There has been a marked increase in the extended written expression involving complex analysis and synthesis of ideas (Field A) and a slight decrease in emphasis on physical skills. So, while Chemistry's relative FP has remained high, the internal pedagogic discourse has shifted, and is reflected in the FP weighting accordingly. These observations draw attention to the need to problematise the notion that 'Chemistry' is a stable and homogeneous pedagogic discourse. Nevertheless, the persisting dominant field position is also related to the call for students to have completed Chemistry before entering many university courses. The extent to which Chemistry is deployed as a pre-requisite and its relationship to various institutions and courses is the focus of the following section.

Table 8.5
Field Positions related to QSA Chemistry syllabi, 2009 to 2014

Year in which Year 12 completed	Syllabus Version	Field A	Field B	Field C	Field D	Field E
2009	Chemistry 1995	2*	3	5	5	3
	Chemistry 2007	4	3	5	5	3
2010	Chemistry 2007	4	3	5	5	3
2011	Chemistry 2007	4	3	5	5	3
2012	Chemistry 2007	4	3	5	5	3
2013	Chemistry 2007	4	3	5	5	2*
2014	Chemistry 2007	4	3	5	5	2*

Note. **Shifts in emphasis denoted by asterisk (*)**

8.3.2 Chemistry as a pre-requisite: Gaining entry to the field

Gaining entry to the field of Higher Education requires an awareness of the “rules of the game” (Bourdieu, 1999, p. 215). The field itself is structured by dominant political and social interests. Prior to the 2013 Federal government election, the Labor Government exerted its political interests and aspirations to fund a demand-driven system of university participation in which “the Commonwealth Treasury finances any qualified student who enrols in higher education” (Marginson, 2013, p. 7). However, since the election of the Abbott-led Coalition government on 18th September 2013, a review of the demand-driven funding system was announced. The review, conducted by Dr. David Kemp and Mr. Andrew Norton, was reported to the Federal Government in February 2014 (Kemp & Norton, 2013). In response to this review, Marginson (2013) suggests that declining government funding, coupled with increases in student enrolment are likely to result in less funding per students, and unless student contributions rise, the demise of the demand-driven system is likely. This suggestion comes despite advocacy on behalf of Universities Australia, the peak body representing Australia’s universities, for the continued funding of a demand-driven sector.

The demand-driven funding model has also exposed debate between the quality and quantity positions of higher education. Marginson (2013) suggests that concerns around preserving the quality of the teaching, learning and research occurring in universities in a demand-driven system have instigated the move to defining and regulating quality in the higher education sector, and hence the introduction of the Tertiary Education Quality and Standards Agency (TEQSA). TEQSA’s role is to regulate and enforce institutional compliance with the Australian Qualifications Framework (AQF) across the higher education sector. As Norton (Norton, 2013)suggests, “the power to issue particular types of qualifications is the most important defining feature of a higher education provider” (p. 10). In this way, quality and qualifications are terms used to differentiate the legitimate work of the higher education sector, within the broader field of education.

In the literature pertaining to higher education, the terms ‘higher education’ and ‘university’ are often regarded as synonyms. Norton (2013) notes that universities are among the “minority” of providers of higher education:

> While universities educate most higher education students, they are a minority of higher education providers in Australia – 44 of the 173 operating in late 2012. This includes 39 full universities and 5 higher education providers with university in their title. The other providers are a range of colleges, institutes, and schools that are authorised to offer higher education qualifications. (p. 10)

In this statement, it is clear that Norton aims to minimise the number of students enrolled in universities and to instead draw out the breadth of the sector, and to highlight the value of the range of privately funded institutions that occupy space within the marketised higher education field. Norton differentiates universities from the rest of the sector on the following premise:

> ‘University’ is a regulated term in Australia. No educational organisation can operate as an Australian university without meeting criteria set out in law. From 2012, Commonwealth Provider Category Standards enforced by TEQSA regulate which institutions can operate as universities. There are 39 full Australian universities in operation. Two overseas universities also operate in Australia, offering their home country qualifications. To do so, they must be approved by a higher education accrediting authority acceptable to TEQSA. (Norton, 2013, p. 14)

Based on this definition, Australian universities are organised into “interest groups” (Norton, 2013, p. 64). While many universities are members of Universities Australia (Universities Australia, 2010), additional groupings have been formed to represent strategic synergies between institutions. According to the Australian Education Network (2014, para. 1):

There are four main groupings of Australian Universities. These have been formed to promote the mutual objectives of the member universities. There are a number of objectives in this including marketing advantages, practical benefits of collaboration, and the increased lobbying power that comes from being part of a group. The four main groupings currently active are:

- Group of Eight (Go8)
- Australian Technology Network (ATN)
- Innovative Research Universities (IRU)
- Regional Universities Network (RUN)

Table 8.6 summarises the groupings for each of the nine publicly funded universities in Queensland. These university groupings constitute players in the field of higher education. Given the broader context in which these university groups are currently operating, an analysis of the ways in which they establish the rules of the game for students is of interest to this study. These pre-requisites comprise part of the rules of the game that students must meet as they negotiate their entrance to university.

Table 8.6
Summary of Queensland universities in relation to university groupings

Go8	ATN	IRU	RUN
The University of Queensland (UQ)	Queensland University of Technology (QUT)	Griffith University (GU)	Central Queensland University (CQU)
		James Cook University (JCU)	Southern Cross University (SCU)
			The University of New England (UNE)

	University of Southern Queensland (USQ)
	University of the Sunshine Coast (USC)

The official guide to pre-requisites of university courses offered throughout Queensland is the *Queensland Tertiary Admissions Centre (QTAC) Course Guide* (2010), which is published annually. The following analysis examines the QTAC course codes (2010) offered by each Queensland university that name Chemistry as a pre-requisite. Instances where Chemistry was named as a pre-requisite were, for the purpose of this study, recorded in an Excel spread sheet. Four categories of pre-requisite status were constructed. The two categories differentiated between instances in which Chemistry was named as a pre-requisite to entry, as opposed to being named as assumed knowledge prior to entry. Nested below these two categories were further sub-categories: 'Chemistry *only*' courses and 'Chemistry *or*' courses. 'Chemistry *only'* courses named Chemistry as the *only* pre-requisite science subject required for entry. In contrast, 'Chemistry *or'* courses, named Chemistry in conjunction with a suite of subjects that would also constitute pre-requisite status. For example, Course A may state Chemistry as the *only* science pre-requisite, while Course B may state Chemistry *or* Physics are equally acceptable as pre-requisites. A limitation of this investigation is that instances of collocation of Chemistry and/or Maths A, and/or Maths B have not been accounted for.

Once each course code had been categorised, descriptive statistics were used to analyse and compare patterns and trends evident between courses, fields and institutions, at the Bachelor degree level of certification. Gale (2011) notes that "searching for field position … involves naming the logic that informs this field, the nature of its competition and the extent to which it is influenced by the logics of other fields" (p. 7). This agenda, informs the analysis. In particular, it aims to explore the logic of the field as constructed through the deployment of specific pre-requisites. As will be discussed, Chemistry — as a secondary school subject — is predominantly called upon by universities to act as a pre-requisite in ways that serve a selection function (Fensham, 1985) and to mark out the stance commanded by institutions within the Higher Education field.

While Chemistry is positioned to 'enable' participation in university courses, the extent to which this is realised is debateable. Despite the rhetoric about Chemistry being an 'enabling science', as discussed earlier in Section 7.3.1 of this thesis, and the purported role of Chemistry as a "stepping stone for further study" (QSA, 2007, p.2), analysis of the deployment of Chemistry as a pre-requisite, by field of education (as summarised in Table 8.7), reveals that in 2010 only 10.6% of the Bachelor degree courses offered by Queensland universities name Chemistry as a pre-requisite to entry. In addition, more course codes named Chemistry *or* another science subject as an acceptable pre-requisite than did those that named Chemistry *only* (4.8% of total Bachelor degree course codes, as compared with 3.3%). The field of education most likely to name Chemistry in relation to a course was *Health and Recreation* (35.9% of course codes), followed by the field of *Science* (30%), then *Primary Industries and the Environment* (26%). Detailed patterns of Chemistry deployment will now be examined in two of these three fields: *Health and Recreation* and *Sciences*, in relation to university groupings.

Table 8.7
Analysis of the deployment of Chemistry as a pre-requisite by Field of Education

Field of Education	**Total number of Bachelor Degrees Course codes**	**Total number of Bachelor degree course**	**Percentage of Bachelor degree course codes within a field naming Chemistry**	**Pre-requisite subject**		**Assumed knowledge**	
				Chemistry *only*	Chemistry *or…*	Chemistry *only*	Chemistry *or…*

		codes naming Chemistry					
Built Environment & Design	38	0	0%	0	0	0	0
Business & Tourism	234	4	1.7%	1	3	0	0
Creative & Performing Arts	68	0	0%	0	0	0	0
Education	121	4	3.3%	2	2	0	0
Engineering & Technology	78	14	17.9%	2	8	4	0
Health & Recreation	153	55	35.9%	7	30	10	8
Humanities & Social Sciences	179	0	0%	0	0	0	0
Information Technology	74	1	13.5%	0	1	0	0
Law	48	1	2.1%	0	1	0	0
Primary Industries & the Environment	46	12	26%	9	2	0	1
Sciences	99	30	30%	16	8	6	
Totals	1138	121	10.6%	37	55	20	9
Percentage of total Bachelor courses				3.3%	4.8%	1.7%	0.8%

Percentage of Bachelor courses that named Chemistry	100%	30.5%	45.5%	16.5%	7.4%

Course codes aligned with the field of *Health and Recreation* were the most likely to name Chemistry as either a pre-requisite or assumed knowledge. Examples of the courses offered within this field include a Bachelor of Pharmacy, Bachelor of Nursing, Bachelor of Sport and Exercise Sciences, Bachelor of Physiotherapy and Bachelor of Medicine/Bachelor of Surgery (MBBS). From Table 8.8, it is clear that the UQ (Go8 grouping) is the most likely to name Chemistry as a pre-requisite in this field (82.3% of course codes). In the Go8 grouping, Chemistry is named as the *only* pre-requisite in just one course; the Bachelor of Pharmacy. In all other instances, Chemistry *or* another science is regarded as acceptable.

The IRU Group is the only other university grouping to name Chemistry as the *only* pre-requisite in relation to this field. Further analysis reveals that of the 19 courses that name Chemistry, five name Chemistry *only,* and all five instances originate from JCU. These courses are the Bachelor of Biomedical Sciences (OP 15), Bachelor of Dental Surgery (no OP specified), Bachelor of Exercise Physiology (Clinical) (OP 16), the Bachelor of Medical Laboratory Science (OP 15) and the Bachelor of Medicine/Bachelor Surgery. At JCU, the OP score to entry is unspecified and is instead based on "special entry requirements in addition to academic achievement … The Chemistry pre-requisite can be satisfied by Physics (4, SA), plus undertaking bridging Chemistry at JCU in the four weeks prior to the start of semester" (Queensland Tertiary Admissions Centre, 2010, p. 147). Meanwhile at UQ, the OP score for entry to the Bachelor of Science/MBBS is 1, and either Chemistry or Physics are acceptable pre-requisites.

In comparison, the ATN group university (QUT) named Chemistry in relation to its *Health and Recreation* field course codes in 60.1% of cases. In all of these instances Chemistry is named as *assumed knowledge* rather than as a specific pre-requisite to entry. As such, Chemistry is not named a specific pre-requisite to the Bachelor of Pharmacy at QUT. In the program outline for the Bachelor of Pharmacy at QUT, it is stated that “first year studies include chemistry, mathematics, physiology, anatomy and an introduction to practice” (Queensland Tertiary Admissions Centre, 2010, p. 151). In comparison at Queensland’s Go8 university (UQ), Chemistry is named as the *only* science subject that will suffice as pre-requisite to entry to a Bachelor of Pharmacy degree.

Table 8.8
Summary of Chemistry deployment in relation to the field of Health and Recreation

University grouping	Total number of Bachelor Degrees Course codes	Total number of Bachelor degree course codes naming Chemistry	Percentage of Bachelor degree course codes within a field naming Chemistry	Pre-requisite subject		Assumed knowledge	
				Chemistry *only*	Chemistry *or…*	Chemistry *only*	Chemistry *or…*
IRU	48	19	39.5%	5	13	1	0
ATN	23	14	60.1%	0	0	7	7
Go8	17	14	82.3%	1	13	0	0
RUN	46	4	8.7%	0	1	2	1

With regards to the field of sciences, UQ was again the most likely institution to name Chemistry in relation to courses. The majority of the courses (70 per cent) name Chemistry *or* Physics as pre-requisites to entry, while only three courses (30 per cent) name Chemistry *only*. These are: Bachelor of Food Technology (OP 12), Bachelor of Occupational Health and Safety Science (OP 11), and the Bachelor of Veterinary Science (OP 1) — which named Chemistry *and* either Physics or Biology.

The IRU group, representing JCU and GU in Queensland, offer the next largest number of courses within the field of sciences. The IRU group name Chemistry in 34.4 per cent of the courses (11 out of 32) within this field. All eleven of these courses are offered by JCU. Nine of these eleven courses name Chemistry *only*, whereas two courses, including the Bachelor of Geology, name Chemistry *or* another science as assumed knowledge only. The nine courses that require Chemistry *only* includes the Bachelor of Biotechnology (OP 17), Bachelor of Marine Science (OP 10), Bachelor of Science (OP 16), Bachelor of Science (Advanced) (OP 6) and the Bachelor of Veterinary Science (no OP specified).

In comparison, while the ATN group university, QUT, offers 15 courses in the field of sciences, Chemistry is only named in relation to four of these and in each instance it is named as assumed knowledge only. These four courses include: the Bachelor of Biomedical Science (OP 12), the Bachelor of Applied Science (Medical Science) (OP 10), the Bachelor of Technology Innovation (OP 12) and the Dean's Scholar Accelerated Honours Program (Science or Mathematics) (OP2).

While UQ named Chemistry in relation to all ten of the courses it offered within the Sciences field, the RUN group of institutions offered the largest number of courses within this field (36), with only one institution and course (USC; Bachelor of Science (Honours) Deans Scholars Program) naming Chemistry *or* another science subject as a pre-requisite to entry. In addition, within this grouping, CQU offers a Bachelor of Science (Industrial Chemistry) (OP 19) with the only pre-requisite to entry named as English. In relation to this course, the program outline states "the program includes an integrated first year covering fundamental concepts and principles of biological, chemical and environmental sciences, providing a foundation for specialisation in later years" (Queensland Tertiary Admissions Centre, 2010, p. 206). The duration of this CQU course is three years full-time, as is the duration of the Bachelor of Science degree offered by JCU.

Taken together, these two cases of the deployment of Chemistry in relation to the two fields of education — Health and Recreation and Sciences — in the Higher Education sector reveal differential patterns of naming Chemistry as a pre-requisite to entry. Furthermore, these differential patterns seem to be associated with the interest groupings of universities. Each university grouping strategically deploys Chemistry, either as a pre-requisite, as assumed knowledge, or through its absence, in order to assert the rules of the game (Bourdieu, 1999) for access to the distinctive credentials awarded by each institution.

Table 8.9
Summary of Chemistry deployment in relation to the field of Sciences

University grouping	Total number of Bachelor Degrees Course Codes	Total number of Bachelor degree course Codes naming Chemistry	Percentage of Bachelor degree course codes within a field naming Chemistry	Pre-requisite subject		Assumed knowledge	
				Chemistry *only*	Chemistry *or…*	Chemistry *only*	Chemistry *or…*
IRU	32	11	34.4%	9	0	2	0
ATN	15	4	26.6%	0	0	4	0
Go8	10	10	100%	3	7	0	0
RUN	36	1	2.7%	0	1	0	0

Marginson and Considine (2000) draw attention to the processes of transition currently underway in Australian universities. That is, the tendency for universities to develop as ‘Enterprise Universities’. Enterprise Universities are characterised by a move to increase corporate-style governance “in which research and scholarship survive but are subjective to new systems of competition and demonstrable performance” (Marginson & Considine, 2000, p. 5). “Enterprise is as much about generating institutional prestige as about income. The fundamental mission of an enterprise university is to advance the competitiveness of the university. At the same time, academic identities are subordinated to the mission” (Marginson & Considine, 2000, p.5). As such, the process of institutional transformation, toward the characteristics of an Enterprise University, is consistent with advancing the relative position of an institution within the field of Higher Education through strategies of governance.

Governance transforms the “distinctive inner culture” (Marginson & Considine, 2000, p. 3) of universities. Moreover, governance is the process whereby “the identity of each university as a distinctive social and cultural institution is shaped, within a global knowledge economy … governance is at the heart of satisfying the different publics that make a claim on the purposes of university” (2000, p. 8). In their study, Marginson and Considine (2000) noted five trends in governance, two of which are relevant to the investigation herein. Firstly, governance is characterised by a strengthening of a university’s executive power in order to “mediate the university’s external relations and fashion its strategies” and, secondly, there is a “discernible decline in the role of the academic disciplines in governance” (p. 10). Marginson and Considine (2000) also note that many people believe that the move toward governance “is the primary cause of what they perceive as a crisis in university purposes and values” (p. 10). A move toward governance across the Higher Education sector, then, highlights that universities actively negotiate and then seek to construct their role and reputation within the field of education, intersecting with numerous social and political fields. Increasingly, actors from the traditional academic disciplines have less input into these decisions, and simultaneously, there is pressure to develop a ‘distinctive inner culture’ in and for the university. As such, it is argued here that the pre-requisites named in relation to courses offered within specific fields of education by each institution are strategic decisions underpinned by the need to mark out a distinctive mission within a marketised Higher Education sector.

Pre-requisite subjects, then, contribute to the “institutional habituses”(Clegg, 2011) of Enterprise Universities. Section 4.4.3 of this thesis drew on literature that discussed student perceptions about the “strategic value” of subjects such as Chemistry, and pinpointed calls made by the Office of the Chief Scientist (2012b, p. 9) for universities to “send accurate signals about the value of mathematics, engineering and science to schools, students, teachers and career advisors”. This perspective views all Australian universities as though their stance in these fields of education is homogenous. While “inter-institutional mimicry” (Marginson & Considine, 2000, pg. 19) is evident in relation to the deployment of Chemistry across institutional groupings, it is also evident that each university grouping has formed a distinctive stance in relation to the deployment of Chemistry as a subject required to enter courses at their institutions, particularly within the fields of Health and Recreation and Sciences. As noted by Gale (2011):

> The search for field position is about identifying the positions individuals and organisations occupy in those fields and what they can do from those positions; that is, the stances available to individuals and groups or the stances they can create from where they are positioned. (p. 7)

Gale's point relates to the notion of "isomorphic closure" (Marginson & Considine, 2000, p. 19), whereby "universities with diverse histories choose from an increasingly restricted menu of commercial options and categories" (2000, p. 19). Taken together, an institution's need to create and occupy a stance with the field of Higher Education is limited by the history of the university and the constraints the university makes as its mission becomes dominated by the need to respond to market-driven demands and conditions. Given these contextual influences, the decision to deploy Chemistry as a pre-requisite to entry, or not, is highly contestable, and is the consequence of institutional habitus.

Bourdieu states that habitus is not a singular, instantaneous being. Instead, he notes that habitus is a:

> particular way of entering into a relationship with the world which contains a knowledge enabling it to anticipate the course of the world, is immediately present, without any objectifying distance, in the world and the 'forth-coming' that it contains … it is also a force, endowed with a law, and therefore characterized [sic] by constraints and constancies underlined by explicit principles of truth to self…it is the site of durable solidarities, loyalties that cannot be coerced because they are grounded in incorporated laws and bonds. … As such, habitus is the basis of an implicit collusion among all the agents who are products of similar conditions and conditionings, and also of a practical experience of the transcendence

> of the group, of its ways of being and doing, each agent finding in the conduct of his peers the ratification and legitimation ('the done thing') of his own conduct, which, in return, ratified and, if need be, rectifies, the conduct of others. This *collusio* [emphasis in original] … is the basis of a practical mutual understanding, the paradigm of which might be the one established between members of the same team, or, despite the antagonism, all players engaged in a game. (Bourdieu, 2000, pp. 142-145)

From this extract, the notion of habitus can be used to illuminate the forces that underlie the differential institutional deployment of Chemistry as a pre-requisite to entry across Queensland's universities. Despite contemporary forces, such as the political imperatives of the mandated targets of the widening participation agenda (Bradley et al., 2008; Department of Education Employment and Workplace Relations, 2009), each university has its own historical trajectory. Each institution, then, must strike accordance — reach a *collusio* — between their historical institutional habitus, and their preferred future habitus, in response to the widening participation agenda.

Broad social and political perspectives on the purpose of universities in relation to the knowledge economy have been discussed extensively throughout this thesis, as the role of Chemistry as an 'enabling science' in relation to the knowledge economy. Universities, then, will consider where and how the strategic deployment of Chemistry, as a pre-requisite, can legitimate their efforts to produce human capital for the knowledge economy. Secondly, each university has an historical trajectory that brings forth with it, a self-referential view of the 'way things should be done'. As is noted by Fensham (1985), " the study of science disciplines at the higher level … turns out to be a useful selective device since comparatively few students successfully learn it" (p. 418). Here, the term 'higher' relates to what Teese and Polesel (2003) refer to as the "hierarchical curriculum" (p. 12). These authors go on to state:

> A hierarchical curriculum needs a stratified school system. This enduring, but evolving relationship between curriculum and schools underlies patterns of social inequality which are

> such a marked feature of mass secondary education and whose persistence and predictability show that they are organized [sic] into the curriculum and how power is accumulated in school systems to exploit it. This structure links two forms of institutionalized [sic] power. On the one side is the knowledge which is codified in school subjects and which represents an historical asset or infrastructure built up over time by generations of use and adapted to the needs and culture of the most educated families. On the other side are the resources concentrated in schools and deposited by successive generations to extract social and economic advantages from the knowledge formalized in school programs. In this structure, it is the curriculum which is the central element. For without its hierarchical and selective nature and the continual pressure it places on families and individuals to distinguish themselves in academic terms, there would be no call on a stratified school system to surmount these demands and demonstrate 'excellence' as the highest levels of the curriculum. (Teese & Polesel, 2003, p. 12)

The curriculum, then, as a "hierarchy of educational opportunity" (Teese, 2007, p. 42), is able to function as a "structure for differentiating opportunities" (Teese, 2007, p. 47). Chemistry is recognised as a "high-status subject" within this hierarchy. Just as Teese (2007) recognises that the hierarchy of curriculum relies upon a hierarchy of schools, it is argued here that the hierarchy of the curriculum is also the foundation of the hierarchy of universities. For example, in the analysis conducted herein, UQ, belonging to the academically elite Group of Eight 'sandstone' universities, was the most likely to name Chemistry in relation to entry into its courses in the fields of Health and Recreation and Science. In contrast, the Regional University Group institutions, were the least likely to name Chemistry in relation to access. On their "About us" web site, the RUN grouping states that "we unlock the creativity, talent and potential of regional communities by making higher education fully accessible and achievable, enrolling higher concentrations of low socio-economic and Indigenous students than metropolitan universities" (Regional Universities Network, 2014). In contrast, the home page of the Group of Eight website states:

> The Group of Eight (Go8) is a coalition of leading Australian universities, intensive in research and comprehensive in general and professional education. The Go8 exists to:
>
> - enhance the contribution of its member universities to the nation's social, economic, cultural and environmental well-being and prosperity;
> - extend the contribution of its member universities to the generation and *preservation of the world's stock of knowledge* [emphasis added];
> - strengthen Australia's capacity to engage in and benefit from global developments, respond to global and local challenges;
> - expand opportunities for Australian students, *regardless of background* [emphasis added], to participate in higher education of world class. (Group of Eight Australia, 2014)

Then, on the Go8 "About us" web page, the reader is provided with a history of the Go8 group. The institutional habitus of each of the university groupings is clear from these mediated mission descriptions. However, the extent to which UQ, as the Go8 institution in Queensland, is expanding opportunities for students "regardless of their backgrounds", particularly in the Fields of Science and Health and Recreation, is questionable given the frequency with which Chemistry, a high status subject in the curriculum hierarchy, is named as a pre-requisite to entry. Perhaps the deployment of Chemistry is more strongly aligned with the purpose of "preserving the world's stock of knowledge" than "expanding opportunities". As noted by Teese and Polesel (2003), preserving of the role of Chemistry is essential in order for the most educated and advantaged citizens to demonstrate their excellence.

The stance taken by UQ exposes a tension in the role of Chemistry, as a secondary school subject, in accessing university courses within the fields of Health and Recreation and the Sciences. As is noted by Adkins (2003):

> Institutions are only fully viable if they are durably embedded in the dispositions of agents operating within the field. Yet agents are not simply the benign carriers of the rule and norms of particular fields. For while the field sets certain limits on practice, nonetheless the actions of agents also shape the habitus of the field and hence the field itself. Thus within fields, distinct ‘games’ are played. (p. 24)

Perhaps the stance taken by elite institutions in relation to the deployment of Chemistry is indicative of a distinctive game within the field of higher education. The rules of this game have come about through, and as a result of, habitus. Here habitus is taken as:

> … a dynamic intersection of structure and action: it both generates and shapes action … the habitus thus produces enduring (although not entirely fixed) orientations to action … transposable dispositions which, integrating past experiences, function at every moment as a matrix of perceptions, appreciations and action. ” (Bourdieu, 1977 cited in Adkins, 2003, p. 23).

The institutional habitus of the elite university works to normalise the expectation that in order for a student to enter a course in the field of Sciences or Health and Recreation, they should have either completed Chemistry or, at the very least, their knowledge of Chemistry will be assumed. Moreover, the distinctive quality (and qualities) of the students, the institution and the courses relating to Chemistry in this manner are generated which, in turn, generates the collective disposition of the institution.

Despite the persistence of the elite institutional habitus, habitus itself is “neither fixed nor inevitable” (Adkins, 2003, p. 27). Rather, habitus is changeable. When the fit between habitus and field is no longer coherent, “increased possibilities may arise for critical reflection on previously habituated forms of action” (p. 27), facilitating a “critical reflexive stance towards formerly normalised — or at least taken-for-granted — social conditions (p. 21).” Opportunities for social transformation emerge under these conditions, as traditional ‘rules of the game’ — norms, expectations, and forms of authority are broken down.

Recognising this manoeuvrability of habitus, provides insight into the various stances that Queensland institutions have taken in relation to the deployment of Chemistry as a pre-requisite to entry to courses in the fields of Health and Recreation and Sciences. For example, the stance taken by the ATN and RUN groups exemplifies this break between the habitus of the elite institution and the field of higher education. Chemistry, in these institutions, is not required to gain access. Instead, it is a body of discipline knowledge that is delivered in the first year of study once the student has gained entry. However, this differential deployment of the academic capital embodied by Chemistry is not without its critics; and some would argue that such differential deployment may further disadvantage students within the hierarchy of the sector. In other words, debating the role of curriculum in relation to institutional habitus is essential to providing insights into why “some changes in objective structures lead to increased possibilities for the development of transforming practices and others do not” (Adkins, 2003, p. 27).

While Chemistry is vital to preserving the reputation of institutions within the sector hierarchy, the deployment of Chemistry poses challenges for Australian universities as they each respond to the widening participation agenda (Bradley et al., 2008; Department of Education Employment and Workplace Relations, 2009) and the targets of social inclusion it mandates. Gale (2011) argues that the stances institutions take with regard to equity are “commanded by their positions in the field” (p. 8) and that practitioners in equity universities — that is, “those with large enrolments of students from disadvantaged backgrounds” (p. 8) — are better placed to respond to the widening participation agenda than those in elite institutions. Meanwhile, Clegg (2011) argues that “less elite institutions who recruit larger numbers of working-class students and are less well-resourced [and] present students with fewer social and cultural demands” (p. 98). However, some authors argue that in their attempts to widen access to higher education, less elite institutions take an approach that distances students from high level academic and cultural capital in their chosen field, through constructing less rigorous learning and teaching experiences. For instance, Crozier, Reay, Clayton, Colliander and Grinstead (2008) argue that:

> the problem for these students lies with the reinforcing of low volume social capital and ultimately constrained learning experiences ... the more students withdraw from the field, either intentionally or not, the less access they will have to the means (habitus and cultural capital), or opportunity to acquire it, to compete for scarce resources." (p. 174)

Here, the role that Chemistry, as a subject ranked highly in the curriculum hierarchy, plays in the equity debate becomes clear. The inclusion — or exclusion — of Chemistry as a pre-requisite, marks out the student, the course and the institution in particular and distinctive ways. The inclusion of Chemistry allows an institution to demonstrate its excellence within the fields of Health and Recreation and Science. Simultaneously, the inclusion of Chemistry also contributes to the reproduction of neoconservative social hierarchies. Conversely, the exclusion of Chemistry results in further implications. While on the one hand, negating the need for Chemistry as a pre-requisite to entry could be regarded as taking a critically reflexive stance with respect to the notion of equity as access, on the other hand the exclusion of Chemistry could also be regarded as an act that denies already disadvantaged students access to the academic and cultural capital that participation in Chemistry imparts. This noted, the force of governance, and changes to the regulation of the Higher Education sector cannot be disregarded as pivotal in these moments of social transformation. As suggested by King and James (2013), the effectiveness of a demand-drive system relies upon "the *responsiveness of institutions* [emphasis added] to the possibilities opened up by deregulation and on the overall volume of government funding" (p. 12). As has been discussed herein, the nature and extent of the "response" available to, and made by, each institution is a site of struggle. Moreover, curriculum — including Chemistry — is deployed strategically in order to generate possibilities that are desirable to the stance of the institution. The final product of these distinctive stances is human capital which embodies the knowledge and skills to fulfil a role within the knowledge economy. The official ways in which Chemistry marks out distinctive human capital is the focus of the following section of this thesis.

8.4 Chemistry: Branding distinctive human capital

The role of human capital, and processes of developing particular forms of human capital in relation to the knowledge economy, is intensifying. According to Adkins (2005), the process of human capital development gives prominence to "embodied performance" (p. 111) which modifies the relationships between people, their labour and the economy. In particular:

> What the concept of human or embodied capital assumes, however, is that people can own or at the very least accumulate forms of capital: that various forms of capital stick to the human subject, a version of personhood which assumes that subjects *may own property in the person* and may abstract or disentangle that property *and trade it as a resource for exchange* … in the new economy *qualities previously associated with people are being disentangled, are the object of processes of qualification and re-qualification*, and moreover … claims to these qualities are made *not through claims towards ownership of these qualities as forms of property in the person* (as labour power), but rather through *claims which operate external to the domain of personhood* [emphases added]. (Adkins, 2005, p. 112)

Here, Adkins draws attention to a number of important considerations. Firstly, human capital theory assumes that elements of property in the person, such as abilities, capacities and skills, constitute the labour power of an individual. The individual who embodies particular degrees of labour power can exchange the use of his/her body and him/herself for wages in the labour market. Secondly, Adkins suggests that this view of property in person may no longer hold a great deal of explanatory power in, what she refers to as, the "new economy"— which she considers to be "organised by cultural principles of the brand" (p.126). Finally, Adkins (2005) argues that "qualities previously associated with people are being disentangled" (p. 112), that is to say, qualities that would have been considered impossible to remove or separate from an individual are being distanced from the person, and as such, these qualities are being transformed as properties with cultural value. In the following analysis, each of these considerations will be employed in turn to examine the 'knowledge and skills' developed by Queensland students of the QSA (2007) Chemistry syllabus as well as the 'attributes' of graduates from three university groups each with a distinctive stance in relation to the deployment of Chemistry as a pre-requisite to entry, in the context of an innovation-led knowledge economy.

In a recent report entitled *Building the capacity to innovate: The role of human capital* (Smith, Courvisanos, Tuck, & McEachern, 2012), innovation is positioned as pivotal to the diversification of Australia's economic base. Moreover, appropriately developed human capital (along with technological capital) is considered central to the development of innovation across various scales (Dale, 1999). In regards to human capital development, Smith et al. (2012) found that "to foster innovation, enterprises need to recruit, hire and retain the right people, people with a variety of personal characteristics, knowledge, expertise and skill" (p. 13). Two such characteristics are the "accumulation of knowledge" (p. 13) and "creativity" (p. 14). However, the authors of this report clearly differentiate between creativity and innovation in the following statement:

> Creativity is the generation of new and useful ideas by individuals, and innovation is the successful implementation of such ideas. For human resources management scholars and practitioners, the differentiation between creativity and innovation is critical, because it is the management of employees, the individuals in the enterprise that elicits creativity, whereas innovation – the implementation of creative ideas – operates at the group and organisational level. (Smith et al., 2012, p. 14)

With regards to creativity, the Chemistry syllabus (QSA, 2007) includes the following statement in its introductory paragraph: "Science education should help students *envisage alternative futures* and *make informed decisions* about science and its *applications* [emphases added]" (QSA, 2007, p.1). In this statement, the student of science is positioned to develop creative thinking and problem-solving strategies, particularly in relation to “envisaged” or imaginary future scenarios. ‘Making informed decisions about the application of science’ is a ‘skill’ or ‘ability’ that Smith et al. (2012) might consider to be the domain of groups or organisations, in that it pertains to the implementation of creative ideas. As such, students of Chemistry can be perceived to have attained abilities and skills that are available at the organisational level. The study of science broadly, according to the QSA (2007, p.1), should also:

- *build upon students' understandings of science* and challenge these where necessary
- *provide excitement, motivation and empowerment*
- *encourage a thirst for and a willingness to incorporate new and existing knowledge*
- encourage critical reflection
- *develop creative thinking skills*
- provide a lens through which to view the world [emphases added]

By examining these syllabus statements, students undertaking study of the sciences broadly, should be enabled to develop their capacities in knowledge attainment and development as well as in creative thinking. The attitudes of the students towards this task should also be developed such that they are “thirsty” (QSA, 2007, p. 6) for such experiences, and open to challenging their own thinking and ideas, along with the knowledge and ideas of the community more broadly. Again, these are skills, abilities and capacities that would be useful at the scale of an organisation competing in an innovation-led economy.

The work of a Chemistry student in Queensland is evaluated according to four general objectives: Knowledge and conceptual understanding; Investigative processes; Evaluating and concluding; and Attitudes and values (QSA, 2007). Of these four general objectives, the attitudes and values objective is not directly assessed or used to determine the final level of achievement of the student. However, as is stated by the QSA (2007) “the dimension Attitudes and values relate to the affective elements that the course aims to encourage" (p. 4). As a result of completing the course of study outlined in the QSA (2007) Chemistry syllabus:

> Students should incorporate chemistry into their view of the world, and realise the impacts of chemistry on it. They should *envision possible, probable and preferred futures* and *take responsibility for their own actions* and decisions to promote ethical practices… [students should] *develop a thirst* for chemical knowledge, *become flexible* and *persistent* learners and appreciate the need for *lifelong learning [emphases added]*. (p. 6)

While the attitudes and values reportedly developed by students through their study of Chemistry are non-assessable, they align closely with the features of human capital development that Smith et al. (2012) considers necessary for the emergence of innovation. However, Smith et al. (2012) state that while the 'capacity to innovate' may indeed be present and observable in human capital, such capacities will not necessarily translate directly to innovation. As such, factors that transform 'capacity to innovate' into 'innovation' were considered by Smith et al. (2012) to be vital in order to leverage an innovation-led economy.

In Adkin's (2005) terms, while students of Chemistry may be able to claim that they have developed the 'capacity to innovate', this capacity alone will not be enough for an individual to leverage labour power within the new economy. This capacity will only have exchange value through its external recognition; through "re-qualification". Instead, what Adkins suggests becomes more significant in the new economy, is a focus on "the effects of their labour (cultural work) on the intended audience" (2005, p. 123). As such, while the QSA syllabus (2007) makes rhetorical statements about the skills and abilities accumulated by students of Chemistry, it is no longer these skills and abilities per se that leverage access to tertiary institutions. A shift of governance in the higher education sector has instead allowed institutions to regard participation in Chemistry as a cultural act, intended for some institutions and not for others. In this way, the act of naming Chemistry as a pre-requisite could be read as an act of branding particular individuals, courses and institutions as the 'innovators' for an innovation-led economy.

8.5 Conclusion

In contemporary Australian policy, Chemistry is positioned as an 'enabling science'; leveraging access to tertiary institutions and underpinning the transition to an innovation-led economy. In this construction, Chemistry, as a secondary school subject, is positioned as a stable and predictable set of learning experiences nationwide. However, analyses presented in this chapter have demonstrated that 'Chemistry' is itself a problematic conception. Each state and territory jurisdiction, Australia-wide, has its own official version of the Chemistry syllabus. Moreover, with regard to the Queensland Chemistry curriculum, there have been numerous versions and changes to the official curriculum over the last 20 years. As such, the 'Chemistry' taught and learnt in Queensland classrooms has been less than stable. In Queensland, there was a significant shift in the pedagogical discourse of the Chemistry curriculum in 2002, when a context-based approach was implemented. Drawing on the work of Bernstein (1999), it was argued that this shift to a contextual-approach was synonymous with a shift from a vertical to a horizontal pedagogic discourse, for the purposes of facilitating access to the abstract, canonical curriculum dominant in a vertical pedagogic discourse. This theoretical position draws attention to Chemistry as a contested site of action that is shaped by struggles over what should constitute an official version of the curriculum, and who should make the decision as to what 'comes to count' as this official version. In Young's (2013), the purpose for such a recontextualisation can be called into question. The extent to which students gain access to "powerful knowledge" in such an approach goes unproblematised in the official curriculum documents despite the QSA positioning Chemistry as an important stepping stone for further study. This is a position that is echoed by the Office of the Chief Scientist (Office of the Chief Scientist, 2012b).

Chemistry is 'bound up' in tertiary entrance considerations in two key ways. Firstly, Chemistry has a highly ranked field position which can be used to distinguish between students with the same overall position applying for a place in a tertiary institution. Secondly, Chemistry may be named as a pre-requisite to entry to particular courses at particular institutions. The analyses presented herein, focussed on a case of Queensland universities, demonstrate that while Chemistry is named in relation to only 10.6% of all Bachelor degree courses offered throughout Queensland, Chemistry was named (either as a pre-requisite or as assumed knowledge) in relation to 82.3% of the courses offered in the Field of Health and Recreation, and (as either a pre-requisite or as assumed knowledge) in 100% of the courses in the Field of Sciences offered by Queensland's elite Go8 institution.

Notions of institutional habitus, in the context of a shift toward governance were employed in an attempt to explain the differential deployment of Chemistry between university interest groups. In doing so, the decision to include or exclude Chemistry as a pre-requisite to entry was implicated in the stance each institution takes in relation to equity and to the widening participation agenda. As Clegg (2011) and Crozier et al. (2008) highlighted, the place of curriculum in the debate over the widening participation agenda is missing from the literature. It is argued here that each institution is engaged in a struggle to secure a position in the field of higher education. The field itself is exposed to global market conditions and, as a result, each institution is forced to make strategic decisions about its stance from a limited set of possible positions. The decision to include or exclude Chemistry as a pre-requisite to courses may be made as a result of institutional habitus (Bourdieu, 1999). Alternatively, as a result of a breakdown between habitus and field, new social conditions of transformation become possible; that is, prevailing social, economic and political conditions make it possible for institutions to change the ways in which they position themselves in relation to the curriculum hierarchy evident in schools. Each institution is able to — and is expected to under de-regulated conditions of provision — mark out a distinctive stance, with respect to access within the field. Making the decision to apply or not apply Chemistry as a pre-requisite to course entry, then, works as a mark of distinction for the institutions and courses that name it and, by association, works to brand the students they enrol as distinctive and excellent. For institutions, Chemistry's inclusion or exclusion is strategic — doing so (re)produces reputation, or carves out a niche as an equity provider according to the desired stance of the institution.

For students, participation in Chemistry can demonstrate excellence and distinction in the marketised fields of secondary and higher education. Following the logic of Adkins (2005), making the decision to participate in Chemistry (or not) at secondary school, then, may become less about the accumulation of skills and abilities needed for success in a particular discipline and more about an act of cultural performance intended for their preferred institutional audience. This a stance that would be disputed by Young (2013) who states that "subjects with their clear boundaries and rules offer them an opportunity to develop new identities as part of new communities of learners" (p. 113).

However, as is noted by Ball (2010):

> In all of this, the conditions of acquisition, the costs, inputs, investments underlying performance and accumulation of symbolic capitals, are obscured, their properties simply seen as ''legitimate competence''. In such misrecognition, children and their performances are essentialised rather than seen as socially, culturally and economically made up. (p. 162)

In other words, a student completing Chemistry may not necessarily develop "legitimate competence" in relation to the discipline, depending on the conditions of recontextualisation — the "selection, sequencing, and pacing of contents" (Young, 2013, p. 109). For secondary school teachers, such recontextualisation is must take into account "pedagogic criteria and their knowledge of the capabilities, experience and potential of the students" (Young, 2013, p. 109). Further to this, King and James (2013) note that the success of the demand-driven higher education sector relies on "student choices dictating the flow", as well as highlighting the need to consider the patterns of enrolment by "people from under-represented social groups such as those from lower socioeconomic status (SES) backgrounds and those living in rural and regional areas." (p. 12).

The analysis presented in the next Chapter, follows from here. It explores the choices of students living in rural and regional Queensland in relation to secondary school Chemistry. The goal is to draw attention to the problematic notion of 'choice' and to introduce the notion of 'risk' in relation to students choosing whether or not to participate in the study of Chemistry during their secondary schooling.

Chapter 9 SET plans and 'Choosing' Chemistry: Teachers as 'brokers' and students as 'entrepreneurs of the self'

9.1 Introduction

This chapter focuses on a key transition of, or made by, secondary school students – that is, as students complete Grade 10 and enter the phase of senior schooling (i.e., Grades 11 and 12). This transition is otherwise known as the 'Year 10 to senior transition'. The nature and purpose of senior schooling in Queensland has been transformed in accordance with the *Education and Training Reforms for the Future* (ETRF) (Queensland Government, 2002a, b). Senior Education and Training Plans (SET Plans), as one of the key planks in the ETRF, require students to formally and systematically articulate their aspirations for their future, ideally in collaboration with their parents/carers. In return, schools are charged with facilitating the SET planning process on behalf of the students, such that each student is able to leverage a future aligned with her/his aspirations.

The significance of the 'Year 10 to senior' transition, as was detailed in Chapter 3 of this thesis, lies in the transformation of the locus of student agency. It is argued here that during the SET planning process students are positioned by teachers, and by policy, as 'entrepreneurs of the self' – whereby students must seek "to 'enterprise' [their] life … through acts of choice" (Rose, 1998, p. 170). Meanwhile the work of teachers has, too, been transformed such that it incorporates the 'brokerage' of educational services and products (Harreveld, 2007). Concomitantly, 'choosing' (or not) to invest in particular educational products and services, such as the subject of Chemistry, positions students as 'responsible choice makers'. It is also argued here that through the establishment of the 'broker' and 'investor' binary the SET planning process systematically mobilises the vocalisation of student aspirations at the cost of "unconventional aspiring" (Parry, Kenway, & Hockings, 2011, p. 5).

In order to explore the tensions between the 'brokerage' work of teachers and the 'investment' work made by students actively engaged as 'entrepreneurs of the self' the analyses presented in Chapter 8 draw on a commodification thesis (Williams, 2005) along with the discourse of the commodity market (Frush, 2008). In particular, these theoretical tools facilitate the construction of the senior secondary school subject of Chemistry as a ‘commodity’, and as such, its role in the ‘broker/investor’ relationship during SET planning can be explicated. As was discussed throughout this thesis, Chemistry serves as the site of examination as it is recognised as an ‘enabling science’ (Tytler, 2007). Declining participation in the enabling sciences is seen to be a major contributing factor in Australia’s Science, Technology, Engineering and Mathematics (STEM) crisis. Consequently, this chapter, Chapter 9, will draw out points of tension that arise in relation to SET planning, as a systemic choice making process operating in Queensland schools, and the participation of students in the subject of Chemistry at three ‘low socio-economic status’ secondary schools in regional Queensland. The findings of this Chapter highlight implications for secondary schools, charged in policy with increasing the participation of ‘non-traditional’ students in the study of STEM subjects, as a means of addressing the STEM crisis.

In order to draw out these tensions, this chapter will proceed as follows. In Section 9.1.1 below, having fully explicated the methodological approach in Chapter 2 of this thesis, a brief overview of the methodological approach is presented. Following that, Section 9.2 introduces key features of the policy moment dominated by the *Education and Training Reforms for the Future* (ETRF) which currently underpin senior schooling in Queensland. The transformation and restructuring of teachers’ work as a result of the SET planning process, and the implications of such transformation on student choice-making – particularly in relation to participation in STEM subjects – is explored in Section 9.3. Then, Section 9.4 of this chapter presents an analysis of the various ways in which students are positioned, that is, by themselves, by teachers and by policy as ‘entrepreneurs of the self’. Chapter 9 concludes with a synthesis of the key ideas to be drawn from the data and its subsequent analysis (Section 9.5).

9.1.1 Framing the Data

As was detailed in Chapter 2 of this thesis, the data presented in this chapter (Chapter 9) constitutes the third phase of analysis in a three phase “sequential, mixed model investigation” (Tashakkori & Teddlie, 1998, p. 150), focused on policy reception. As was stated in Chapter 2, the reception of policy — as a unit of analysis — is concerned with the effects of policy in a given context (Blackmore, 2010).

Purpose and Research Questions

The purpose of this analysis is to examine the process of school subject ‘selection’ for students in three secondary schools experiencing social and economic disadvantage. Of particular interest are potential interactions between systemic choice-making initiatives such as SET planning and student participation in the ‘enabling sciences’ such as Chemistry. Table 9.1 below summarises the methodological approach employed and the research questions to be examined throughout this chapter.

Table 9.1
Summary of methodological approach - Policy reception phase

Unit of Analysis	Phase/Focus	Methodological Approach	Analytic Tools	Guiding Research Questions
Policy reception	Year 10 into senior schooling: SET plans	Mixed methods	Summary statistics	How do systemic pathway and planning initiatives influence pathways through secondary school science, and to STEM fields of study at university?
Aspirations, capitals and transitions	Student voice	Mixed methods	Narrative analysis of interview transcripts	How do students navigate the process of ‘choosing’ Chemistry, in low SES secondary schools in rural/regional Queensland?

The data sets analysed in this study were selected in response to the methodological scope articulated by Elliott (2008, p. 415) who describes the potential narrative qualities of cohort data and the “scope for innovative work that weaves together the different types of [qualitative and quantitative] evidence to produce new narrative forms”. With the methodological rationale in place, attention will now be turned to the data sources drawn upon to formulate preliminary findings.

School locations and contexts

Data were collected from three state secondary schools situated in different geographical locales; namely, urban, rural and remote locations throughout North Queensland, Australia. Each school is categorised as a low socio-economic status school according to their ICSEA Index (which the author recognises as problematic, however the use of this index will not be the focus of the discussion herein). Each school has been allocated a pseudonym and are, therefore, referred to throughout this Chapter as Brolga SHS – a rural school; Kookaburra SHS – an urban school; and Emu SHS – a remote school. Primary data, in the form of interviews with students and teachers as well as data related to student SET plans, were collected at each of these three school sites. Each of the primary sources of data are elaborated upon in the following Sections (9.1.1.3 and 9.1.1.4). In order to contextualise the primary data collected at each school site, secondary data, in the form of publicly available reports and websites, were also collected and reviewed using document analysis techniques informed by Denscombe (2007).

Interview data

Semi-structured interviews were conducted at each school site with both students and staff (all of whom have been allocated pseudonyms). Student interview statements are further annotated, following their pseudonym, with either a (C) for having completed four semester of Chemistry, or a (W) for students who withdrew from their study of Chemistry prior to completing four semesters of work. For example Jack (C); Emma (W).

In total, six staff members were interviewed across each of the three school sites. These staff held a range of positions in the schools: one Deputy Principal (Dave), two Heads of Senior Schooling (Cathy and Sharon) and two Senior Chemistry teachers (Helen and Dianne) being interviewed in total.

Twelve high school students completing Grade 12 in 2010 were interviewed across each of the three school sites. Recruitment of student interviewees was managed by each school and was based on the students' participation in the subject Chemistry for four or less semesters through Grades 11 and 12. The small number of students interviewed is indicative of the small numbers of students participating in the study of Chemistry at each school site. Six of the 12 students interviewed were male and six were female. Seven of the 12 students had completed four semesters of Chemistry; four of these were male and three, female. Of the five students who had withdrawn from Chemistry (that is, they had completed less than four semesters of Chemistry), four were female and one was male.

The interviews were digitally recorded and then later transcribed. Interview transcripts were returned to the participants for member checking prior to further analysis taking place. NVivo8 was used to code the interview data thematically. For the staff interview data, coding themes were derived from the work of Harreveld (2007) and Harreveld and Singh (2007) in relation to the transformation of the nature of teachers' work that has resulted from the ETRF – most specifically the role of 'broker' of educational services that has been added to the suite of responsibilities of, and for, teachers in the senior school. Student interview data were coded with themes derived from the work of Sellar and Gale (2011), whereby, mobility, aspiration and voice are theorised as a new "structure of feeling" (p. 115) for student equity in higher education which focuses on people's capacities in relation to higher education participation. Once organised thematically, the data was then analysed using Critical Discourse Analysis informed by Fairclough (1992, 1995, 2001, 2003, 2010).

SET plan data

Senior Education and Training (SET) plans for each senior student enrolled in Year 12 in 2010 were held in paper copy at each of the three school sites under study. Each SET plan was reviewed individually and the data contained within was collated in a Microsoft Excel spread sheet whilst in the field for later analysis.

It is important here to highlight the diversity of SET plan data that was 1) collected, 2) stored, 3) reported on, across each of the three school settings. At the time the data was collected in 2010, usual SET planning practice required each school in Queensland to develop and administer its own SET planning process and proforma locally. This diversity of approaches to SET planning relates directly to the diversity of data forms that were therefore available for collection. In other words, the SET plan data fields were not uniform across each of the three school sites and, therefore, not all data fields were able to be collected with uniformity, nor compared with uniformity between each site. Such a diversity of approaches to SET planning highlights a significant point of tension within what is framed as a systematic, state-wide process of student support and guidance. However, despite the variety of their form, data concerned with each student's original subject choices along with changes to their subject choices during the senior years of schooling and articulations of, and any subsequent changes to, their aspirations were able to be collected. It is this data which informs the analysis presented herein.

9.2 The Education and Training Reforms for the Future (ETRF) policy moment

In Queensland, the Year 10 to Senior transition was intentionally and explicitly transformed as part of the ETRF policy moment (Queensland Government, 2002a, b). The ETRF transformation was structural and involved "three central planks" (Harreveld, 2007, p. 285) to enable a new qualifications system managed in, and by, Queensland secondary schools. The first plank is the *Queensland Certificate of Education* (the QCE) which, in principle, according to Harreveld (2007, p. 285) "will enable the tailoring of learning programs to individual students' needs and ambitions". The second plank involves SET plans. SET plans are, according to the Queensland Studies Authority (2010a), systemic 'choice-making' and planning tools 'ideally' completed by students in collaboration with their parents, under the guidance of expert school staff, during Year 10.The third plank is the *Registration of Young People System* (the RYPS). This plank includes the establishment of electronic learning accounts into which learning programs can be "banked" (Harreveld, 2007, p. 279). In order to provide background to the analyses undertaken in this chapter, the ETRF and two of the three central planks – namely, the QCE and SET planning – will now be discussed in more detail.

9.2.1 The Education and Training Reforms for the Future (ETRF)

The ETRF is a secondary school reform agenda integral to the *Smart State* policy suite of Queensland (Queensland Government, 2005b). The priorities of the *Smart State* agenda sought to transform Queensland's traditional industries such as mining, tourism and agriculture by employing "innovation" and "international competitiveness" as well as growing "emerging" industries that can "take the state's economy into the information age" (Queensland Government, 2005a, p. 1). The *Smart State* Policy Suite was complemented by a 2008 Department of Premier and Cabinet publication entitled *Toward Q2: Tomorrow's Queensland*. This publication indicated a shift of emphasis – *to* the information age and the jobs of the future that were to "emerge":

> The Queensland Government has already invested heavily in diversifying the state's economic base from our traditional strengths in mining, tourism and agriculture to future industries of aviation, health & education services, medical research and technology. Under Smart State, 60,000 new jobs in knowledge industries have been created. (Department of the Premier and Cabinet, 2008, p. 13)

The ETRF was positioned to respond to the emergent labour market transformation, in what is referred to as the "rapidly changing and increasingly complex world [that young people live in] that demands more education and training throughout [their] lives" (Harreveld & Singh, 2007, p. 8). According to Harreveld and Singh (2007, p. 3), the ETRF's senior phase of learning reforms focussed on "participation, retention, transitions and pathways" were based on policy decisions made in response to globally changed social, political and economic conditions – policy decisions aimed at increasing "direction and hope to the future work/life trajectory of young Queenslanders". The ETRF aimed to connect the notions of supported transitions for students – from middle school to senior school, from senior school to work, or from senior school to tertiary education – and the idea of "socially responsible pathways for education and training into the future" (Harreveld & Singh, 2007, p. 3) by ensuring that students engaged in either learning or earning in the senior phase of schooling. Through their review of the ETRF, Harreveld and Singh (2007) found that one of the key outcomes of the reform process had been the “tying together of social justice with concerns about prosperity” (p. 3). In addition, they found the ETRF to have made nine major achievements. Two of these nine are of particular relevance to the data presented herein. Firstly, as they note, one of the major achievements of the ETRF was that “senior secondary schools themselves now manage young people’s access to creditable education and training opportunities with other learning providers” and, secondly, “the goodwill and networking deliberately generated and mobilised through these reforms which have enhanced the social capital available to all participants for the benefit of young Queenslanders” (Harreveld & Singh, 2007, p.4). The extent to which these ‘achievements’ have been realised at the school sites under study will be discussed in relation to the data presented herein.

As a result of the ETRF, the purpose of Year 10 was transformed such that it became the foundation for the Senior Phase of Learning, and individual schools and school communities were granted local and contextual flexibility to decide how Year 10 would act to build supportive and responsible transitions and pathways in the Senior Phase of Learning. This enhanced ‘flexibility’ was reported to allow schools to “better prepare young people in Year 10 for their future studies” (Queensland Government, 2002b). Data presented in Sections 9.3 and 9.4 of this chapter will leverage a critical reading of the impact of such ‘flexibility’ on the teachers and students engaged in teaching and learning at the school sites under study.

9.2.2 The Queensland Certificate of Education (QCE)

While Grade 10 is positioned as the beginning of senior schooling for Queensland students, completion of the senior phase of schooling, for most students, occurs at the completion of Grade 12. Students who have completed, and are regarded as eligible students, are awarded the QCE. The QCE credential is issued by the QSA and is an internationally recognised qualification. As such, the QCE recognises learning that the student may undertake in a variety of settings including the school subjects, vocational education and training (VET) and university subjects undertaken whilst at school, as well as a range of community learning that the student may undertake whilst enrolled as a senior student in a school. According to the QSA (2010a), the merits of the QCE include the range of flexible pathways that a student may engage with throughout her/his senior years of study.

In order for a student to be awarded a QCE, she/he must complete her/his studies in accordance with a particular pattern, as is outlined below:

> To gain a QCE students need: an amount of learning (20 credit points) → at a set standard (sound achievement, pass or equivalent) → in a set pattern (at least 12 credit points from completed core courses of study) + an additional 8 credit points from a combination of any courses of study + meet literacy and numeracy requirements. (Queensland Studies Authority, 2012b, p. 2)

In the event that a student has not achieved the amount of learning required in the set pattern by the end of Grade 12, she/he is able to continue adding to their learning account for up to seven years after leaving school. In this way, students are 'banking their learning achievement' in their QSA learning account for withdrawal later in life. Overall, the QCE has been conceptualised in order to "allow students to tailor *their* senior pathway to suit *their* interests and support *their* future goals [emphases added]"(Queensland Studies Authority, 2012b, p. 2). However, it is argued here that the extent to which the students engaged in learning at the three school sites under study, are, in fact, 'responsible' for tailoring *their own* pathway decisions requires problematisation, and this point will be drawn out in the data analysis to follow in Section 9.3 of this chapter. In Grade10, QCE planning facilitates this tailoring process by requiring each student to develop a SET Plan. SET planning will now be discussed in Section 9.2.3 below.

9.2.3 Senior Education and Training (SET) Plans

For students in Queensland, making the transition from Grade 10 to Grade 11 involves the completion of a Senior Education and Training (SET) Plan. Harreveld and Singh (2007, p. 37) regard the SET planning process as a "key transition planning tool" in the ETRF structural reform. According to the QSA (2010a, p. 2):

QCE planning starts in Year 10, when students develop a Senior Education and Training (SET) Plan. The SET plan helps students structure their learning around their abilities, interests and ambitions. The plan is agreed between the students, their parents/carers and the school, and maps out what, where and how a student will study during their senior phase of learning – usually Years 10, 11 and 12. The SET plan should be developed by the end of Year 10, updated as necessary and regularly reviewed to monitor progress.

For students, SET planning constitutes the first official, systematic effort requiring the formal articulation of their aspirations for life beyond school. To support this effort, the nature and purpose of the SET planning process is represented for students in a statement entitled *Senior Education and Training Plans: A Guide for Young People* (Queensland Studies Authority, 2010a). This Guide details four phases of the SET planning process for students, namely: Stage 1 – Thinking about the future; Stage 2 – Exploring options; Stage 3 – Documenting the plan; and Stage 4 – Implementing the plan.

Stage 1 involves each student examining her/his strengths and ambitions as well as their life and career goals. With regard to this, the QSA Guide indicates that while young people should expect Stage 1 to be co-ordinated by their school the students themselves should draw on a range of "understandings" apparently developed in their prior years of schooling in order to complete the SET planning process. These understandings include:

> personal skills such as responsibility, respect for others and decision making; team work, leadership and communication skills; life skills such as budgeting and goal setting; how different societies and communities function; the world of work; the value of artistic expression; you have also explored where you fit into this world and how you can contribute. (Queensland Studies Authority, 2010a)

Stage 2 of the SET planning process involves the provision of extensive career and education advice, which the QSA Guide suggests to the students, is also the role of the school/learning provider. In the next stage, Stage 3, the Guide indicates the need for young people to “work closely with your parents/carers and your school/learning providers to document your SET plan” (Queensland Studies Authority, 2010a, p. 7). At this stage, students should also expect that their school will provide them with a set of Privacy Terms and Conditions for their SET plans. During the final stage of the SET planning process, Stage 4, students are encouraged to “actively works towards” (Queensland Studies Authority, 2010a, p. 9) achieving the goals articulated on their SET plans. Stage 4 also involves students regularly checking their Learning Account online, a process which the students should expect to be supported by their school. The QSA Guide for students states that is the role of the school to “support you to monitor and adapt your plan. Different strategies may be used including: preview sessions with a mentor and peers; personal interviews; requested meetings” (2010a, p.9).

Therefore, in general terms, the SET planning procedure involves each student reviewing her/his achievements – ideally in co-operation with their parents/guardians; thinking about their future aspirations, and making ‘appropriate plans’ to realise those aspirations. However, as was noted earlier, SET plans are implemented with a great deal of variability in Queensland schools, often compounded by challenges including limited parental involvement, limited student regard for the value of the SET planning process and difficulties with providing on-going professional development for the school staff involved (Harreveld & Singh, 2007).

Regardless of these challenges, SET plans are imbued with a variety of official purposes and agendas, the details and articulation of which are left to individual school communities to achieve. Such articulation is purported by Harreveld (2007) to provide ‘flexibility’ and ‘responsiveness’ for students and schools alike with the usage of these terms constructed as being of benefit. Instead, as will be highlighted through the analysis presented in Section 8.3 below, increased ‘responsiveness’ and ‘flexibility’ may not always translate to increased benefits to students engaged in the SET planning process in “exposed” school sites – that is, “a school site in which academic and social demands are in competition” (Teese et al., 2009). As advocated here, the school sites under study (Emu SHS - remote; Brolga SHS - rural ; and Kookaburra SHS - urban) are ‘exposed’ to these competing demands, which in turn impact on the nature of pathways provision occurring at each of these three school sites.

9.3 SET Plans as tools of restructure in the senior school

The following section (9.3.1) explores the role of teachers in the SET planning process at each of the schools under study; namely, Emu SHS, Brolga SHS and Kookaburra SHS. The data and subsequent analysis presented seek to respond to the following guiding research question: Does SET planning influence pathways to and through the sciences for students who are studying Chemistry in exposed school sites?

9.3.1 Describing and comparing the school contexts

The data pertaining to Brolga SHS, Kookaburra SHS and Emu SHS provided in Table 5.2 below are drawn from the official *My School* (Australian Curriculum Assessment and Reporting Authority, 2012b) website; each school's 2011 Annual Report; and from school websites. Further data has been extracted from *Next Step* 2011 reports for each school. *Next Step* reports are generated by Queensland's state government Department of Education and Training (2011a) annually and report on the initial study and employment destinations of Grade 12 students after leaving school. Overall, the 2011 *Next Step* reports had a response rate of 80.8%. Individual *Next Step* Reports are not referenced here in order to maintain the confidentiality of the schools that participated in the study presented herein. Following Table 9.2, features of these data that are salient to the argument are drawn out in separate sections for each of the school sites under study.

Table 9.2
Comparison of measures and outcomes for three schools under study

Post-school Destinations	Brolga SHS	Kookaburra SHS	Emu SHS
Location	Rural	Urban	Remote
2010 ICSEA index	916	878	837
% of students in each ICSEA quartile (4^{th}, 3^{rd}, 2^{nd}, 1^{st})	55,23,15,8	55, 21, 19, 5	N/A

Total student population (Years 8-12)	500	535	904
Boys, Girls	252, 248	266, 269	485, 419
% Indigenous Students	15%	24%	33%
% ESL students	1%	0%	N/A
Attendance rate	88%	78%	84%
FTE Teaching staff	43.7	47.9	81.9
FTE non-teaching staff	19.2	19.2	56.6
Finances			
Total net recurrent income	$6,776,273	$7,392,351	$14,384,008
Per student net recurrent income	$13,553	$13,817	$15,926
Total capital expenditure	$196,446	$160,877	$4,665,568
Disciplinary absences			
Short suspensions (1 to 5 days)	127	109	306
Long suspensions (6 to 20 days)	26	75	22
Exclusions	1	12	0
Cancellation of enrolments	0	22	0
Satisfaction survey			
Percentage of parents/caregivers satisfied that their child is getting a good education at school (2010), 2011	(N/A) 64%	(70%) 85%	(77%) 81%
Percentage of students satisfied that they are getting a good education at school (2010), 2011	(57%) 72%	(56%) 68%	(67%) 79%
Outcome	Brolga SHS	Kookaburra SHS	Emu SHS

% of students in learning	65.4%	38.1%	47.3%
Combined VET total	46.2%	21.4%	29.7%
University	19.2%	16.7%	17.6%
% of students in earning	28.8%	47.6%	37.4%
Full-time work	19.2	11.9	19.8
Part-time work	9.6	35.7	17.6
Seeking work	5.8%	9.5%	14.3%
Not studying	0%	4.8%	1.1%

Note. **ICSEA index = Index of Community Socio-Economic Advantage. The median ICSEA value is 1000; ESL = English as a second language; FTE = Full-time equivalent; VET = Vocational Education and Training. Table generated from data published by ACARA (2012), Department of Education and Training (2011) and each school's 2011 Annual Report.**

Brolga State High School

Brolga SHS is located in a rural setting, about one hour from a major regional centre in Queensland. In 2010, the school had 500 enrolments; 252 were boys and 248 were girls. Fifteen percent of the student population identified as Indigenous, which was greater than the Queensland average of 8.4% (Queensland Government, 2011). As stated in the School Annual Report, the school's student population comes from a diverse range of family backgrounds with the proportion of students from low socio-economic backgrounds and/or single parent families increasing over time. Concomitantly, Brolga SHS's ICSEA index is noted to be 916, with the median ICSEA value being 1000, resulting in the school being regarded as a 'low socio-economic status' school (Australian Curriculum Assessment and Reporting Authority, 2012b). In 2010, 65.4% of the Year 12 students leaving school entered into further learning. Of these, 46.2% pursued a VET pathway (regional average: 25.9%), while 19.2% accepted or deferred a position at a university (regional average: 32.7%). A further 28.8% of students entered the workforce in either a full or part-time capacity (regional average: 31.3%), while 5.8% sought employment (regional average: 8.3%) (Australian Curriculum Assessment and Reporting Authority, 2012b; Department of Education and Training, 2011b).

According to the school's official summary on the *MySchool* website, Brolga SHS school prides itself on offering a full range of curriculum options for students. Again, in the school annual report

Brolga SHS claims to have a "strong focus in our senior school on achievement of quality OP scores…with major focuses in Mathematics and Sciences, English and Performing Arts." Vocational Education and Training (VET) courses are also facilitated through partnerships with the local TAFE. Students are able to complete a Certificate II in Engineering, Automotive, Retail or Hairdressing and a Certificate III in Child Services.

Kookaburra State High School

Kookaburra SHS is located in the outer suburbs of a major regional centre in Queensland. In 2010, the school had 535 enrolments; 266 of these were boys and 269 were girls. Twenty-four percent of the student population identified as Indigenous, which was three times higher than the reported Queensland average of Indigenous student participation (Queensland Government, 2011). In the 2011 School Annual Report, Kookaburra SHS makes explicit statements about valuing its students' diverse backgrounds. In 2010, the ICSEA index for Kookaburra SHS was 878 (Australian Curriculum Assessment and Reporting Authority, 2012b). According to 2011 *Next Step* data, 38.1% of students were engaged in further learning at the completion of Year 12, with 21.4% entering VET courses (compared to the regional average of 25.9%), with 16.7% attending university, much less than the regional average of 32.7%. A further 47.6% of students entered the workforce in either a full or part-time capacity (10% higher than the regional average), with the retail sector being the primary field of employment for these students. However, 9.5% of students graduating from Year 12 in 2010 were seeking employment (regional average: 8.3%), with a further 4.8% neither studying nor employed. As such, of the three school sites under study, Kookaburra SHS produced the greatest proportion of students not engaged in either employment or further study after completing Grade 12.

In relation to curriculum, Kookaburra SHS states that it has developed a strong tradition of providing students with a large number of educational opportunities as well as emphasising the development and extension of the individual. Kookaburra SHS lays claim to a full range of innovative curriculum development which "guarantee the competitiveness" of their graduates in the real world.

Furthermore, Kookaburra SHS claims that its “staff are up to date with the latest developments in curriculum design and delivery.”

Emu State High School

Emu SHS is a multi-campus school located in a remote location in Queensland. In 2010, 904 students (485 boys and 419 girls) were enrolled at the school, with 33% of the student population identifying as Indigenous; four times that of the Queensland average, and the largest proportion of students who identify as Indigenous in the three schools under study. According to Emu SHS’s *My School* website, this is a feature of their school community that is “embraced”.

In 2010, the Emu SHS ICSEA index was noted as 837 (Australian Curriculum Assessment and Reporting Authority, 2012b) the lowest of the three schools under study. However, in contrast to Brolga SHS, that explicitly emphasises the “low socio-economic backgrounds” of its student population, Emu SHS does not focus on this aspect of its students’ backgrounds in any of its published written material. Instead, the school publishes affirmational statements that recognises and values the hard work and high performance of its students. The role of individualised pathways and personalised learning programs in the success of the students who attend Emu SHS is also emphasised on the school website (Australian Curriculum Assessment and Reporting Authority, 2012b). The school’s mission statement also points to the significance of pathway planning to the achievement of high quality outcomes for each student. These pathways, according to *Next Step 2011*, resulted in 47.3% of students moving into further training after Year 12 in 2010 with 29.7% of students moving into VET courses (regional average: 25.9%), and 17.6% of students attending university (regional average: 32.7%). A further 37.4% of students moved into either full or part-time employment (compared with the regional average of 31.3%), while 14.3% of students were still seeking work, with a further 1.1 % neither studying nor employed. This represents the highest proportion of students seeking work of each of the three school sites under study.

Despite this, Emu SHS, as a member of the Queensland Minerals and Energy Academy (see Figure 5.1), actively promotes their role as a pathway provider for all students, and has forged strong partnerships with the mining sector. According to the school's 2011 Annual report, such partnerships have afforded a range of "distinctive curriculum offerings" as well as a range of extra-curricular activities, some of which are of particular relevance to this study, including science and engineering camps – with particular emphasis on encouraging girls in engineering, and Gifted and Talented Programs – including a program for Year 7 students in the areas of Maths and Science. In addition, bursaries (funded by mining companies) are offered to Year 11 students, enabling them to transition into a School-based Apprenticeship or Traineeship (SAT) in their preferred trade or field. Furthermore, since 2007, a "Skills for the Future" program was offered for Year 9 and 10 students to give them an opportunity to attend a Skills Centre operated by a mining company, such that students could experience trade skills one afternoon each week for one term.

Figure 9.1 An image captured from the home page of Emu SHS's website communicating their affiliation with the Queensland Minerals and Energy Academy

9.3.2 Comparison of QSA Year 12 Outcomes data

Each year, the QSA publishes outcome data for the Year 12 graduates for each school in Queensland. Presented here are comparisons drawn from three QSA Outcomes reports – the 2008 Year 12

Outcomes published May 2009; the 2009 Outcomes published August 2010; and the 2010 Outcomes published June 2011.

On the first page of each of these consecutive QSA reports (2009, 2010b, 2011b) the identical summary statement can be found: "The data show that Queensland's Year 12 students are graduating from high school with the skills and qualifications to follow a range of rewarding work, further education and training." Through such affirmational declarations, the Queensland Government is able to legitimate their ETRF agenda in senior schools in Queensland. As is summarised in Table 9.2below, the outcomes of interest that are measured and reported in the QSA Outcomes reports include the number of students who received an OP or tertiary ranking; the number of students who received on OP in the 1 to 15 range (with a score of 1 being the highest OP score attainable), as well as the number of students who did not receive a credential at the completion of Grade 12. These credentials may be either an OP; a QCE a Queensland Certificate of Individual Achievement (QCIA); an International Baccalaureate Diploma (IBD) or a VET qualification. In other words, students in this category left school without any of the standard qualifications issued to Year 12 graduates as part of the reformed pathways through senior school.

Figure 9.2 Summary of Year 12 outcomes for each of the schools under study

Outcome	**Brolga SHS**			**Kookaburra SHS**			**Emu SHS**		
	2008	**2009**	**2010**	**2008**	**2009**	**2010**	**2008**	**2009**	**2010**
Number of students awarded a senior statement	68	79	67	45	73	60	122	166	117
Number of students awarded a QCIA	0	0	0	2	2	2	2	4	0
Number of students awarded a QCE at the end of Year 12	48	61	52	26	40	33	65	109	93
Number of students awarded one or more VET qualifications	27	58	51	41	71	48	94	127	103

Number of students who completed a SAT	10	16	13	2	7	8	31	32	24
Number of students who received an OP	31	43	30	15	25	27	47	63	42
Number of students who did not receive one or more of the following qualifications: OP, QCE, QCIA, IBD, VET	12	6	3	3	1	9	13	16	5
Percentage of OP/IBD students who received an OP 1 to 15 or an IBD	74 %	74%	73%	60%	72%	48%	55%	60%	76%
Percentage of students who are completing or completed a SAT or were awarded one or more of the following qualifications: QCE, IBD, VET	79%	86%	93%	91%	97%	83%	81%	86%	95%
Percentage of QTAC applicants receiving an offer	96%	90%	96%	100%	100%	94%	86%	87%	94%

Note. Table compiled with data sourced from QSA (2009, 2010, 2011).

The three outcomes in Table 9.2 that are of most interest to this thesis are the number of students awarded a QCE at the end of Year 12 (row 3); the number of students who did not receive a qualification (row 7); and the percentage of OP students who received on OP 1 to 15 (row 8). Table 9.3 presented below summarises data drawn from the QSA and shows the range of OP scores attained by students at each of the schools under study. Schools are required to report against the percentage of students who obtain an OP score in the 1 to 15 range, and as such this data has come to represent an important measure of school performance.

Table 9.3
Summary of range of OP scores for 2010 for each school under study

School	Year	1- 5	6 - 10	11 - 15	16 -20	21 - 25	Total with OP
		OP Range					
Brolga SHS	2009	6	11	15	10	1	43
	2010	3	11	8	4	4	30
Kookaburra SHS	2009	1	10	7	3	4	25
	2010	3	4	6	8	6	27
Emu SHS	2009	10	12	16	16	9	63
	2010	8	14	10	9	1	42

Note. Table compiled with data sourced from the QSA (2010, 2011).

Brolga SHS

At Brolga SHS, it is clear that the number of students who receive a qualification at the completion of Grade 12 has increased (see Table 9.2). The data shows that 79% of students received a qualification in 2008, while in 2010, 93% of the Year 12 cohort were graduated with a recognised credential.

With respect to OP score attainment, the number of students receiving an OP score has fluctuated over the three years from 2008 to 2010. As shown in Table 9.2 above, 31 students received an OP score in 2008. In 2009, this increased to 43 students, while in 2010, the number of students receiving an OP score decreased to 30. While more students received an OP score in 2009 compared to 2008 and 2010, it is of interest to note that most of these additional OP scores were located in the 11 to 15 and 16 to 20 OP score range, resulting in a relatively stable percentage of students receiving an OP score in the 1 to 15 range (74% in 2008; 74% in 2009 and 73% in 2010) (see Table 9.2). In other words, while more students were awarded an OP score, this provided little leverage to the school in terms of the QSA's official measure of accountability related to improvement in the percentage of students achieving an OP score in the 1 to 15 range.

Kookaburra SHS

At Kookaburra SHS (see Table 9.2), while the number of students receiving an OP score has increased (from 15 in 2008 to 27 in 2010), the percentage of students who received an OP score in the range of 1 to 15 has actually declined from 60% in 2008 to 48% in 2010. In other words, while more students obtained an OP score, the number of students achieving an OP score in the 1 to 15 range has not commeasurably increased. Again, this pattern of OP score achievement provides little leverage for the work of Kookaburra SHS in relation to official measures of accountability.

Emu SHS: Emergence of 'making the numbers look right'

Like Brolga SHS and Emu SHS, the pattern of OP score attainment at Emu SHS has also fluctuated. However, the changes follow a different, and, arguably, a more strategic, direction. As shown in Table 9.3, the total number of students who received an OP has, in fact, decreased over time. In 2008, 47 students received an OP score; in 2009 this increased to 63 students, while in 2010, the numbers decreased again to 42. This decrease in raw numbers of students receiving an OP score follows a pattern similar to that reflected in the data for Brolga SHS, whose numbers of OP scores also decreased, following a short sharp increase. Concurrently, the number of OP scores received by students at Kookaburra SHS steadily increased over time.

The difference between the attainment of OP scores at Emu SHS compared to Brolga SHS is that the numbers of students who received an OP score decreased, while the percentage of students receiving an OP in the 1 to 15 range has increased from 55% in 2008 to 76% in 2010. This increase in the percentage of students who received an OP in the 1 to 15 range provides leverage against this official key accountability measure for Emu SHS. A similar increase in percentage was not evident in the data for Brolga SHS. In addition to this strategic expansion in the OP 1 to 15 range, Table 9.4 shows that the number of students who received an OP in the 15 to 25 range also decreased; in other words, the less strategic tail of their OP score data had shortened. So, while fewer students received an OP, the OP scores that were issued ranked highly in relation to the official QSA outcome report data.

It is argued here that these patterns of OP score attainment are reflective of strategic student pathway planning processes that are occurring at Emu SHS. Such processes contribute to outcome data that is beneficial to the school by leveraging success against key accountability frameworks of interest to the QSA. Lending weight to the argument of strategic pathway planning processes at work is the emergence of the notion of 'making the numbers look right' in the interview data from the teachers at Emu SHS a point of significance that is elaborated upon in Section 9.3.5 of this chapter.

Having presented an overview of each of the contextual features of the schools under study drawn from the analysis of publicly available secondary data, attention will now be turned to the presentation and analysis of the interview and SET planning data collected at each of these school sites. Section 9.3.3 begins with an examination of the 'intensification' and 'diversification' of the role of the senior teacher in relation to SET planning. Moreover, implications of the transformation of the teachers' role for students faced with making subject 'choices' in the SET planning process is examined. The chapter then moves to examine the ways in which 'mitigating risk' serves a dual purpose in an era of neoliberal accountability measures.

9.3.3 Intensification and Diversification: Resources, forces and 'robust hope'

The notion of the intensification of teachers' work is not new. Almost two decades ago, Apple (1986) posited the notion that teachers' work is penetrated by external policy demands which require teachers to achieve more with fewer resources. Intensification results in the de-professionalisation of teachers, as the nature and features of their daily work are determined by external forces. However, it is argued here that the force of intensification and the impetus for professionalisation of teachers has been discursively employed by the ETRF such that 'intensification' leads to better outcomes for both teachers and the students they serve. Such discursive efforts work to both mobilise and normalise the act of 'brokerage' into the everyday work of senior secondary school teachers. Such discursive positionality is evident in the work of Harreveld (2007) who regards the work of senior secondary school teachers as "repositioned" by the ETRF as is demonstrated through this passage:

> … school teachers now engage in inter-sectoral and inter-agency *brokerage* of work experiences, vocational and academic courses; provide flexible learning services; plan holistic engagement strategies addressing young people's social emotional and financial needs as well as their learning needs; and *grow their innovative leadership capacities as a result* [emphases added]. (Harreveld, 2007, p. 284)

From this, it is clear that the intensification of teachers' work, such that it incorporates brokerage, is positioned by Harreveld as a positive addition to the work of teachers – allowing them to 'grow their innovative leadership capacities'; in other words, to develop their professionalism as a teacher. Harreveld (2007) further discusses the merits of teachers' engagement with traditional and emerging knowledge industries as well as the benefits that may be derived by working in cross-sectoral articulations. What is clear, at least from Harreveld's stance, is that the traditional role of the senior secondary teacher as a discipline specialist has been transformed, and transformed in ways that, as quoted above, "address young people's social emotional and financial needs as well as their learning needs" (p. 284). However, as will be demonstrated in the data presented below the merits of 'professionalisation' resulting from intensification, as purported by Harreveld, are not as clear cut for teachers interviewed in this study, nor is it clear cut for the students who rely on the professional expertise of their teachers during the SET planning process.

To begin the discussion of the intersecting forces of 'intensification' and 'professionalisation' a summary of tasks performed by Cathy as part of her role as Head of Senior Schooling at Kookaburra SHS is presented in Table 9.4 below. During her interview, Cathy spoke at length about the various roles and responsibilities she plays in the senior secondary school. These have been summarised according to the various domains to which the tasks relate. From Table 9.4 it can be seen that Cathy's work is stretched across five domains of practice, only one of which – categorised as 'teaching' – is related to the traditional pedagogical features of teachers' work. The other domains relate to her role as an administrator, facilitator and manager of pathways provision for the students who attend

Kookaburra SHS. The range of domains across which Cathy works speaks to the multiplicity of roles of the contemporary senior secondary school teacher.

Table 9.4
Summary of the scope and nature of tasks completed by Cathy, a Head of Senior Schooling at Kookaburra SHS

Task Domain	Overview of nature of tasks associated with the domain
QCS test	Preparation, planning and conduct of the QCS test
VET in schools	Promoting and managing the VET program in the school Identifying the students who want to participate in VET Identifying courses for the students who want to participate in VET Identifying an appropriate training provider for that course and student (online, or through various Registered Training Organisations) Liaising between the student and the training provider Making necessary timetable adjustments to allow for school-based traineeships to proceed Monitoring student outcomes achieved through training provider Monitoring and evaluation of SAT subjects taught at school Conduct internal audits and internal reviews of all VET subjects taught in the school Development of evaluation proformas and processes to enable evaluation of SAT subjects taught at school Organise courses that require hands-on components to be delivered at the school Assure whole of school compliance with Australian Quality Framework
SET planning	Overseeing the completion of SET plans Conducting in class lessons with students so that they are able to make informed decisions on their SET plan Organise and oversee the career expo
Work Education	Organising and authorising tax file number applications for all students Writing and editing resumes Organise work experience placements for students in Year 11 and Year 12 cohorts Monitor students on work experience
Teaching	Head of Department of Social Sciences – oversee assessment items, internal moderation, QSA monitoring and verification packages

Teach two classes
Behaviour Management role – care of at risk students in Years 8 to 12.
Overseeing Distance Education subjects offering through the school – supporting students engaged in Distance Education.

It is evident in Table 9.4 that Cathy's work is multiplicitous in nature and stretches far beyond that of a traditional discipline specialist. The role of teacher as a broker of educational services and products is in ascendance, while the role of a pedagogue — although remaining a significant aspect of a senior secondary school teacher's work — becomes less visible. This stance is supported by interview data collected from Cathy. The pedagogical nature of Cathy's work is the last feature of her work that she recounts in her narrative, in fact, the recount of her pedagogical work is reduced to two short sentences "I teach. I teach two classes." In contrast, the explication of her work as a broker consumes the majority of her narrative. Furthermore, as can be seen in the interview excerpt below, Cathy describes the lack of stability and clarity surrounding her role in the shifting terrain of the senior school. Salient points within the extract have been bolded for emphasis:

> At the moment, pretty much *it [the nature of her work] changes every week*, there are *new, more and more, tasks that are identified as being part the head of senior schooling role* **…** and a lot of that comes down from admin, so, instead of the deputies doing it, now I am expected to do it, so I need to say that *my role is unclear at this stage*, and a lot more *planning needs to go into identifying what are my duties and what am I expected to do* [emphases added]. (Cathy, 11/11/10)

The impact of intensification "is strongly mediated by the cultural and structural characteristics of the school as an organisation and by processes of interpretation by individual teachers" (Ballet & Kelchtermans, 2008, p. 48). As such, the demands of an external policy, such as SET planning, which underpins the ETRF, and the subsequent capacity of such policy to 'steer' the practice of teachers, is mediated by teachers themselves and the school communities in which they work. What is clear in

Cathy's statement above is the powerful structural and cultural features of the school, as evidenced by the lack of clarity surrounding the purpose, nature and features of her daily work. As such, it is argued that Cathy's enactment of SET planning policy is undermined by the inherent 'flexibility' in the school's approach to the role and responsibility of the Head of Senior Schooling in relation to SET planning. In order to extend upon Cathy's explication of her shifting and multiplicitous role in the senior school, Cathy was asked to describe how her role, as Head of Senior Schooling, aligned with the role of the guidance officer in her school setting:

> It's [the guidance officer's role is] a bit of everything, and *a lot of people get my role confused with her role,* and sometimes *there is a lot of overlapping* … Definitely a lot of overlapping and therefore I feel like my time is often wasted, when she could be doing certain things, that should be clearly her role, so I think [name] *spends a lot of time doing a lot of guidance for our student cohort*. In terms of, probably *more mental health, support and family issues and supporting students at risk, because we do have a lot of students at risk* [emphases added]. (Cathy, 11/11/10)

Further in the interview, Cathy describes the overlap between her role and that of the guidance officer as "frustrating". In this sense, and given Teese, Lamb and Helme's (2009, p. 6) definition, Kookaburra SHS could be regarded as an "exposed site"; that is, a school at which academic and social demands are in competition. In exposed sites, human resources such as Guidance Officers are involved in the more immediate needs of the students. Under the ETRF, it became clear that the transformed senior phase of schooling "required more than the provision of a part-time, incidental guidance from the margins of the school curriculum" (Harreveld & Singh, 2007, p. 48). Consequently, local governance structures called District Youth Achievement Plan (DYAP) management committees were put into place. The DYAPs were comprised of stakeholders relevant to the local setting: officials from employment, education and training sectors; business and industry representatives; parent and community organisations and according to Harreveld (2007, p. 276) "DYAPs were the ETRF's binding mechanism because they linked planning, resource allocation and integrated service delivery." The DYAP Management Committees oversaw two funding streams designed to drive change at the local level: Central Purchasing Unit Funding, which was to be used to re-engage young people already disengaged with schooling, and Access to Pathways Funding, which could be used to fund a range of initiatives, from workplace learning, to purchasing industry or vocational education and training experience, to using experienced knowledgeable mentors to work with young people 'at risk' (Harreveld, 2007). Overall, the DYAP initiatives were designed to ensure that the work of exposed schools was not further marginalised, and that additional support could be put into place to avoid situations where scarce resources, such as Guidance Officers, were even further stretched in the attempt to manage SET planning as part of the ETRF.

In order to gauge the extent to which the DYAP Management Committees and their supporting role was evident to, or realised by, staff in schools, Cathy was asked if she was aware of any additional funding or support that had been provided to Kookaburra SHS to oversee the SET planning process. In her response, Cathy described how schools receive an additional $3.30 for every tax file number application that is completed at the school, about which she commented "really isn't much." Further to this, Cathy stated:

> I know that when students who are enrolled in VET, that part of the grant monies that schools normally receive, the student will bring along certain money. When there are students enrolled in VET, you get more grant money for the school, but that's it, *there's no extra money anywhere. And we just have to do it* [emphases added]. (Cathy, 11/11/10)

Cathy was then asked if she had personally received any additional support or training to administer the SET planning process in her school:

> *No. It's just expected that it gets done … I'm not trained in guidance and career counselling, but you pick it up* [emphases added]. (Cathy, 11/11/10)

The same question, concerning the availability of funding or support for the SET planning process, was asked of Dave, a Deputy Principal at Emu SHS. It is clear from Dave's response that additional funding or support to manage the SET planning process had not been realised at Emu SHS either – a school that could also be regarded as an exposed site:

> Not that I am aware of [laughs]. *No*, I mean, when you get your TRS budget you allocate it every year, and I know I am just spending mine willy nilly at the moment … so *there's no in kind support*, as far as I know, *there's no operational support given to us, and there's certainly no financial support. It's just something else that schools do* [emphases added]. (Dave, 15/11/10)

The impetus to cope with new policy demands, such as those related to SET planning, are linked to teachers' desires to "maintain their social recognition as competent ('proper') teachers and colleagues, a recognition which is a central aspect of their professional identity" (Ballet & Kelchtermans, 2008, p. 48). The imperative to cope with new policy demands is evident in the statements from both Cathy and Dave and speaks back to Harreveld's (2007) sense of 'professionalisation' discussed earlier. Rather than intensification building professionalism, the imperative to retain professional reputation drives the impetus to normalise intensification. This statement is largely supported by a review of the 2011 School Annual Reports for the 2010 academic year. The areas of professional development received by staff show that none of the schools under study received any explicit training for administering SET plans. This lack of targeted support and professional development for teachers lends weight to the position that unsupported intensification at exposed schools only deepens the imperative to cope, and leaves students to be served by teachers who are not trained to support students as the policy imperative intended.

In the ETRF white paper (Queensland Government, 2002b) *schools* are discursively positioned as the agents responsible for administering, monitoring and updating SET plans on behalf of their students. Such positioning implies that the 'school' is an agentic, nominal entity that will work to achieve this goal. However, what is clear from the interview data presented above is that the *school* does not do this work on behalf of the students; *teachers*, working in schools, carry out this work on behalf of the students they serve. Perhaps, then, the work undertaken by teachers such as Cathy and Dave is indicative of what Harreveld refers to as "mobilising the goodwill and organisational capabilities of people in schools" (2007, p. 277) – an effort deemed as "essential for the success of these [DYAP funded] initiatives" (2007, p. 277). However, perhaps part of the challenge in exposed school sites is the amount of goodwill that is open to withdrawal.

Additionally, Cathy spoke about the Head of Senior Schooling Support Network that had "crashed" because the teachers who ran the support network were too busy to make time to meet. It is argued here that "mobilising the goodwill and organisational capabilities of people in schools" (Harreveld, 2007, p. 277) comes at a cost for the teachers who are positioned to carry out this systemic work without the necessary commensurate systemic support or resources. Furthermore, as a result of intensification of teacher workload associated with managing SET planning, students in exposed school sites are being underserved, resulting in efforts counterproductive to the rhetorical purposes of SET planning. The data presented herein shows that the SET planning process at the exposed school sites under study is not systemically resourced. Moreover, teachers, who are not trained in career guidance, work alongside Heads of Senior Schooling who are, in their words, "stretched" and "unsupported" in facilitating the SET planning process. Therefore, it is argued that intensification associated with SET planning, rather than building professional capacity, instead requires teachers to cope and to draw on their goodwill in order to manage the SET planning process for the students who attend the exposed school sites under study here.

9.3.4 Leveraging expertise through vacillating teacher roles: 'Broker' and 'Pedagogue'

Until this point, the ways in which SET planning has impacted on the work of Heads of Senior Schooling and Deputy Principals in the schools under study has been explored. However, the work of classroom teachers, working as discipline specialists has also been transformed as a result of SET planning. The professionalism and discipline expertise of senior secondary classroom teachers is critical to the SET planning process at the school sites under study. For example, senior discipline specialist teachers, such as Chemistry teachers, are delegated the authority to help students to make ‘informed choices’ about their future careers and aspirations. As such, the work of the senior secondary classroom teacher vacillates between that of discipline specialist, and that of broker of educational services and products. Despite receiving no training or professional development in career guidance or pathway planning, classroom teachers, as disciplinary specialists, are allocated authority to make decisions about a student’s capability to engage in the discipline/subject in which the teacher specialises. Helen, a Chemistry teacher and Head of Science Department at Kookaburra SHS, spoke about the nature and extent of her involvement in the SET planning process:

> First of all, we had to *put together a subject selection book*, and I designed my Chemistry, Biology, Multi-strand, all of those pages and I *made sure the pre-requisites and expectations were really clear in that booklet*, then I actually went to the Year 10 classes and explained all the subjects to them and what each of the subjects would involve. *I had a PowerPoint presentation to all of the Year 10s where I explained myself the subjects then,* those *kids had interviews with the Guidance Officer and Senior Schooling HOD where they were counselled through which subjects to take*, then, *I got a list of kids who had chosen Chemistry, I went back to their grades from Semester 1 year 10, and I advised the guidance officer of who I thought wasn’t suitable, and who I thought was going to be fine.* Now, if they failed science, I didn’t necessarily say “you can’t do it”. I tried to find out how and why and then saw if they were improving, they might have been on the way up. From there, the Guidance Officer then went back to the kids and said *why have you chosen chemistry*, and *if they had chosen it for a career that needed it, but their grades weren’t so good, we would still let them in. But if they had just chosen it because mum said or dad said, then they were counselled around it. But you will still always get kids in it who should not be … because you can’t say no* … but, this year’s process has been way better than previous years. *Like, [in the past] the kids have just gone off and done whatever they wanted, chosen their subjects, and I’ve got to sign to say yes. I’ve seen that they want to do Chemistry, but it was a one minute conversation in the corridor,*

> *you know, so the kids weren't selecting as wisely. I think Chemistry next year should be better because the kids have been counselled* [emphases added]. (Helen, 11/11/10)

In this extract, what becomes evident is that the work of the teacher as both 'broker' and as 'pedagogue' is intertwined. Helen, in this instance speaks about designing a subject information booklet to explain the requirements for the science subjects on offer at the school to the students. Helen also delivers a PowerPoint presentation to the Year 10 students wherein the nature, features, pre-requisites and expectations for each science subject offered by her department are outlined. Work of this nature is precisely the kind of "repositioned" brokerage work that Harreveld (2007, p. 284) describes in relation to vocational and academic courses. Helen acts as a broker, spruiking the potential merits and risks of each subject. Once this information has been presented, students may 'choose' to 'do' the subject, (that is, invest their time, resources and efforts into the subject), or make the choice not to invest. This 'backgrounding work' undertaken by Helen is critical to the SET planning process. Through Helen acting as a broker, providing background information about the subjects in the ways she has described, students are positioned as having received the information they need to make, drawing on Helen's words, 'a wise selection'.

A second point of interest in this extract is that once a student had made a 'choice' following an interview with the Head of Senior Schooling and/or the Guidance Officer to study one subject or another, her/his choices were scrutinised by Helen, again acting as a broker. In this instance, Helen's brokerage work aims to assist the student with making "socially responsible" choices (Harreveld & Singh, 2007, p. 3). Making socially responsible choices is a perspective that is echoed by Education Queensland (2010, para. 2) who state "SET Plans help young people learn about themselves, set realistic goals and explore how to achieve those goals. It is a great way to help young people take responsibility for their future". The language used by Education Queensland to describe the purpose of the SET planning process forms an unproblematic perspective regarding the potential for differentiated take up of neoliberal subjectivities by students. Helen states that a student's own career aspirations were an adequate reason to take a risk with a subject like Chemistry, and yet, a parent's suggestion that Chemistry should be undertaken as the primary reason for the choice is perceived to be of less value than if the student expressed the decision as their own choice. This point is exemplified by the statement “if they [the student] had just chosen it because mum said or dad said, then they were counselled around it.” In this act, parents are positioned outside the field of expertise to contribute to ‘wise’ or ‘sensible’ choice making. In this way, they are seen to be without the embodied cultural capital (Bourdieu, 2004) necessary to legitimately participate in such decision-making. Such a position sits at odds with dominant neo-liberal discourses of choice, whereby parents are positioned as central to the successful educational outcomes of their children through active choice-making in an education market (Apple, 2007). The parents in this case are silenced, and not regarded as important to the choice-making process.

Dianne, a senior Chemistry teacher from Brolga SHS, was asked if she could explain the pathway students take to gain access to Chemistry, and the different pathways that students take through Science in Year 10:

> Well currently *in Year 10*, and *we’ve been doing this for a few years*, we’ve had the *extension*, we’ve had the “*engineering*”, and we’ve got *other classes called “applied”*. And they’re *identified in Grade 9, based on their science grades* and *where they want to be*. One of the “applied” classes this year, has done a lot of science related to gardening and that sort of thing, and that’s been based on literacy and numeracy skills, that group. But the other *applied groups* are people who really weren’t doing well at Science, who have no interest in it. It’s [i.e., the study of Science] compulsory until the end of Grade 10 of course, and so they *were never in the picture*, so we’ve *already* sort of *choofed the people off who may never do it, and the other people [in the extension and engineering groups] are probably going to choose a science then at Grade 11 and 12* [emphases added]. (Dianne, 19/11/10)

Here, Dianne indicates the extent to which particular groups of students are likely to proceed with a pathway through to the study of science subjects in Grades 11 and 12. She indicates that the students who are in “applied” Science “were never in the picture”, while students in the “extension” and “engineering” groups are “probably going to choose a science”. These statements speak to the relationship that Bourdieu (1990) describes between objective probabilities and agents’ subjective aspirations. Bourdieu argues that a close relationship between these two features of choice-making do not necessarily indicate that such choices are made freely and uninfluenced by habitus. Instead, Bourdieu contests that these decisions have already been made. In this way, “the most improbable practices are therefore excluded, as unthinkable, by a kind of immediate submission to order that inclines agents to make a virtue of necessity, that is, to refuse what is anyway denied and to will the inevitable” (Bourdieu, 1990, p. 54). In light of Bourdieu’s conceptions, the counselling provided to students at Brolga SHS, as described by Dianne, calls into questions the extent to which the students are actively and authentically involved in their choice-making, and are instead subjected to pre-emptive categorisation of their futures.

In SET planning policy, students are positioned as active choice-makers or ‘entrepreneurs of the self’ (Rose, 1998); however, what is clear is that the habitus of the student, as perceived by the teacher, may already have precluded options for some students. Bourdieu (1990, p. 54) highlights that such decisions are largely “inevitable”. However, in contrast, Dianne goes on to explain that there may be exceptions to the initial categorisation of students as either “in the picture”, or not. Exceptions arise when a student becomes meta-cognitive of the need to engage with a subject such as Chemistry because of its role as a pre-requisite for entry into a particular course at university. Such meta-cognition is synonymous with the student’s perception the value of Chemistry as a commodity in an education market (Marginson, 1997) and, accordingly, the student’s choice is accommodated by the school on the premise of transformation in the student’s meta-cognition of their own ‘logic of habitus’. In other words, the student has become cognisant of the rules and dispositions that are necessary to respond to the current cultural context of tertiary entrance – they have developed a ‘feel for the game’. In this way, as the school consents to an ‘atypical’ student participating in the subject of Chemistry; ‘the virtue of necessity’, as described by Bourdieu, is activated.

Dianne also speaks about a new model of guidance through participation in the Sciences. She indicates that the Applied, Engineering and Extension groups will not be as predominant, and instead, all students will work on the same topics; however:

> … they will be still *streamed off to some extent, based on their desires at the end of Grade 9 for their future careers and on their results and on not only on their results, on what their teachers feel their potential is* [emphasis added]. (Dianne, 19/11/10)

Dianne talks about the role of teachers actively "streaming students off" based on the students own aspirations for their careers at the end of Year 9, along with their results in sciences, and importantly "not only their results, what their teachers feel their potential is". What is clear here is the extent to which teachers are able to exercise their subjective authority in evaluating students' choices. Dianne explicitly states that the teacher's "feelings" about a student's potential to engage in STEM subjects are just as valid as the student's own desires and achievements. The statement itself works to background the student's own choices and desires, while the teacher's evaluation of the student's choices, based on feelings, is privileged. Such externalised legitimation would be referred to by Bourdieu (2000) as misrecognition, which is one of the key foundations of symbolic violence. Misrecognition occurs when some people are denied access to particular resources, skills, or capitals, and yet those who are denied access do not question that denial. Instead, they regard the practice of denial as part of the natural order of things. In this way, students, who trust in their teacher's authority, have the potential to be exposed to misrecognition. Misrecognition, then, is able to be activated before a student becomes meta-cognitive of their own logic of habitus. The SET planning process and subject 'choice' then becomes a complex set of interactions between the recognition of embodied cultural capital, the student's meta-cognition of their own logic of practice, and the impact of misrecognition on the extent to which students are able to actively engage with subject 'choice'.

In order to balance this complex set of interactions, the work of senior teachers as brokers of educational products and services in the context of the ETRF has come to include 'mitigating risk' on behalf of the students. Nevertheless, as will be discussed below, the motivation for such risk mitigation work is couched largely in a discourse of 'brokerage reputation' rather than a discourse of 'service to the student'.

9.3.5 'Mitigating risk' and 'making the numbers look right': The hallmarks of expert brokerage

The brokerage work that teachers are now engaged in is evident in both the literature and in the lived experience of the teachers that were interviewed as part of this study. It is argued here that the brokerage work of teachers is conducted with dual purposes, and, for some teachers, the dual nature of this work is apparent. Whilst the reported and rhetorical objective of the brokerage work conducted on behalf of the student is to enhance the long-term success and pathways of each individual student, well-mediated brokerage work is also of strategic benefit to the school. Reputations of schools can now be built around their capacity to successfully manage the pathways of their students. 'Pathways management' is an education service that builds (or demolishes) a school's reputation as a broker of education products and services. The dual purpose of the brokerage work undertaken by teachers; alongside the recognition of the need for a school to demonstrate its' competence as broker of educational products and services, is apparent in the following excerpt from an interview conducted with Louise, the Head of the Science Department at Emu SHS:

> We're pretty conscious developing kids in Grade 11 to reach their full extent in Grade 12, but by the same token, teachers … have high expectations, [they] are *driven by getting the best outcomes and they're very data-driven; we want the numbers to look right* … they *identify pretty early whether kids have it or don't have it* [emphasis added], and the kids are going to feel some pressure from that and teachers maybe suggesting that they, hopefully in a nice way, that maybe it might be a bit stressful for them. (Louise, 15/11/10)

In this excerpt, Louise describes how the teachers in the senior school are "driven by the best outcomes" and that they are "very data-driven", and finally, that the staff "want the numbers to look right.” Clearly, the next sentence concerned with whether “kids have it or don’t have it” is a tool for identifying which students are likely to contribute to ‘making the numbers look right’. Student aspirations are monitored and shaped, “hopefully in a nice way”, such that students are counselled in order to make different choices – choices that are largely strategic in terms of building school reputation as a pathway provider and, as such, the way the numbers look is critical to leveraging reputation in an educational era dominated by narrow measures of accountability (Lingard, 2010).

In order to further the analytical discussion, the discourse of the commodity market drawn from (Frush, 2008) will now be activated. Analogous to the role of teachers as brokers of education products and services, is the notion that curriculum subjects act as the commodities being transacted between the school, as the ‘brokerage firm’ and the student as the ‘investor’. In this commodification metaphor, the QCE and SET plan act as a commodity portfolio held by the student. As an investor, the student then holds commodities that may include QSA subjects (for example, Chemistry, SAT subjects, VET qualifications or other such credentials), for later exchange in the Higher Education sector, or in the labour market.

Investing in commodities is a complex endeavour. Investors new to the commodity market are well-advised to find a skilled broker, and to have some knowledge about the commodity into which they themselves are planning to invest. Expert commodity brokers are constantly guarding against excessive countenance of risk in a commodity portfolio, and, according to Frush (2008), there are two forms of risk that are most commonly encountered and need to be mitigated. These are termed ‘overexposure risk’ and ‘knowledge and expertise risk’. On knowledge and expertise risk, Frush (2008, p. 33) states:

> … investing in commodities require[s] more knowledge and expertise than does investing in most other investments. If you possess this knowledge and expertise, you are positioned well to invest in commodities. If you do not, seeking the help of a professional advisor with the requisite knowledge and expertise may be a smart move.

Analogously, for teachers acting as brokers and students acting as investors, the evaluation and mitigation of ‘knowledge and expertise risk’ entails weighing up the knowledge and expertise that each potential investor (student) possesses about the subject Chemistry. As was discussed previously, Louise, from Emu SHS, considers some students to simply “not have it”. Similarly according to Dianne, from Brolga SHS, some students “were never in the picture”. Such statements are synonymous with the notion of lacking ‘knowledge and expertise’ about the commodity, and as such, the student is not regarded as being well positioned to invest in the commodity that is Chemistry. Investment by the under-prepared is not likely to lead to gains and/or returns for the student or for the school. Consequently, these students are steered away from such a ‘risky’ investment decision.

Evaluating students in light of their knowledge and expertise risk is further exemplified by the following quote from Dave, a Deputy Principal at Emu SHS. Prior to becoming a Deputy Principal, Dave had been a senior science teacher, predominantly teaching Physics, but also having taught Chemistry, Biology and Multi-strand Science:

> Physics, Chemistry, they are your big sciences, they are harder and you’ve really got to have the Maths and English skills to go with it. If you don’t have that, you are going to struggle. More and more we are trying to have that harder chat and say look, *you really need to realise that you are setting yourself up to struggle and possibly fail. More and more, kids have got to realise that in Year 8,* because they’ve got to start performing at the best they can in Year 8, *because it influences what extension or stream class they could be in in Year 9, which then affects Year 10 which is going to affect, obviously, their senior classes* [emphases added]. (Dave, 15/11/10)

The “hard conversations” that Dave describes are based on the leveraged premise of expertise that comes from employing the disciplinary expertise of teachers to make judgements about the knowledge and expertise risk of the student considering whether or not to study Chemistry in their senior phase of schooling. From Dave's comments, it is clear that Chemistry is not regarded as a subject that can be entered into lightly. A prospective student must have strengths in numeracy and literacy to be able to meet the demands of this subject. Students not displaying these strengths are counselled away from the physical sciences, their aspirations moulded and trimmed down to size through the SET planning process. Student voices are censored into forms that then shape and re-narrate their aspirations. Chemistry is regarded as a subject that has a "strong cognitive architecture", "located in the top levels of the curriculum hierarchy, where the needs of the most academically adept prevail" (Teese, 2000, p. 197). Moreover, "this historical bias reflects the unequal capacity of different social groups to influence the content of the curriculum and to exploit the scale of opportunities that it contains" (Teese, 2000, p. 196). Further to this idea, Teese and Polesel, (2003) describe an association between low achievement in upper secondary school, and low aspirations for tertiary education. Perhaps, as this interview data indicates, these aspirations are not arrived at in a vacuum. Perhaps, students who are not regarded as high-achieving are being explicitly told that their aspirations are not realistic, and instead they should consider a pathway that is safer and more achievable. The intersecting fields of under study; namely, career guidance and STEM education, are each legitimated and steered through their own policy mandate. Career guidance is steered through the ETRF and SET planning platform while STEM education is steered through the innovation-security discursive continuum evident in Federal and State policy (discussed in Chapter 6 of this thesis). However, these fields work in tension, and, in doing so, their oppositional agendas continue to reproduce existing social inequalities associated with entry into Chemistry for the students at the exposed school sites under study. In this way, Chemistry contributes to the reproduction of privilege (Bourdieu & Passeron, 1990).

In following quote, Louise, the Head of the Science Department at Emu SHS, describes the role that teachers play in intersection between career guidance and SET planning and participation in the subject of Chemistry:

> There's the time we have allocated to go over and speak to the students*; it wouldn't necessarily be a Chemistry teacher going over and doing that* [emphasis added]. We sort of take it in turns, and one person will do all of the sciences. They have a handbook that outlines the content of the courses and the expectations, and the pre-requisites and *we're starting to try and use stronger language. Rather than "recommended" we're using the word "pre-requisite" in terms of the science that they need to have done and the grades they need to have achieved. Other than that, I guess it comes down to the knowledge or opinions or guidance offered by the individual SET plan interviewer … it would just be like the luck of the draw as to whether or not they had any insight into Chemistry* [emphasis added]. So, probably *kids get lumped into categories … they're high achieving science-type students, or they're, you know, vocational-type students and I think sometimes that influences the subjects that they get guided towards* [emphasis added]. (Louise, 15/11/10)

When comparing the comments of both Dave and Louise, it is clear that students are categorised by the systemic procedures and record keeping that occur in the school, well before the point of choice is actually presented to them. What is not clear is whether or not students are cognisant that the knowledge and expertise they develop in their middle years of schooling is being used to make decisions about their credibility as in investor in particular subject (commodity) areas in the senior phase of schooling. Furthermore, while Dave indicates that these "hard conversations" need to take place, Louise indicates that the expertise of the broker in each case may or may not be of a standard relevant to assist the student to make informed choices – she states that it is the "luck of the draw as to whether or not they [the teacher] had any insight into Chemistry." In this way, the inherent knowledge and expertise risk is brokered by the teacher. As Frush (2008, p. 33) states: "If you do not [possess the knowledge and expertise needed to invest in a particular commodity], seeking the help of a professional advisor with the requisite knowledge and expertise may be a smart move."

As well as leading to students who are under-served in their consideration of Chemistry, a lack of broker expertise may also undermine the work of schools seeking to build reputations as pathway providers. As is indicated by Louise, students are “categorised” as either “high-achieving science-types” or “vocational-types”. It is suggested here that as the schools endeavour to “make the numbers look right”, more students are regarded as ‘too risky’ to invest in the commodity of Chemistry, since they could not be regarded as ‘high-achieving science types’. In fact, the label itself collocates the notions of ‘high-achieving’ and ‘science types’, implying that it is not possible to be a ‘science-type’ without being ‘high-achieving’, indicating the nature of the knowledge and expertise required by the student to be authorised to participate in the study of Chemistry. It is possible that this evaluation of investor risk by schools as brokerage firms, made in a political climate dominated by narrow neoliberal measures of accountability, is one factor contributing to a decline in the number of students undertaking study in the enabling sciences during their senior phase of schooling.

Under circumstances of risk mitigation, students are actively discouraged from making risky choices in order to ensure the school’s performance against key accountability measures ‘look right’. While such attainment leverages the reputation of the school as a successful pathway provider, the focus shifts away from the service of students, to an aggregated statistical representation of ‘success’ at pathway provision. This argument is supported by re-considering the data that was presented in Section 9.3.2 of this chapter. At Emu SHS, while fewer students received on OP score, a larger percentage of those who did receive an OP score were in the valued range of 1 to 15. Through strategic pathway provision, the school worked to mitigate ‘overexposure risk’:

> Investors need to be aware of the commodities exposure they already have in their portfolio, and not invest in more commodities than is appropriate for their risk and return profile. Doing so can create more risk than is suitable in a portfolio, and that can make for sleeplessness nights, uncertainty over future performance, and greater swings in a portfolio’s market value. (Frush, 2008, p. 33)

Through strategic work to mitigate over-exposure risk, students are counselled into and away from subjects such as Chemistry. In this way, the students themselves come to embody forms of institutionalised cultural capital that are valuable to the official measures of accountability established by the Queensland Studies Authority. Bourdieu describes the strategies for the conversion of forms of capital in the excerpt below:

> Because the material and symbolic profits which the academic qualification guarantees also depend on its scarcity, the investments made (in time and effort) may turn out to be less profitable than was anticipated when they were made. *The strategies for converting economic capital into cultural capital,* [emphasis added] which are among the short term factors of the schooling explosion and the inflation of qualifications, *are governed by changes in the structure of the chances of profit offered by the different types of capital* [emphasis added]. (2004, p. 20)

Here, Bourdieu describes “changes in the structure of the chances of profit” as key to the strategy of converting economic capital into cultural capital. In this way, the costs and benefits associated with encouraging ‘risky’ students into the study of Chemistry are rearticulated in terms that resonate with the market. Earlier, teacher interview data showed that no additional funding or support is made available to schools during the SET planning process. Furthermore, the only additional funding that schools received came from students who are enrolled in VET courses. These students are the ‘vocational-types’ categorised by Louise – the type that are counselled away from subjects such as Chemistry, and instead, are counselled into VET courses. As such, it could be argued that strategic pathway planning aims to benefit the school by efficiently converting the scarce economic resources available into the greatest amount of cultural capital possible – ideally, in proportions that allow the school to demonstrate its reputation as a ‘pathway provider’. In light of this position, the number and percentage of students who hold the right balance of ‘commodities’ (subjects) in their ‘portfolios’ (QCE) leverages symbolic profits for the school providing the pathways, as well as potentially contributing to economic efficiencies in pathways provision.

Given this argument, addressing the STEM crisis in senior secondary schools is not a simple matter of encouraging more 'non-traditional' students into the sciences, as is suggested by Federal policies such as *Inspiring Australia* (Department of Innovation Industry Science and Research, 2010). Overexposure risk, from a systemic perspective, can result in the numbers 'looking wrong'. Schools, therefore, may actively discourage some students away from study in the enabling sciences due to pressures from narrow accountability frameworks that fail to take into account the number of 'non-traditional students' who are encouraged to enrol in an enabling science. Instead, the narrow measures of accountability faced by schools focus on the percentage of students who receive on OP score in the 1 to 15 range and the numbers of students who receive a VET qualification.

Drawing on interview data from Dave and Louise, as presented earlier in this section, what is clear is that the perceived knowledge and expertise risk of students limits the number of students who are permitted to make the 'choice' to participate in the enabling sciences in their senior phase of schooling. The dominant 'risk management' discourse discussed so far is, at times, problematised by the teachers interviewed in this study, as will be discussed in the following chapter section.

9.3.6 Speaking back to the 'risk management' discourse

Dianne, from Brolga SHS, offered a comment about the role Chemistry plays for students actively engaged in mapping out their futures:

> Sometimes you wonder whether, with a couple of them, you wonder why they took [Chemistry] in the first place [laughs] but they've stuck with it. I mean, by the same token, *it's still a good subject to have under your belt, even, no matter what your success was, because it does apply to so many things too* [emphasis added], you know. I know my daughter that did Chemistry, *she struggled and didn't do very well, but she … needed Chemistry for what she wanted to do at uni, and she has found that even though she didn't pass it, her knowledge of it still helped her* [emphasis added] and unfortunately, *I find this thing with the QCE these days,* that they've got to get their 20 points, that *if they're failing a*

subject or think it will be a struggle to pass it, they either don't do it, or swap out of it and yet, they still learn stuff even if they were getting a limited. It's a shame now that kids are pushed out of subjects as soon as they drop below a sound, even though they're still learning some valuable stuff [emphasis added]. (Dianne, 19/11/10)

In the above excerpt, the discourse of mitigating risk is once again activated; however, Dianne draws upon the discourse in a different way. That is, rather than accepting that mitigating risk is *always* a good strategy, Dianne begins to speak back to the official discourse of the ETRF agenda, and the structure of both the QCE and SET planning as key tools in the reform. Dianne begins to question the idea that students must always make 'responsible choices', because in making a choice whereby success is not guaranteed, the risk is of a different nature. Rather than overexposure risk, what Dianne is suggesting is that the risk of failure deters students from exposing their QCE pathway to subject (commodities) that are both perceived to be, and actively communicated to the students to be, too difficult for them. The result could perhaps be termed 'underexposure risk', where less and less students have the option to attempt to study Chemistry, and subsequently more and more students regard the enabling sciences as an endeavour too difficult or too risky to engage in.

An excerpt from the interview conducted with Cathy, and included below, also speaks back to this notion of risk management, but from a systemic perspective:

> [SET planning] it's a valuable process to do … because kids need to be made to think about what their goals are, and what they want to do…This is what Education Queensland needs to do – Education Queensland needs to employ Guidance Officers who have a full-time role in the school, and they need to employ career development people who have a clear and distinctly different role, full time. During SET planning time, or whenever, they need to employ or contract, a number of people to go into schools to conduct the SET plans with the students, and their parents. (Cathy, 11/11/10)

Cathy's critical insights generate an awareness of the pragmatic and difficult circumstances in which SET planning occurs. The generation of such critical insight requires a clear understanding of the context in which the SET planning process takes:

> The much harder thing to achieve is to identify and describe a vision for the future that is based upon *an understanding of the forces and resources within the present order that are capable of transforming it for the better in the future*, [emphasis added] a significant dynamic for action in the here and now – to discern, in other words, the unrealised opportunities which lie dormant or unfulfilled in the recesses of the present. (Halpin, 2003, p.10 cited in Harreveld, 2007)

Cathy clearly articulates a perceived value in the SET planning process, particularly in terms of "making" students think about what their goals are. Later in the interview, Cathy also clearly and frankly articulated the real limitations of implementing this policy in a school setting that is not adequately resourced to do so, including: students not taking the process seriously, wasting time, not being able to adequately involve parents, and consuming the limited IT resources in the school for weeks at a time. It could also be argued, that in presenting her critique of the SET planning process, Cathy is not explicitly attempting to construct a binary between neoliberal marketisation and social justice. Cathy engages in exactly the discourse that Halpin (2003) would seek for her to do – that is, she identifies and describes a vision for the future, based on her understanding and experiences in mediating the forces and resources of SET planning in an exposed school site.

Section 9.3 of this chapter has focussed on the intersections of the SET planning process, the intensification of teachers work in the senior secondary school in relation to SET planning, as well as the complex interactions between SET planning and pathways through the Sciences. Themes of 'risk mitigation', and 'making the numbers look right' for senior secondary schools whose work is currently embedded in narrow, neoliberal measures of accountability were examined, with a particular focus on the role that Chemistry plays in sorting the students into "high-achieving science types" from the "vocational types".

The following section of this chapter, Section 9.4 will examine the SET planning process from the perspective of Year 12 students from Emu SHS, Brolga SHS and Kookaburra SHS who were interviewed in November, 2010, and who, at some point in their senior years of schooling, had studied Chemistry. A key idea that develops through this section, from the student perspective, is the important role that managing overexposure risk plays in the management of their commodity portfolio (QCE).

9.4 Students as 'entrepreneurs of the self'

> For investors who want to gain an edge, investing in commodities can produce the golden results they are looking to achieve ... Smart investors know the benefits of allocating to fundamentally different asset classes such as commodities. If an investor does not invest in commodities, he or she will build a suboptimal portfolio in which there is lower return potential and higher risk levels, leading to underperformance. (Frush, 2008, p. 19)

As was discussed in Section 9.2.3, the QSA authored a student's Guide to accompany the SET planning process (Queensland Studies Authority, 2010a). In this Guide, students are simultaneously positioned as both passive recipients of advice, and active determiners of their own aspirations and futures. Furthermore, the Guide makes unproblematised statements about the 'opportunities', 'attributes' of, and the 'understandings' held by, students embarking on the SET planning process. These statements appear alongside unproblematised discussions of the role of parents/carers during the SET planning process, which according to the Guide, consists of four stages, the first of which being Stage 1.

Stage 1 of the SET planning process, as described by the Guide, requires each student to locate essential "skills" in herself/himself and to begin to define her/his attributes in accordance with the official SET planning discourse. Of further interest is the seemingly 'unproblematic' manner in which the guide presents the notion of ‘opportunities’ that all students have had to develop this skill set. Furthermore, the Guide makes further unproblematised claims such that all students will have developed a sense of “how they fit into this world, and how they can contribute” (Queensland Studies Authority, 2010a, p. 6). In contrast to this official position, Cathy, the Head of Senior Schooling from Kookaburra SHS, recalls the words of her students who ask: “How can we be expected to know what we want to do for those QTAC forms? I am only 17”. This statement suggests that the notion of Year 10 students entering the SET planning process with a sense of surety and direction is ‘hopeful’ to say the least and calls into question the extent to which the SET planning ‘guide’ contributes to ‘othering’ (Skeggs, 2004) students who may not have had ‘experiences’ or ‘opportunities’ that fortify their sense of self-worth and aspiration.

The SET planning guide stipulates that at Stages 2 and 3 of the SET planning process, students should expect significant input and guidance from the school, its teacher, and their parents in exploring, and then documenting, a career trajectory. Again, the SET planning guide unproblematically discusses access to the necessary physical and human resources to facilitate the SET planning process. The role of the teacher as broker is also evident here. What is contentious between the position of the Guide and the interview data collected from both teachers and students is the integral role of the parent in the decision making process. Throughout interviews with teachers, parental involvement in the SET planning process was largely perceived as problematic – “too time intensive” (Cathy, 11/11/10), and whereby students were steered away from making decisions to participate in the subject of Chemistry “just because Mum or Dad suggested they should” (Helen, 11/11/10). Marginalisation of the parent from the SET planning process is also evident in the student data that will be discussed in Section 9.4.1 below.

Once students have negotiated a plan with their brokers, and this plan has been endorsed by their parents, students are once again positioned as active in forging their future. As the SET plan Guide states, students will “actively work towards *their* goals (p. 9)”. In addition to working to achieve “*their*” goals, students must then also keep track of their progress toward “*their goals*” by accessing and managing their Learning Accounts. In this way, students are positioned as having appropriate and manageable pathways in place and all that remains for the students to do is to complete the work, to the required standards, and "*their aspirations*" will be realised.

In the sections that follow, interview data from students is presented. The data explores the extent to which the experience of SET planning as detailed by the QSA Guide (2010) and discussed above, corresponds to the actual experiences of students. It explores the extent to which student goals and aspirations, as documented in SET plans are "*theirs*", that is, it explores the extent to which the 'official' aspirational pathways of students are directed by their own hand compared to that of their brokers. Furthermore, Section 9.4 of this chapter explores the extent to which SET planning as a process brokered by teachers and in which parent voice is marginalised, 'shapes up' or 'trims down' aspirations for some students more than others.

9.4.1 SET Planning: Commonalities of experience

As was mentioned in Section 9.1.1 of this chapter, a review of paper SET plans for the Year 12 cohort of 2010 held by each of the schools was conducted. During the review process, it became evident that the structure, layout and nature of the proforma that comprised the SET plan itself, varied from school to school – each school had a locally developed and printed version of the SET plan because at the time the review was conducted in November 2010 no centralised version of a SET plan existed. The nature of the SET planning process itself also varied from school to school. At some schools sites, the proformas were completed by students in their own time, while at other school sites class time was made available for students in order for them to complete the proforma. The amount of class time available to do so also varied from one lesson to many lessons.

At each of the school sites under study, once the students had completed the SET plan proforma, they would attend an interview with school staff and, ideally, their parents, to discuss and evaluate their aspirations and career trajectory. However, the degree to which parents were involved in the SET planning process was highly variable from site to site. All of the students interviewed reported that they had referred to formal university admissions guides and associated publications on more than one occasion before completing their SET plan. Variable human and physical resourcing issues at each school site also meant that the students may not have met with a school staff member qualified in career guidance. Rather, students and their parents/guardians, if in attendance, would have been more likely to have met a teacher or a member of the school administration staff with little to no professional development in the administration of the SET plan process, and not necessarily any direct expertise or teaching experience in relation to the variety of subjects that the students were considering. At each school site, the SET planning interview sessions were organised as an intensive block of time, ranging from an afternoon/evening to a few afternoons in one week. During their interviews for this research, the students were asked if they felt that the SET planning process had been useful for them. Only three of the twelve students interviewed did not think that writing a SET plan was a useful activity with which to have been engaged.

Once completed and endorsed by the parent/guardian, the SET plan was filed in the school administration centre. The SET plans were filed variously from school to school. At Emu SHS the SET plans were filed by Year 12 care-class and the SET plan, along with copies of mid-term school reports and subject selection and request to change forms were filed together. At Kookaburra SHS, the SET plans were filed along with copies of Semester reports and requests to change subject forms. At Kookaburra SHS, student files were alphabetised rather than grouped according to care-class. At Brolga SHS, general access to the file area was not permitted. Instead, files of the students that the school had selected to be interviewed were made available for review. In the files from Brolga SHS, were SET plans, filed alongside copies of any request to change subject forms as well as a copy of the Semester 1 report card only.

In total, across the three school sites under study, 307 SET plans were reviewed. Table 9.5 below summarises the SET plan review findings. As is evident in Table 9.5, Chemistry rarely features as a subject selected by students at each of the school sites under study. For example, at Kookaburra SHS, only eight of the SET plans reviewed featured Chemistry (13.3% of the total number of plans reviewed). At Brolga SHS, 16 SET plans included the study of Chemistry (12.8% of the total number of plans reviewed at this school). At Emu SHS, 18 of the SET plans reviewed featured Chemistry (14.8% of the total number of plans reviewed). The small number of students who, at Grade 10, elected to study Chemistry is reflected in the small number of students who were interviewed in this study.

Table 9.5
Summary of SET plan review

SET plan review	Indigenous status of student	Kookaburra SHS	Brolga SHS	Emu SHS	Total
Number of SET plans reviewed		60	125	122	307
Number of SET plans without science[1]		38	93	69	200
Female	non- Indigenous	13	39	21	73
	Indigenous	6	5	16	27
Male	non- Indigenous	12	42	24	78
	Indigenous	7	6	8	21
Number of SET plans with at least one science subject		22	32	53	107
Number of SET plans with Chemistry		8	16	18	42
Female	non- Indigenous	4	11	8	23
	Indigenous	0	0	0	0
Male	non- Indigenous	4	5	9	18
	Indigenous	0	0	1	1

Note. **One student at Brolga SHS did not have a designated gender, and as such is counted in the 93 students without science on their SET plan, but does not appear in the gendered count of the number of SET plans without science.**

During the SET plan review additional patterns of science participation became clear. These patterns related to the gender and Indigenous status of the students. For instance, seven of the eight Indigenous male students from Emu SHS who did not have a science subject included on their SET plan had not been assessed for science in Year 10, thereby largely precluding them from the study of a science in the senior years of schooling. In addition, of the 16 Indigenous female students from

Emu SHS who did not have a science subject on their SET plan, five of these students had attained an average grade of B+/A- in their Year 10 Science marks. Furthermore, non-Indigenous female students at Brolga SHS more commonly selected Chemistry than did non-Indigenous male students. Further examination revealed Physics as the science subject most commonly selected by non-Indigenous male students at Brolga SHS.

In addition to the review of the SET plans using document analysis, 12 students in total were interviewed across each of the study school sites – Emu SHS, Kookaburra SHS and Brolga SHS. As noted previously, the student names presented are pseudonyms, and statements are annotated with either a (W) to indicate that the student withdrew from Chemistry prior to completing four semesters of study, or a (C) to indicate that the student completed 4 semesters of Chemistry. Each of the twelve students had completed a SET plan in 2008 when they were in Grade 10.

At the time of commencing Grade 10 in 2008, each of the 12 students interviewed in this study had elected to study Chemistry. However, by the time the students were interviewed in November 2010, five of the 12 students who had originally selected to study Chemistry had withdrawn and elected to study a different subject in its place. All 12 students spoke about Chemistry's role as a pre-requisite to tertiary courses as the primary reason for its original selection. Only three of the students interviewed mentioned that they liked science or were doing well at science in Grade 10. In each of these three cases, an intrinsic interest in science or past success at science was offered as a secondary reason for choosing Chemistry.

Only two of the 12 students interviewed had known someone else who had completed Chemistry at school. These were the same two students who had someone other than their school friends and their teacher who they could go to for help if they were experiencing difficulty with the Chemistry content and both of these students went on to complete four semesters of Chemistry. All of the students who completed four semesters of Chemistry had access to hot knowledge (Smith, 2011); that is, they were able to ask other people about their experiences with the study of Chemistry when initially choosing to study Chemistry. Six of the 12 students interviewed mentioned speaking with teachers or a guidance counsellor during the process of making their choice, however the students did not perceive these interactions with Guidance staff to be as valuable as those interactions and discussions that they held with their family members. Furthermore, according to the *QSA Student Guide to SET planning* (QSA, 2010), students should review their SET plan on regular occasions, reflecting on their aspirations and goals, and modifying or adjusting the plan as required in consultation with teaching staff. Of the students interviewed in this study, half of the students reported that they did not recall looking at their SET plan again after having originally written it.

As was described in Chapter 2, student interviews were coded using themes derived from the work of Sellar and Gale (2011), whereby mobility, aspiration and voice are theorised as a new "structure of feeling" (p.115) for student equity in higher education. Sellar and Gale (2011, p. 115) state that the "framework extends from established approaches that focus on *barriers* to accessing education in order to focus on people's *capacities* in relation to higher education participation". Such an approach is justified by Gale (2011, p. 116) who argues that the current policy moment of Higher Education in Australia, "demands and resources more complex and expansive understanding of inequalities across what is now a global field of Higher Education". As theoretical categories, 'aspiration', 'mobility' and 'voice' provide alternative means for re-examining the problems for groups such as the students interviewed in this study, who are currently underrepresented in Higher Education, and for whom, tertiary study is expressed as a primary goal and aspiration once they have completed secondary school. As such, the student interview data has been analysed and is presented in relation to the capacities of mobility, aspiration and voice for students of Chemistry such that the goals and aspirations both articulated and documented during the SET planning process can be explored.

9.4.2 Mobility and Chemistry

All of the students interviewed described the mobilising power of Chemistry. Not only did all students recognise Chemistry's significance as a pre-requisite for science-related tertiary study, they ascribed additional power to Chemistry – it leveraged possibility. To draw once again on the commodity portfolio analogy, the approach an investor takes to gain exposure to commodities is by trading in what are referred to as ‘futures’ and ‘options on futures’, with the specific commodity serving as the underlying asset in a speculation on future returns. This is recognised as a risky endeavour, and, as such, brokerage firms with professional commodities trading advisors are usually engaged to manage an account, on behalf of the investor, called a futures managed fund (Frush, 2008). In analogous ways, the role of the student has shifted to that of an investor, and the QCE is arguably transformed as a very specific form of an investment portfolio; namely a *futures managed fund*. The student must make the choice whether to invest in specific commodities (subjects like Chemistry) or not, but in doing so, they rely on what is purported to be expert advice from teachers, who act not only as brokers as was discussed in Section 9.3.5 of this chapter, but more specifically, as futures commodity traders. Chemistry is positioned as a powerful commodity by both teachers and students, playing a role in exposing the students’ investment portfolio (QCE) to options and futures that might not otherwise be available. For example, in Gemma’s case, as is presented below, investing in Chemistry served just that purpose – providing the exposure her QCE needed to a high return commodity, in case the other commodities she has chosen to invest in do not offer the return that she is expecting:

> Really, I want to do Arts, I know that, but I just wanted to keep a science subject in my pocket, basically, because I wasn’t sure, I might change my mind or something, so I thought, you need science if you want to do anything in the Medical or that side of the thing, so that’s basically why I chose chemistry. (Gemma [W], 15/11/10)

For Kevin, Chemistry served a similar purpose, creating exposure to a commodity that is perceived to have a high return:

> I chose Chemistry because of the information I was given, like the pre-requisites for pilot was English, Mathematics B and Physics, but Chemistry was um, recommended. So, even though

> it wasn’t a pre-requisite, even though they’d recommended it, I’d chosen to taken it because it just made me look more attractive to the air force. (Kevin [C], 15/11/10)

Here, in Kevin’s statement, Chemistry is imbued with strategic value, even though its presence in his QCE was not required in order for him to work towards his goals. Chemistry was simply recommended, and, as such, for Kevin, any potential risk of investing was perceived to be outweighed by the potential return on including this commodity in his ‘futures managed fund’. Similarly, as is articulated by Jack in the statement below, there is a perception about the power of Chemistry to de-mobilise particular futures and options –through its absence in a QCE:

> I think one of the main influences was choosing Chemistry in Grade 10, cause if I didn't do Chemistry, I wouldn't have any science courses, which pretty much gets me off all my choices that I chose. (Jack [C], 11/11/10)

Jack perceives that the inclusion of Chemistry in his QCE portfolio is critical to the chance of him fulfilling any of his future aspirations. Moreover, if Jack doesn’t invest in Chemistry now, then his current aspirations can be taken away.

It is noted that the strategic value of Chemistry was also found to be significant in a study conducted by Lyons (2006) where one quarter of the students interviewed commented that they had chosen a physical science primarily for strategic reasons. Chemistry is regarded by the students in this study as providing leverage to and mobilising hitherto unattainable aspirations. Participating in Chemistry grounds the students’ aspirations in real pathways, contributing to the demonstration that they are working toward their goals – making evident their responsible choices toward realising their full potential.

However, the mobilising capacity of Chemistry, that is to say, the role that Chemistry plays in mobilising and materialising student aspirations, is not uniformly experienced by students. As mentioned previously in this chapter, five of the 12 students interviewed withdrew from their study of Chemistry at some point during their senior years of schooling. For example, for Gemma, a female student who withdrew from Chemistry, her inability to subscribe to the norms required to be successful in the study of Chemistry was equated to the inability of the teacher to make these norms apparent during their instruction and assessment practices:

> I don't mean to be harsh against teachers or anything, just the feedback wasn't enough really. Like, I think that's for every subject really cause you can't, teachers give minimal feedback, like they're not allowed to or something, the, the syllabus or something, but yeah, that's what made it a bit hard, because I wasn't sure which areas to work on so I could improve and stuff. (Gemma [W], 15/11/10)

Similarly, Emma expressed the significance of the teacher's role in enabling the mobilising capacity of Chemistry:

> [The teacher] ...only... paid attention to the ones that really got it. And if you didn't get it, you were stupid. (Emma [W], 11/11/10)

As evidenced here, both Emma and Gemma articulate the significant role of the classroom teacher in developing each student's willingness to persist in circumstances where they already feel vulnerable. Furthermore, both Emma and Gemma felt that more support was available to the students who 'already got' Chemistry, whereas students experiencing difficulty were left feeling less supported by the efforts of the classroom teacher. In view of this, Appadurai (2004, p. 66) argues that "the poor are frequently in a position where they are encouraged to subscribe to norms whose social effect is to further diminish their dignity, exacerbate their inequality, and deepen their lack of access to material goods and services." This notion again speaks to Bourdieu's (2000) concept of misrecognition, in which denial of resources or services is regarded as the normal order of things. From Emma and Gemma's perspective, the availability of resources for the more able students speaks to this sense of diminished access to the study of Chemistry. As well, through their comments, the importance of the dual capacity of a senior teacher to act not only as an expert commodity broker, but also an expert discipline pedagogue, becomes apparent.

It is argued here that the capacities of mobility and aspiration are integrally connected, but perhaps not in ways that would appear immediately logical. Students author their own aspirations which the system then interprets and either trims down or scales up, depending on the perceived 'knowledge and expertise risk' embodied in each student. Students then work towards an authorised version of 'their aspirations', and, in doing so, attempt to mitigate against overexposure risk for their own portfolios – weighing up decisions about expected return for their investment in particular commodities such as Chemistry. As will be seen in Section 9.4.3 below, some students are enrolled in, or counselled away from leaving Chemistry despite a lack of aspirations to participate, while other students are counselled away from enrolling in Chemistry despite having clearly articulated aspirations that require the mobilising capacity of Chemistry. These 'risky' students have their aspirations trimmed down, while those who appear to be a safe investment, have aspirations that are scaled up the curriculum hierarchy (Teese & Polesel, 2003).

9.4.3 Aspirations and Chemistry

In relation to the capacity of aspiration, Smith (2011) has described the role that network capital can play in resourcing students from low socio-economic backgrounds to aspire in new ways. Social networks can provide access to informal or 'hot knowledge' about a topic, while cold knowledge, as more formal knowledge, is usually accessed through University websites and admission guides.

For Megan, for example, access to hot knowledge has allowed her to see that there are multiple pathways to her end goals, and as such she too has built in back-up plans to her aspirations:

> I have applied for some science courses in case I didn't get into [first preference courses] because I've spoken to some people and they've said that if you start with science courses, and then that can lead you into other pathways once you are into uni. (Megan [C], 19/11/10)

Sarah made requests of her teacher, a font of cold knowledge to scaffold success in assessment by providing models of the kinds of answers that would be awarded at particular standards, thereby allowing her access to the kind of knowledge needed to decode the secrets to success for Chemistry:

> So I used to request ... our teacher … to give us A standard questions, [the teacher] would just give us the B and C, and I'm like can we please have some A standard questions, so he would go make some up just for me! [laughs] (Sarah [C], 15/11/10)

The student interview data also exposed how a student's aspirations can be dramatically altered by a lack of access to hot and/or cold knowledge. Emma had elected to study Chemistry with a goal to study Zoology. She withdrew after the third term of Year 11 after struggling to maintain a passing grade, and decided to follow a pathway to enrol in a Bachelor of Arts:

> Emma [W]: Yeah, I was disappointed at first, like, cause, I don't know, it was something, I have always wanted to do, work with animals, and then yeah, it was kind of a let-down that I couldn't do it, but yeah, I don't know, if I couldn't do it at high school, then I probably couldn't do it out of school as well. It really stressed me out, so I was just like, might as well give it up now, find something else to do.
>
> Interviewer: Did anyone talk to you about bridging courses for Chemistry?
>
> Emma [W]: Ah nooooo… not that I know of. (Emma [W] & Interviewer, 11/11/10)

It could be argued here, that in failing to systematically provide adequate resources to support SET planning, students such as Emma are subjected to systemic forms of symbolic violence (Bourdieu, 2000) whereby the State, interpreted through the (in)action and (in)ability of the teachers to provide the advice or the knowledge necessary to make an alternative choice, is implicated in the "world-making" of the student. According to Bourdieu (2000), world making consists of:

> setting apart and putting together, often at the same time, and tends when the social world is involved, to construct and impose the principles of division likely to conserve or transform the vision of its divisions and therefore of the groups which compose it and of their relations. It is in a sense a politics of perception aimed at maintaining or subverting the order of things by transforming or conserving the categories through which it is expressed. The effort to

> inform and orient the perception and the effort to make explicit the practical experience of the world go hand in hand, since one of the stakes in the symbolic struggle is the power of knowledge…" (p. 186)

It is argued here that SET planning acts as one tool in the legitimation armoury of the State, used to 'make the world' it requires in order to further its own position, both in and through policy. The penetration and mediation of student aspirations by the State through SET planning allows the State to co-locate its own political aspirations with that of individuals.

9.4.4 Voice and Chemistry

The extent to which students are positioned to speak back to the 'risk management' discourse appears to be limited. All students are required to complete a SET plan. The completion of the SET plan then triggers the development of a Unique Learner Identifier, and opens the Learning Account for the student, held by the QSA. Students who wish to be seen as 'responsible' are left without a choice – they must complete a SET plan. Despite this, not all students felt that writing a SET plan assisted in the clear expression of authentic goals and aspirations, as is exemplified by the following excerpt from the interview transcript of Megan:

> Interviewer: do you think that writing a SET plan was a useful thing for you to do?
>
> Megan [C]: Honestly ... No
>
> Interviewer: Ok, tell me why.
>
> Megan [C]: Because … I ... I don't know, *I kind of have my own goals and writing them down doesn't really help me at all* [emphasis added], I just thought it was a waste of time because *if you don't ... know ... what your goals are* [emphasis added], I don't think writing them down was going to help me because yeah, I don't know, it just, it was a bit *forced* [emphasis added] kind of thing. (Megan [C] & Interviewer, 19/11/10)

In Megan's statement, the extent to which her officially articulated goals are authentically *hers* is brought into question and this sits at odds with the QSA Student Guide perspective that students are articulating *their* goals and aspirations. Megan indicates some disparity in her response. Initially, she claimed to "have her own goals". Then Megan speaks from the perspective of a student "who doesn't know what their goals are". In the event that one's goals are clear, writing them down was not 'helpful' to her as a student. Equally, in the event that one is unclear about one's goals, being forced to arrive at a set of goals and aspirations is also unhelpful – "forced" and, therefore, not necessarily reflective of a student's authentic goals and aspirations. This calls into question the extent to which SET plans can be positioned as "authentic" pathway planning tools as purported by the QSA (2010).

Along with the coercion to participate in SET planning, regardless of how lucid one's aspirations might be, there is also a sense of coercion within the SET planning process to either move in to, or to move out of, Chemistry– as is exemplified by Matt's interview data that is presented below. Matt was a student who had attended Emu SHS since commencing Grade 8, and who was regarded as a high achiever within the senior cohort. Matt recalls the subjects that he selected to study during his senior phase of schooling:

> In Year 11 *I did suicide six*, so, it's *Physics, Chemistry, Biology, Maths B, Maths C and Board English*…hmmm, yeah, *I felt like it was expected of me* anyway because I had been pretty good academically in, in junior schooling so, I sorta thought, it wasn't like my big thing, I wasn't excited to do it or anything [emphases added]. (Matt (W) 15/11/10)

On his SET plan, Matt wrote that studying Medicine was his goal, but then during Year 12, Matt withdrew from the subject of Chemistry (along with Physics and Maths C) after feeling expected to take on the "Suicide Six" due to his academic success in Year 10. Instead, Matt enrolled in Drama, Hospitality, and Film, Television and New Media, and decided that he was more interested in Nursing than Medicine. Later in the interview, Matt was asked to describe what he remembered about the SET planning process. He recalls that he and his parents attended a meeting held at the school library and that “there [were] three different tables of teachers, but I got to speak with the guidance counsellor so, it was just me and Mum and Dad and the guidance counsellor”. Matt was then asked to describe what he, his Mum and Dad and the guidance counsellor spoke about. Matt recalled that the conversation focussed on “what I wanted to do when I left school ... like, we went through my results saying oh you look like you are going good enough to do these sort of subjects and that sort of thing.”

Matt’s responses indicate that his interaction with the guidance counsellor was somehow not the norm for all students. Matt places emphasis on the fact that there were three different tables of teachers waiting to meet with parents and students according to their interview schedule, however, he spoke with the guidance counsellor – not just a regular teacher – in order to discuss his aspirations. Matt’s recollection of the guidance counsellor reviewing Matt’s results and deciding that he was academically “good enough” to study the complement of subjects Matt referred to as the “Suicide Six”. After further reflection about the SET planning process, Matt discussed how his aspirations had “come full round”, as is detailed in the interview transcript excerpt presented below:

> Interviewer: Ok so your original goal … that you had written down on your SET plan … was to do Medicine wasn’t it?
>
> Matt [C]: Yeah, well I’m still going into Medicine but I just don’t really want to, I don’t know if I wanted to be, like a doctor or that sort of thing, and I strayed away from that, and at one stage I was thinking of doing a trade before I went to uni, and now I’ve come back to wanting to go to uni again, so yeah.
>
> Interviewer: So you’ve almost finished Year 12, and as we were walking over [to the interview room] you were telling me you have put Nursing down as your goal.
>
> Matt [C]: Yeah, it’s four of my six [QTAC] preferences I want to be like, more I suppose, hands-on just with people, as well, because I really like working with people and stuff like that and you’ve got those options to travel and that sort of stuff, and nurses can really go

anywhere, lots of jobs … I've been through a whole field of things and so I've kind come full round, yeah.

Interviewer: And so you said you were thinking about a trade, what kind of trade were you thinking of?

Matt (C): Yeah, carpentry… or an electrician, and I also thought about being a chef at one stage, [laughs], yeah.

Interviewer: Yeah right, so what lead you back through those decisions, as in moving away from the sciences into a trade, and...

Matt (C): Oh, just not knowing what I wanted to do. I sort of did think that I would go to uni eventually, down the course, like and sort of, lots of discussions with Dad as well and he is saying is that, you know, like, if I want to go to trade then you'd be getting money and you'd be getting experience and you could still go [to uni] later on, but I sort of, since then I thought, well I sort of want to go to uni when I'm young and actually get a bit of experience on the job and everything like that in uni and I mean, then if I still want to do a trade, I can still go do that, I mean, it's a bit harder to go when you're older, well not really, it's the same as going to uni when you're older, but you'll be with older people when you go to do an apprenticeship whereas you'd be surrounded by younger people if you go to uni later, so, yeah. (Matt & Interviewer, 15/11/10)

Throughout the transcript, Matt articulates the variations in his aspirations with his ideas shifting between getting a trade, or perhaps studying nursing at university. However, the SET planning process identified Matt as a young man who displayed the capacities to invest in the "Suicide Six". In this case, Matt was directed into a STEM pathway due to his knowledge and expertise risk being perceived to be low – he displayed the right credentials and previous successes in investing in Science and Maths, and seemed a 'sure thing' in the higher echelons of the curriculum. His investment would surely see him rewarded. When asked to describe his perceptions of the difficulties that lead up to his withdrawal from the "Suicide Six" pathway, Matt replied:

> Matt [C]: It didn't really work out … I put a lot of effort in and I suppose for that I went pretty well … but it's just, most of it was just because I wanted to change sort of, and it was really stressful, it wasn't just Chemistry, it was the whole workload from all 6 subjects … I like to be able to socialise and stuff like that, and I couldn't have done both, the schoolwork and the socialising.
>
> Interviewer: Yeah, so you would have had to have been completely dedicated to —
>
> Matt [C]: To school work, yeah! And that's probably why they call it the Suicide Six! [laughs]. (Matt & Interviewer, 15/11/10)

In this interview excerpt, Matt describes the pressures and stress associated with studying the "Suicide Six" pathway – studying those subjects that Teese (2000) would regard as located in the top levels of the curriculum hierarchy and as possessing strong cognitive architectures. Further to this, Teese and Polesel (2003, p. 166) position the ways in which working class students identify themselves in relation to academic work as "conditional and problematic…with their success relative to more advantaged students that is crucial for whether they complete school and whether they proceed to tertiary studies." It is argued here that Teese and Polesel's conception is, too, potentially, both conditional and problematic. Clearly, despite being a working-class student, Matt had developed a repertoire of skills and strategies to authorise his participation in subjects at the top levels of the curriculum hierarchy. What was missing in this choice making was his voice.

Arguably, Matt made choices that were "expected of him" rather than following his authentic aspirations. In the end, he withdrew from Chemistry, not because he could not have achieved success in this subject (he was still passing the subjects when he withdrew), but because the life he imagined for himself did not feature a "stressful" life dedicated to work in the absence of his social networks – his friends, family and community. So, while the nature and demands of Chemistry as a senior secondary school subject played a minor role in the exclusion of Matt from the top levels of the curriculum hierarchy, Chemistry as a subject did not produce this outcome in isolation. Rather, it was in being branded as a “high achieving science type” and what such branding meant for the ways in which he was expected to imagine himself and his future in the world, and in turn, the ways in which this branding shaped the ways in which he was imagined by others, that lead Matt to the point at which he withdrew from the study of Chemistry.

9.5 Conclusion

In this chapter, Chapter 9, interview data from six teachers and 12 students from three ‘exposed’ school sites — Emu SHS, Brolga SHS and Kookaburra SHS — located in remote, rural and urban locations, respectively, across regional North Queensland, alongside contextual secondary data about each of the school sites mentioned above, has been presented and analysed.

A significant feature of the policy terrain that has transformed the nature of teaching and learning in the senior phase of schooling in Queensland; that is, ETRF, was described in Section 9.2 of this chapter, along with a discussion concerning the features of a key tool in the ETRF reforms, Senior Education and Training Plans or SET plans.

Research publications concerned with the evaluation of the ETRF process, such as those produced by Harreveld (2007) and Harreveld and Singh (2007), concede that while there are some challenges associated with the iterative process of the ETRF, generally the settings of the ETRF can be regarded as largely successful. The locally differential articulation of the SET planning process, as described in this chapter, is indicative of the mixed extent to which SET plans achieve their rhetorical purpose. It is suggested here that, at least in the exposed school sites under study in this thesis, SET planning is best regarded as a symbolic policy. It is mandatory for schools to implement SET planning, however the implementation of said policy is not accompanied by any additional physical, human or financial support. As a paradoxical consequence, the SET plan triggers forms of symbolic violence (Bourdieu, 2000) against the students it is purported to support and guide. Similarly, harnessing the ‘goodwill’ of the teaching staff at each site in order to ensure the success of SET planning, results in teachers being subjected to stress and uncertain role requirements.

Any reformation manoeuvre, which relies on mobilising teachers' goodwill, cannot be regarded as a sustainable endeavour. Data presented in Section 9.3 of this chapter provides some leverage to the argument of the present strain on the goodwill of senior teachers as a result of the lack of systemic support available to schools in the articulation of the SET planning policy initiative, despite a sense that the SET planning process, in and of itself, and in accordance with its rhetorical agenda, has inherent value. Furthermore, the transformation of senior secondary school teachers into brokers of educational products and services, leveraged on the back of disciplinary expertise, and without explicit professional development to build the capacity of senior teachers' work in this field, was also shown to be a problematic notion. As such, much of the brokerage work conducted by teachers is concerned with risk mitigation, often for the purpose of building the reputation of the school, rather than with a focus on quality service delivery to the students. Furthermore, teacher's "feelings" were invoked to judge the capacity of a student to participate in an academic pathway of her/his choosing. These subjective judgements made by teachers worked to silence students' aspirations and voices, along with parental voice, with implications for the future social mobility of the students concerned. This intensification and diversification of the role of the secondary school teacher as both broker and pedagogue contributes to two flow-on conceptions. Firstly, the ways in which students are positioned as entrepreneurs of themselves, and secondly, the conception of school subjects as commodities in a marketised education system.

While the student interview data presented and analysed in Section 9.4 of this chapter provides some agreement to the proposition that social and cultural capital feature significantly in a student's decision to choose Chemistry (or not), it also demonstrates that individual student capacities of aspiration, mobility and voice influence decision making (Sellar & Gale, 2011). Furthermore, the data illustrates the extent to which students aspirations' are not 'their own' – having been required to subject their aspirations and choices to official scrutiny in order to mitigate 'risky choices'. The rhetorical benefit of the risk mitigation process is to provide benefit to students — to ensure that they have access to an education and training pathway on which they can find success. It is argued here that risk mitigation is as much about preserving the reputation of schools, as it is about meeting the needs of the students served in these school sites. In an era of neoliberal accountability, schools who work with traditionally underserved students are ‘exposed’ to the vagaries of remote managerial discourses and measures of accountability. ‘Making the numbers look right’ becomes important in the preservation of the school’s reputation and in legitimating the work that schools perform on behalf of their students. In a climate where measures of accountability that would be of interest to this thesis – for example, how many students were supported through enabling science courses once they had indicated they were experiencing difficulty, or perhaps the number of students who completed four semesters of QSA subjects such as English, Maths B, or Chemistry – do not exist in the official discourse of accountability available for schools to report against.

Subjects, such as Chemistry, can no longer be conceived as being only a body of discipline specific knowledge to be mastered by the student. Subjects, such as Chemistry, become commodities brokered in a marketised education system. Under the ETRF, students communicate and document their aspirations in a SET plan and then begin accumulating credentials in their QCE towards their authorised aspirations. This process is analogous to that of an investor holding an investment portfolio that includes a futures managed fund, which provides some exposure to the commodity market, but whose futures and options are managed in ways that mitigate against ‘knowledge and expertise risk’ and ‘overexposure risk’. As such, school subjects, as commodities, are either ‘invested in’ (chosen) or regarded as too ‘risky’ to warrant ‘responsible investment’. The act of ‘investing’ in Chemistry, or not investing as the case may be, maps out particular pathways for students. Through both hot and cold knowledge, students come to understand Chemistry’s value in the Higher Education market and must then decide whether or not to ‘make the investment’.

As highlighted in Chapter 8, Chemistry holds status as a pre-requisite subject for entry into selected Science, Engineering, Technology and Allied Health tertiary courses in Australian universities. It follows then, that secondary school students with aspirations to study in the sciences or science-related fields at a tertiary level must consider embarking on the 'successful' navigation of the Chemistry curriculum, in order to gain access to their tertiary course of choice. However, for many students, this 'investment option' is not available – their previous performance in junior science and/or maths (that is their perceived 'knowledge and expertise risk') may have already precluded them from being permitted into the high risk/high return investment stream that is Chemistry. Long before students appear to have the option to 'choose' '*their* own' pathway, and articulate '*their* own' aspirations through the SET planning process, many students have already been branded as high-achieving science types or those with the capacity to become professional innovators; or vocational types, or those limited to fulfilling roles in the workforce as skilled innovators. The cultural act of 'choosing' to participate in Chemistry is, for many of these students, reduced to a 'stressful' illusion (Adkins, 2005).

Chapter 10 Conclusions and Implications

10.1 Introduction

This thesis has demonstrated the need to re-direct research efforts in light of understanding the crisis in science education that is, reportedly, underway in Australia, as well as in other post-industrial countries (Tytler, 2007). In the Australian context, Tytler conceptualised four aspects of the STEM crisis:

- decreasing participation in post-compulsory Science subjects, especially the 'enabling' sciences of Physics, Chemistry and higher Mathematics;
- evidence of students developing increasingly negative attitudes to Science over the secondary school years;
- a shortage of qualified science teachers; and
- a shortage of science-qualified people in the skilled workforce (Tytler, 2007, p. 7).

Throughout contemporary research reports, academic papers and policy discourse, these four aspects of the crisis are related back to the work of both teachers and schools, as the social agents that enact science curricula and the associated pedagogical decisions. Following on, these declines result in fewer students studying in science courses at university, and consequently Australia faces "shortages" of science-qualified human capital. Hence, the crisis is conceptualised as one of supply, with the supply-side of Australia's science being responsible for this crisis system (Office of the Chief Scientist, 2012a). However, as is recognised in the literature (Goodrum & Rennie, 2007; Office of the Chief Scientist, 2012a,b), despite many initiatives aimed at improving teacher and teaching quality, the numbers of students participating in the sciences in the post-compulsory years of schooling continues to decline.

Conceptualising the STEM crisis as a crisis of supply infers that Australia, as a nation-state, is both experiencing and responding to unmet labour market demand for people with STEM qualifications. The work presented by and through this doctoral thesis suggests that in order to break ground on the STEM crisis, it may be more fruitful to examine the potentialities of a relationship between student participation in the study of STEM subjects during their post-compulsory years of schooling, and a re-conceptualisation of the crisis; as a crisis of demand.

This chapter begins with a review of the research reported in this thesis, followed by the understandings that this study offers about the re-conceptualisation of the STEM crisis, through a consideration of the implications of this re-conceptualisation for students, teachers, schools, and universities navigating this policy moment. The chapter closes with a consideration of the limitations of this study, and a discussion about future research possibilities that may arise as a result of the initial work presented in this study.

This study was undertaken at a particular policy moment in Australia. The widening participation agenda initiated through the *Review of Australian Higher Education* (Bradley et al., 2008) and its targets to increase the participation of low socio-economic status people in higher education, and mandated through the Federal Government response (Department of Education Employment and Workplace Relations, 2009) provides significant steerage to the scope of the political work undertaken with regards to addressing the STEM crisis. In addition, the school sector is undergoing an *Education Revolution* (Commonwealth of Australia, 2008) alongside a curriculum reform agenda, enacted through ACARA (Australian Curriculum Assessment and Reporting Authority, 2009, 2012a, 2013a, b) and reforms to nationalise professional standards for teachers and professional development frameworks for teacher certification (Australian Institute for Teaching and School Leadership, 2012, 2014a, b) In addition, federal policy imperatives narrate the aspirations of Australia, as a nation-state, with regards to the Innovation agenda (Commonwealth of Australia, 2009a; Department of Innovation Industry Science and Research, 2010), which is conceptualised here as a globalised, and globalising, policy imperative with significant steerage-at-a-distance from the OECD (OECD, 2000a, 2004a; OECD Centre for Educational Research Innovation, 2011).

The common thread stitching each of these policy imperatives together is their ideological cultivation informed through human capital theory (Becker, 1975; Bowles & Gintis, 1975; Schwab, 1996; Sweetland, 1996). As such, much of the focus in this policy assemblage is on the development of a national human capital profile imbued with STEM skills and capacities. The supply-side of Australia's science system is charged with meeting the goal of STEM-trained human capital, within this globalised policy framework, underpinned by human capital theory. Measures to improve the rates of participation and performance of students in relation to science are then framed as solutions to this problem. However as noted by Bacci (2009):

> policies by their very nature imply a certain understanding of what needs to change (the 'problem') which suggests that 'problems' are endogenous – created within – rather than exogenous – existing outside – the policy making process. Policies *give shape* to 'problems'; they do not *address* them (p. x).

More specifically, Robertson and Dale (2009, p. 33) note that the production of policy has become more concerned with "problem-*framing*" rather than finding a solution to a problem. Given these understandings of the shifting role of policy, the study presented herein sought to problematise the notion of the STEM crisis as a crisis of supply, using a policy as practice approach (Blackmore, 2010) and drawing on Critical Discourse Analysis (Fairclough, 2010) as the primary analytical tool.

10.2 Overview of the Research

This study utilised a critical, sequential mixed-model approach (Elliott, 2008; Tashakkori & Teddlie, 1998), and contained three units of analysis, namely: policy production, policy articulation and policy reception (Blackmore, 2010). The policy production phase of the research involved the analysis of an assemblage of Federal policy documents related to the policy moment described above. The results of this phase of analysis were presented in Chapters 3, 4, 5, 6 and 7 of this thesis. The policy articulation phase of analysis involved document analysis of two key documents: The QTAC course guide (2010), and the QSA Chemistry Syllabus (2007). These documents were used to evidence the articulation of policy used to conceptualise the STEM crisis as a crisis of supply. These findings were presented in Chapter 8 of this thesis. Finally, in the policy reception phase of the study, teachers and students from three state secondary schools located in North Queensland were interviewed: Emu State High School (located in remote North Queensland), Brolga State High School (located in rural North Queensland) and Ibis State High School (located in a large urban centre in regional North Queensland). Each school is officially recognised as a low socio-economic status school, due to the ICSEA value it has been assigned. In total, six teachers and twelve Year 12 students were interviewed. In addition to interviews, a document analysis SET plans of the Year 12 cohort from each school was also conducted. From this analysis, the patterns of student engagement with the study of Chemistry were able to be determined. Chemistry was selected as the focal point for the policy articulation and policy reception phases of this study due to the subject being officially established as an enabling science during the policy production phase of the analysis. Just what it enables, and for whom, were questions that were addressed during these final two phases of the research. The research was informed by a number of research questions, as presented in Table 10.1:

Table 10.1
Summary of research questions

Phase of research	Overarching research question	Guiding research questions
Policy production	What is the ‘official’ rendition of the STEM crisis?	How is the ‘crisis’ in STEM education framed in policy discourse?
		How did Chemistry come to regarded as an ‘enabling science’?
Policy articulation	How is Chemistry positioned in the field of Education?	How is Chemistry related to tertiary access?

		What skills/abilities/capacities does participation in Chemistry foster?
		What is being enabled by calls for increased participation in the enabling sciences?
Policy reception	How do secondary school students navigate the process of 'choosing' Chemistry	How do systemic pathway and planning initiatives influence pathways through secondary school Chemistry, and to STEM fields of study at university?
		How do students navigate in low SES secondary schools in rural/regional Queensland navigate the process of 'choosing' Chemistry?
		Who is being enabled by the study of Chemistry?

The analytical framework employed throughout the thesis was informed by critical theory (Apple, 2006, 2007; Apple et al., 2009; Bernstein, 1999; Bourdieu, 1984, 1990, 2000, 2004; Bourdieu & Passeron, 1990). Critical Discourse Analysis (Fairclough, 2010) was the primary analytical tool employed in the attempts to re-conceptualise the STEM crisis, and to examine the relationships between Chemistry and a range of social actors and agencies named in relation to the STEM crisis and the widening participation agenda, in particular, students, teachers, schools and universities.

10.3 Review of key findings

This thesis contributes to a small body of research that has investigated the potential for structural and systemic factors to be impacting on student participation in STEM subjects during the post-compulsory years of schooling. Literature reviews to date have not located any other studies in

Science Education that have taken a policy analysis approach to interrogating the crisis from the perspective of students and teachers. As such, this study is among the first to examine the ways in which conceptualising the crisis as a crisis of supply, in the current policy moment, has impacted upon student participation in Chemistry, especially with a focus on regional North Queensland.

Of Tytler's (2007) description of the four key elements of the STEM crisis, one in particular — "decreasing participation in post-compulsory sciences, especially the 'enabling sciences' of Physics, Chemistry and higher Mathematics" (p. 7) was the focus of critical analysis to elucidate the construction of the crisis. Part 2 of this thesis — focussed on policy production — examined the policy assemblage working to legitimate the STEM crisis as a crisis of supply. This section of the thesis aimed to do this in two ways. Firstly, to examine the notion of "decreasing participation" and secondly, to question the extent to which teachers, and their work, could be blamed for this decreasing participation, as well as the perception that Australian students are underperforming in relation to international benchmarks. Chapter 3 drew attention to the contemporary work by the Office of the Chief Scientist (OCS) (2012a) in which the role of both schools and universities are described as the supply-side of Australia's science system. The Federal government and the business sector are positioned as the primary funders of the supply-side of the system, and as such, schools and universities are positioned to respond to the strategic direction set by these agencies. Justifying strategic direction is one feature of political legitimation efforts (Fairclough, 2010). It was argued that data can be used to construct an official rendition of the problem, and as such, political strategies to rectify the problem can be considered as legitimate.

One premise of the STEM crisis is "decreasing participation" in the post-compulsory sciences. While numerous reports have been published in attempts to quantify the "decrease in participation", Ainley, Kos and Nicholas (2008) were the first to report declines against specified definitions of participation. Data reported by Ainley et al. (2008) show that a decrease in participation is not evident in terms of raw numbers, with absolute enrolments in science subjects having increasing over the last two decades. The notion of decreasing participation is evident when participation rates are examined. In other words, the proportion of Year 12 students studying a STEM subject has decreased. Moreover, the proportion of Year 12 students studying two or more STEM subjects has decreased to an even greater extent. Further evidence reported suggests that low socio-economic status students, rural and regional students and students who attend state schools are among the groups of students least likely to study Chemistry in the post-compulsory years of schooling. Regardless, reports by the OCS (2012a, b) fail to take these findings into account, and it is argued here that doing so negates the experiences of many Australian students. Presenting aggregated data, allows the OCS to universalise the crisis, making it seem as though the crisis is affecting all Australian students to the same extent. However, failure to account for differential patterns of participation significantly undermines attempts to legitimate the STEM crisis. The particular needs and experiences of target equity groups are fused with a broader political agenda and this is counterproductive to the calls made by the widening participation agenda which seeks to increase participation of low SES Australians in higher education. Efforts to increase participation could be well informed by better understanding the differential patterns of participation.

After having examined "decreasing participation" in secondary school sector, patterns of participation in higher education sector were examined. Reports commissioned by either the Australian Council of Deans of Science or the Federal Government show that in the years prior to 2020, there have been numerous data collection, collation and enumeration methodologies employed, thus making the process of generating and comparing enrolment trends difficult. However, during the period 2002-2009/10, data handling was consistent across jurisdictions, and as such some trends for this period were able to be reported. These data showed that the proportion of enrolments in STEM courses had actually remained relatively stable over time. Moreover, growth in enrolments in the Natural and Physical sciences were comparable to system-wide results. As such, 'decreasing participation' was not a trend evident at the broad field of study. However, 'decreasing participation' was very evident at the level of the narrow field of study. For example, enrolments in a Bachelor level Chemistry degree declined by 23.6 per cent over the period 2002-2009/10. Course completion data was of more concern to 'decreasing participation', with completion rates in Chemistry among the lowest reported rates of course completion. It is suggested here that these findings are indicative of students 'playing the market' and using a participation in a Bachelor of Science to leverage access to a more vocational pathway in the Health fields of study. An additional feature of 'decreasing participation' was also evident in relation to the higher education sector. That is, the perceived quality of enrolling students was reported to be in decline. This concern was expressed in terms of students with lower ATAR scores, and general under-preparedness for university study. It is this qualitative feature of 'decreasing participation' along with declining enrolments and rates of course completions that are used in attempts to construct the work of teachers and schools as central to the supply crisis.

The role of teachers and teacher quality in relation to declining student participation in STEM subjects during the post-compulsory years of schooling was explored in Chapter 4. In addition, the perception of student under-performance against internationally benchmarked assessments of scientific literacy including TIMMS and PISA was also explored, with critique surrounding the legitimacy of blaming teachers for the reported declines. It was argued that the term 'quality' was deployed to construct teachers and their work as legitimate issues for the STEM crisis, and therefore as legitimate sites of action to address declines in relation to both student participation and student performance. However, analyses presented in the chapter revealed moments where attempts to implicate the role of teachers in the crisis fail, thereby undermining attempts at legitimation. For instance, the notion of 'appropriate qualifications' was identified as a point of contention amongst stakeholders in the field of education. Debate over the depth and breadth of necessary teacher qualifications persists, despite newly authored *Professional Standards for Teachers* (Australian Institute for Teaching and School Leadership, 2014a, b), and the associated framework for *Teacher Performance and Professional Development* (Australian Institute for Teaching and School Leadership, 2012). Furthermore, research reported in this chapter showed that secondary school Chemistry teachers are largely qualified and experienced. Teachers working in rural and remote schools, or schools servicing low socio-economic status communities were likely to be teaching 'out-of-field'. Some studies offered cautions about reducing quality teaching to disciplinary expertise as, by doing so, opportunities to develop pedagogical approaches and strategies in STEM education become limited.

Teacher quality was also implicated in the apparent decline in student performance against international benchmarks. However, further analysis revealed that the performance of Australian students has remained relatively stable over the last three testing cycles, and it is the ascendance of the students from China (represented through results from Shanghai and Hong-Kong) that have meant Australia's international ranking has slipped. Studies have argued that this leap to a public discourse of decline may be the result of PISA envy (Dinham, 2013), or the practice of policy externalisation (Sellar & Lingard, 2013), whereby the success of China is used to justify calls for education reform in Australia. What is of more concern to this study, herein, are the disparities in performance between Australia's high SES students, and students from low SES backgrounds, state school, and remote and rural geographies and Indigenous students (Thomson, 2013; Thomson et al., 2013). While these disparities have been clearly and predominantly discussed in reports to government, the official renditions of the STEM crisis, as reported by the Office of the Chief Scientist, do not focus on this aspect of the crisis. Instead, Australia's aggregated international ranking is used to justify calls to improve teacher quality. These practices of policy externalisation work to avert the public gaze from less politically desirable projects such as addressing issues of structural inequity facing Australian schooling system, yet it does little to address the issue of STEM participation for 'all Australians'.

The literature also holds teachers to blame for the choice students make to participate (or not) in STEM subjects in their post-compulsory years of schooling. The work of teachers, and specifically, their enactment of 'ineffective' pedagogies that lead to student boredom and disengagement is much discussed in the literature (Department of Education Science and Training, 2003, 2006; Goodrum et al., 2001; Tytler, 2007; Tytler et al., 2008). However, in relation to blaming teachers for declining participation, it was argued that the notion of 'effective' or 'ineffective' pedagogy is ambiguous, and a measure of effectiveness can only be evaluated in relation to a clearly articulated purpose for Science Education. Following from there, a critical review of the literature revealed that there has been, and continues to be, debate around the purpose of STEM education. STEM education is charged with a dual purpose – developing a scientifically literate citizenry as well as preparing future scientists for university study. Despite previous research that has shown that framing STEM education results in neither purpose being achieved well, the new ACARA national science curriculum (Australian Curriculum Assessment and Reporting Authority, 2011, 2013a) mandates the same approach. As such, it is argued that the official view of effective science teaching is setting teachers and students up to fail from the beginning.

Since teachers are regarded as not providing effective teaching, the Office of the Chief Scientist (2012b) recommended a program of 'collaboration with schools', which, when the funding allocations are examined in detail, reveals that schools are not the direct recipient of the funding package "for schools"(Garrett & Melham, 2012). It was argued that this approach to collaboration with schools amounts to a mistrust of teachers on the part of the Federal government, and it forces teachers to embrace regulated autonomy or be perceived to be contributing to the crisis. While notions of poor pedagogy were noted to be frequently cited as reasons for declining participation, only three studies suggested that the strategic value of STEM subjects may significantly impact on students decisions to study them, or not. Moreover, one study noted that schools, too, were found to recognise the strategic value of STEM subjects, and were reported to discourage interested students from studying STEM subjects in order to avoid their place in league tables slipping and to maintain their positional advantage in the marketised education sector. This finding highlights a paradox within the construction of the STEM crisis, and works to undermine attempts to legitimate teacher quality as a key issue in the STEM crisis. While on the one hand, decreasing student participation is central to the STEM crisis, student quality and positional advantage may work to limit student participation. This finding highlights a gap in the research related to student participation in science subjects in the post-compulsory years of schooling, and that is, the potential influence of systemic factors that may be contributing to patterns of student participation. This study seeks to contribute to this paucity of research.

Fairclough (2010, p. 5) suggests that an approach to researching a 'crisis' could be exploring:

> The emergence of different and competing strategies for overcoming the crisis, and the processes through which and the conditions under which certain strategies can be implemented and can transform existing systems and structures. This formulation is based upon a theory of crisis which among other things sees crises as events which arise from the character of structures, and sees strategies and structures as in a relationship such that the effects of structures gives rise to strategies oriented to changing structures. If it also sees strategies as having a partly discursive character, one 'point of entry' for research could be focussed on discursive formations of strategies and how they may contribute to their success or failure. This might include for instance analysis of *explanations of* the crisis and *attributions of blame*, *justifications for* and *legitimations of* particular lines of action and policy, and *value claims and assumptions in explanations*, *justifications and legitimations* [emphases added].

Chapter 5 examines the extent to which Innovation, as a globalised and globalising policy imperative steered by the OECD, works to *justify* particular lines of Australian Federal action and policy. In addition, Chapter 5 examines the *assumptions* evident in the re-structuring of ministerial responsibility for the portfolios of Science, Education and Innovation, through time. The analyses revealed that ministerial responsibility for the Science portfolio has shifted through time, and this its alignment and re-alignment with the portfolios of Industry and Education reflect governmental aspirations to leverage a transition to an innovation-led economy in which "techno-scientific knowledge is understood as a central driver of economic growth" (Bullen, Fahey & Kenway, 2006, p. 6). Moreover, the points of re-structure reflect the national response to Innovation as a globalised policy imperative. This chapter also drew attention to the significant role played by the OCS, as a newly established structural agency, in responding to the STEM crisis and in (re)-shaping Australia's innovation agenda. The OCS has produced the most recent official renditions of the nature and scope of the STEM crisis, along with descriptions of the sites of the STEM crisis. These sites include schools, universities and students themselves. These official representations of the sites of the STEM crisis allow the government to justify a range of globalised policy intent and actions (Fairclough, 2010). Once the crisis has been explained and justified, particularly in relation to the globalised policy imperative that is Innovation, the Federal Government seeks to legitimate these policy actions in relation to the STEM crisis. Chapter 6 followed on from here, examining the discursive attempts to legitimate the sites of action for the STEM crisis.

Four categories of discourse were found to be operationalised through the policy assemblage under study – the discourses of (i) security, and its binary (ii) risk; and (iii) opportunity, and its binary, (iv) quality. Taken together, it is clear that through their policy assemblage, the Labor Government sought to encourage young Australians to regard participation in Science and Science-related fields as 'opportunities' that will leverage employability and therefore, security, in an innovation-led economy. In this way, the discourses of 'opportunity' and 'security', are deployed in policy to construct Innovation as an order of discourse, thereby steering subjects and subjectivities in particular ways in relation to the Innovation Agenda. More specifically, the categories of discourse evident in the policy assemblage under study seek to encourage young people to secure their inclusion in the knowledge economy. Be that as it may, it is argued here that the capacities of these discourses to legitimate the Innovation agenda are weakened by two significant tensions that become evident when the STEM crisis is interrogated from a demand perspective. Firstly, there is a lack of clearly articulated labour market demand for Bachelor degree graduates with STEM skills. Secondly, this lack of clearly articulated labour market demand is linked to the unstable representation of STEM-skills in policy discourse through time. Each of these tensions mediate the extent to which young people respond to the Innovation agenda as an ideological proposition.

Analysis of Graduate destination data in Chapter 7 revealed that the scope and nature of the labour market demand for STEM graduates is, at best, unclear. Chemistry graduates are among those most likely to be seeking employment at the completion of their degree, and this is a trend that has increased over time. The choice to study in the Natural and Physical Sciences, then, may be regarded as risky. These data undermine political efforts to construct Innovation as an order of discourse (as discussed in Chapters 5 and 6 of this thesis) – the discourse of security is once again weakened by evidence weighted towards its binary, risk.

Moreover, it was argued that while the terms 'STEM', 'Innovation' and 'enabling' appear with high frequency throughout the policy assemblage under study herein, the policy discourse practices evident in the same assemblage fail to establish coherent links between the ideational meanings of these three terms. Discursive hybridisation (Fairclough, 2010) is used to establish the conditions required to deploy the term 'STEM-skills' and to then narrate the role of 'STEM-skills' in relation to the Innovation agenda. However, it was argued that the government's capacity to legitimate the relationship between 'STEM-skills' and the Innovation agenda is undermined by weak discursive practices that fail to cohere the ideational meanings of both 'STEM' and 'skills'.

These weak discursive practices lead to a hollow conceptualisation of 'STEM' which, in turn, makes defining the nature and scope of the labour market demand difficult. For many students, including women and students who live in rural and regional Australia, opportunities for employment in these fields are unclear or, at best, may be highly competitive. It was argued here that failure to explicate the characteristics of the STEM skills that are in demand contributes to the decline in student participation in STEM courses, particularly in the post-compulsory years of schooling, and therefore undermines political efforts to construct Innovation as an order of discourse. Marginson, Tytler, Freeman and Roberts (2013) noted that "there is a lack of clear data in Australia concerning destinations of STEM graduates and the role of STEM training in a variety of professions. There is also lack of data on qualifications of teachers of STEM" (p. 24). These findings support the argument made herein that there is both a poor understanding of the domestic labour market demand for STEM-skills and a lack of clarity surrounding the role that STEM-education plays in graduates gaining a STEM-occupation.

Taken from a student's perspective, choosing to participate in STEM study could be construed as risky and this conclusion contradicts the rhetoric of security espoused in the Innovation policy assemblage presented in Chapter 6 of this thesis. Consequently, the government's inability to legitimate a strong labour market demand for STEM-skills undermines any policy efforts to construct Innovation as an order of discourse. Moreover, it was argued that the lack of clear evidence for strong labour market demand is a weakness in the government's legitimation efforts and is, in itself, contributing to the STEM crisis. A critical explication of 'demand' must be included alongside other measures in any future policy attempts to address the 'STEM crisis'. It is argued here that despite calls from Industry for an increase in STEM graduates, what they are actually seeking is the development of a human capital profile imbued with STEM-skills that can be used to leverage economic transitions in traditional manufacturing. In other words, the AIG is seeking to leverage the development of human capital with specific *qualities*, rather than an increase in the *quantity* of STEM-graduates.

In constructing the STEM crisis as one of supply, the notion of demand has been largely ignored in official policy discourse. Notions of the need to increase the STEM capacities of Australia's supply of human capital dominate the innovation policy assemblage. This need is shaped by the OECD, working as a globalising force in the Innovation agenda. Discourses of 'security' and 'opportunity' dominate the innovation policy assemblage, as ways of constructing a sense of urgency for nation-states and individuals alike to respond to the innovation agenda; for failure to participate in the Innovation agenda would result in a loss of quality of life. An inability to participate in the innovation agenda would leave nation-states and individuals vulnerable to the market; an arena in which traditional social contracts of security can no longer be guaranteed. As such STEM skills, capacities and abilities were held as central features of the human capital profile to leverage access to the innovation agenda. Policy discourse identifies Chemistry as an ‘enabling science’(Department of Education Science and Training, 2003, 2006; Department of Industry Innovation Science Research and Tertiary Education, 2012), and that human capital trained in these enabling sciences were essential to leveraging economic growth in an innovation-led economy.

Given the official recognition of Chemistry as an enabling science in policy discourse, this secondary school subject was selected as the focus of a case study involving the relationship of Chemistry to tertiary entrance in Queensland. The results of analyses presented in Chapter 8 show that ‘Chemistry’ is itself a problematic conception. Each state and territory in Australia has its own official version of Chemistry, defined through curricula documents. What is more, these different versions of Chemistry are not stable through time. In the period between 1992 and 2011, Queensland schools have enacted five official versions of the Chemistry syllabus. Despite this state of affairs, policy documents refer to Chemistry as though students across the nation are engaged in stable, homogeneous teaching and learning experiences. It was argued that failure to problematise the various recontextualised forms of Chemistry also fails to acknowledge that students — within schools, between schools and between State and Territory jurisdictions — will have had different experiences in their studies of Chemistry.

In Queensland, the Chemistry curriculum underwent a significant transformation in 2002 when it mandated teaching Chemistry in context. Chemistry was also noted to have its own official field position, and this understanding was used in conjunction with Bourdieu’s (1999) notions of field and habitus to argue that the deployment of Chemistry as a pre-requisite has become a strategically aligned with the equity stance (Gale, 2011) that institutions take in relation to the widening participation agenda. Document analysis of the QTAC course guide revealed that Queensland’s elite university was more likely to deploy Chemistry as a pre-requisite in relation the fields of Science and Health and Recreation than any other institutional grouping. These strategic decisions reflected institutional habitus (Clegg, 2011) and this analysis brings a new light to bear on previous studies (Lyons & Quinn, 2010; Venville et al., 2010) that discussed whether or not students recognised the strategic values of Chemistry within a marketised education system.

In addition, it was noted that Chemistry holds an elevated place in the curriculum hierarchy (Teese, 2000; Teese et al., 2009; Teese & Polesel, 2003), and as such, this subject is able to function as a "structure for differentiating opportunities" (Teese, 2007, p. 46). Just as Teese (2007) recognises that the hierarchy of curriculum relies on a hierarchy of schools, it was argued in Chapter 8 that the hierarchy of the curriculum is also the foundation for the hierarchy of universities. To elaborate on this point, the work of Adkins (2003) was used to highlight why debating the role of curriculum in relation to institutional habitus is essential to providing insights into why "some changes in objective structure lead to increased possibilities for the development of transforming practices and others do not" (p. 27). As was discussed in Chapter 8, the nature and extent of 'response' available to, and made by, each institution is a site of struggle, and curriculum, including Chemistry, is deployed strategically in order to generate 'possibilities' that are desirable to the stance of the institution. The final product of these distinctive stances is human capital which embodies the knowledge and skills to fulfil a role within the knowledge economy.

The official ways in which Chemistry marks out distinctive human capital was then the focus of the remainder of Chapter 8. Here, the analysis called into question the validity of human capital theory as an ideological underpinning for the policy assemblage under study herein. Adkins (2005) suggests that giving prominence to "embodied performance" through attributes such as skills and capacities may no longer hold a great deal of explanatory power in the 'new economy' which she considers to be organised by "cultural principles of the brand" (p. 126) and which give rise to mediated forms of personhood that sit externally to those qualities that would have been through to have been embodied by individuals. Finally, Adkins (2005, p. 112) argues that "qualities previously associated with people are being disentangled", that is to say, qualities that would have considered impossible to remove or separate from an individual are being distanced from the person, and in so doing, are being transformed as properties with cultural value. Analysis of the QSA Chemistry Syllabus (2007) revealed that the knowledge, skills, attitudes and values reportedly developed by students through their study of QSA (2007) Chemistry aligned closely with the features of human capital development that Smith et al. (2012) considers necessary for the emergence of innovation. However, Smith et al. (2012) state that while the 'capacity to innovate' may indeed be present and observable in human capital, such capacities will not necessarily translate directly to innovation. As such, factors that transform 'capacity to innovate' into 'innovation' were considered by the report's authors to be vital in order to leverage an innovation-led economy.

In Adkin's (2005) terms, while students of Chemistry may be able to claim that they have developed the 'capacity to innovate'; this capacity will not be enough for an individual to leverage labour power within the new economy. This capacity will only have exchange value through its external recognition; through re-qualification. Instead, what Adkins suggests becomes more significant in the new economy, is a focus on "the effects of their labour (cultural work) on the intended audience" (2005, p. 123). As such, while the QSA syllabus (2007) makes rhetorical statements about the skills and abilities accumulated by students of Chemistry, it is no longer these skills and abilities per se that leverage access to tertiary institutions. A shift to governance in the higher education sector has instead allowed institutions to regard participation in Chemistry as a cultural act, intended for some institutions and not for others. In this way, the act of naming Chemistry as a pre-requisite could be read as an act of branding particular individuals, courses and institutions as the 'innovators' for an innovation-led economy.

Having considered how policy that constructs Chemistry as an enabling science in efforts to address the STEM crisis is articulated in the case of Queensland universities, the thesis moved to consider how these policies are received by students, teachers and schools attempting to navigate the process of 'choosing' Chemistry. Chapter 9 presented analyses of interview data with teachers and students, and data extracted from SET plan documents, from three ‘exposed’ schools sites in North Queensland.

A significant feature of the policy terrain that has transformed the nature of teaching and learning in the senior phase of schooling in Queensland; that is, the ETRF, was described in Section 9.2 of this thesis, along with a discussion concerning the features of a key tool in the ETRF reforms, SET plans. It was argued that such a reformation manoeuvre, which relies on mobilising teachers’ goodwill, cannot be regarded as a sustainable endeavour. Data presented in Section 9.3 of this chapter provides some leverage to the argument of the present strain on the goodwill of senior teachers as a result of the lack of systemic support available to schools in the articulation of the SET planning policy initiative. Furthermore, the transformation of senior secondary school teachers into ‘brokers’ of educational products and services, leveraged on the back of disciplinary expertise, and without explicit professional development to build the capacity of senior teachers’ work in this field, was also shown to be a problematic notion. As such, much of the ‘brokerage work’ conducted by teachers is concerned with risk mitigation, often for the purpose of building the reputation of the school, rather than with a focus on quality service delivery to the students. Furthermore, teacher’s “feelings” were invoked to judge the capacity of a student to participate in an academic pathway of her/his choosing. These subjective judgements made by teachers worked to silence students’ aspirations and voices, along with parental voice, with implications for the future social mobility of the students concerned. This intensification and diversification of the role of the secondary school teacher as both ‘broker’ and ‘pedagogue’ contributes to two flow-on conceptions. Firstly, the ways in which students are positioned as entrepreneurs of themselves and secondly, the conception of school subjects as commodities in a marketised education system.

While, the student interview data presented and analysed in Chapter 9 provided some agreement to the proposition that social and cultural capital feature significantly in a student’s decision to choose Chemistry (or not), it also demonstrates that individual student capacities of aspiration, mobility and voice influence decision making (Sellar & Gale, 2011). Furthermore, the data illustrates the extent to which students 'aspirations' are not 'their own' — having been required to subject their aspirations and choices to official scrutiny in order to mitigate 'risky choices'. The rhetorical benefit of the risk mitigation process is to provide benefit to students — to ensure that they have access to an education and training pathway on which they can find success. It was argued that risk mitigation is as much about preserving the reputation of schools, as it is about meeting the needs of the students served in these school sites. In an era of neoliberal accountability, schools who work with traditionally underserved students are 'exposed' to the vagaries of remote managerial discourses and measures of accountability. 'Making the numbers look right' becomes important in the preservation of the school's reputation and in legitimating the work that schools perform on behalf of their students

Subjects, such as Chemistry, can no longer be conceived of only as a body of discipline specific knowledge to be mastered by the student. Instead, these subjects become commodities brokered in a marketised education system. Under the ETRF, students communicate and document their aspirations in a SET plan and then begin accumulating credentials in their QCE towards their authorised aspirations. This process is analogous to that of an investor holding an investment portfolio that includes a futures managed fund, which provides some exposure to the commodity market, but whose futures and options are managed in ways that mitigate against 'knowledge and expertise risk' and 'overexposure risk'. As such, school subjects, as commodities, are either 'invested in' (chosen) or regarded as too 'risky' to warrant 'responsible investment'. The act of 'investing' in Chemistry, or not investing as the case may be, maps out particular pathways for students. Through both hot and cold knowledge, students come to understand Chemistry's value in the Higher Education market and must then decide whether or not to 'make the investment'. It follows then, that secondary school students with aspirations to study in the sciences or science-related fields at a tertiary level must consider embarking on the 'successful' navigation of the Chemistry curriculum, in order to gain access to their tertiary course of choice. However, for many students, this 'investment option' is not available – their previous performance in junior science and/or maths, that is their perceived 'knowledge and expertise risk' may have already precluded them from being permitted into the high risk/high return investment stream that is Chemistry. Long before students appear to have the option to ‘choose’ ‘*their* own’ pathway, and articulate ‘*their* own’ aspirations through the SET planning process, many students have already been branded as ‘high-achieving science types’ or ‘professional innovators’; or ‘vocational types’ or ‘skilled innovators.’ The cultural act of ‘choosing’ to participate in Chemistry (Adkins, 2005) is, for many of these students, reduced to a ‘stressful’ illusion.

10.3 Returning to the research questions

This study was structured to address three overarching research questions (listed below). In this study, policy was regarded as a “policy as practice in terms of the social practices involved in the production of policy, the practices involved with the articulation and vernacularisation of policy through processes of its reception, as well as the intent and effects of policy changing practice” (Blackmore, 2010, p. 101). Moreover, as stated by Bacchi (2009, p. x) “policies give shape to ‘problems’ they do not address them”. As such, in order to answer the overarching research questions, it is first necessary to examine the forces and fields working to shape Chemistry, as a secondary school subject; the transitions of students as they move through secondary school; and the social, political and economic context in which schools, and their teachers work. As such, each of the overarching research questions were approached with these broad objectives in mind.

1. *What is the ‘official’ rendition of the STEM crisis?*

The parameters of the STEM crisis were initially articulated by Tytler (2007). In considering the official rendition of the STEM crisis, as evidenced through reports by the Office of the Chief Scientist (2012a,b), data describing declines in STEM participation and performance were interrogated. Teachers, and their lack of qualifications and poor pedagogical content knowledge are blamed for this official rendition of the crisis. However, critical analysis revealed that re-conceptualisation of the STEM crisis as a ‘crisis of demand’, or more specifically, a crisis of ‘demand for quality(ies)’ may prove to be more fruitful in understanding why students may, or may not, be choosing not to participate in the enabling sciences in secondary school, as well as in the Bachelor level degrees in narrow fields of study of the enabling sciences of Chemistry and Physics.

2. *How is Chemistry positioned in the field of Education?*

Chemistry, as a secondary school subject, is unproblematically positioned as a stable, homogenous learning experience, located high on the curriculum hierarchy (Teese, 2000; Teese et al., 2009; Teese & Polesel, 2003). In addition, Chemistry has an official field position that proves advantageous weighting in the event of competition of a position in university. Chemistry is also frequently named as either assumed knowledge or as a pre-requisite to entry to many university courses in Queensland universities (QTAC, 2010). However, the analyses conducted herein reveal that in Queensland, the mandated approach to delivering the Chemistry curriculum has varied through time. As such, studying 'Chemistry' should not be regarded as a ubiquitous experience for all Queensland students. Nevertheless, the deployment of Chemistry as a pre-requisite was found to be a strategic manoeuvre aligned with the stance that each university would prefer to take in relation to the widening participation agenda. In this way, the act of naming Chemistry as a pre-requisite could be read as an act of branding particular individuals, course and institutions as the 'innovators' of the future – those students who will have access to the security promised by participation in the Innovation agenda.

3. *How do secondary school students navigate the process of 'choosing' Chemistry*

In order to answer this question, a particular case of students from low SES secondary schools was examined. These schools represented different geographies of North Queensland; remote, rural and urban. The act of choosing Chemistry required students to subject their aspiration and choices to official scrutiny through the SET planning process. The rhetorical purpose of this scrutinisation was reported to be to benefit to the students, such that they would avoid making 'risky decisions' and instead, would be steered along a path likely to end in success. Senior secondary school teachers are positioned to broker this process for the students, in a process analogous to working as a commodity broker trading to mitigate against 'overexposure risk' and 'knowledge and expertise risk'. However, narrow measures of accountability often resulted in brokerage that benefited the school, conceptualised as the firm. In their efforts to 'make the numbers look right' students were strategically counselled into or away from Chemistry, in some cases despite of the aspirations students expressed to the contrary. Such strategic streaming relies on the branding (Adkins, 2005) as either 'high achieving science types' or 'vocational types'. Only the brand of 'high achieving science type' is afforded access to the risky commodity that is Chemistry.

10.4 Considering the limitations

The analyses conducted during the policy production phase of the research were not exhaustive of all policies within the field. It is possible (and likely) that the inclusion of additional policy documents would nuance the readings advanced in this thesis.

The data related to Chemistry's role in accessing universities, as explored in Chapter 8 of this thesis, was drawn only from the State of Queensland. Analyses of the interactions between Chemistry, as a pre-requisite, and universities in other Australian States and Territories was not undertaken. As such, the findings of this case cannot be extrapolated beyond the State of Queensland. In addition, the course entry requirements for Queensland universities were examined for the Year of 2010 only. Pre-requisites to entry may have since changed and additional research would be required in order to ascertain whether or not the trends evident in 2010 continued to be evident in other years.

Another limitation is the small number of interviewees in this study. However, this number is a feature of the small cohort sizes of students studying Chemistry through to Year 12 in many remote, rural and urban schools in North Queensland. In an attempt to overcome this, member checking was undertaken to ensure that the interview transcripts portrayed the interview with accuracy and integrity. As such, while this reduced sample size will indeed have shaped the overall research finding, the number of interviewees sampled is indicative of the problem of 'decreased participation' from the perspective of schools in North Queensland.

Finally, while this research project has presented an alternative way of reading and conceptualising the STEM crisis, and the role of Chemistry within it, this study constitutes only one reading. As such, the arguments and re-conceptualisations presented herein require further debate and consideration by other, more experienced, scholars in the field to test their merits. Moreover, conducting this research through the lens of critical theory invokes particular kinds of readings, and as such, when viewed from a different theoretical standpoint, it is likely that other conclusions may be drawn.

10.5 Opportunities for future research

Re-conceptualising the STEM crisis as one of 'demand' rather than 'supply' provides multiple opportunities for further research. For example, investigations into science student perceptions of labour market demand, with a particular focus on comparing perceptions between remote, rural, urban and metropolitan centres would provide further evidence for the argument of re-conceptualising the crisis as one of demand. Further, detailed, analysis of the differential patterns of labour market demand would also be of benefit to considering the STEM crisis from a demand perspective.

In addition, problematising the role that Chemistry, as a secondary school subject plays in perpetuating the crisis, has revealed other areas for future research. For example, conducting narrative interviews with university representatives about the who makes the decision the include (or exclude) Chemistry as a pre-requisite, and what factors influence these decisions, would generate further evidence to test the suggestion made herein that universities decide whether or not to deploy Chemistry as part of their stance in relation to the widening participation agenda. As well, exploration of participation in Chemistry as a cultural act, as informed by the work of Adkins (2005), would also generate further evidence that could be used to test the notion that Chemistry is deployed as means of branding individuals, courses and institutions of distinction.

More broadly, similar policy analysis studies could be conducted in relation to other 'enabling fields' including Physics and higher Mathematics, in order to examine if these disciplines are invoked in similar ways in relation the STEM crisis, and the political efforts made to address it.

10.6 Final remarks

This work has attempted to demonstrate that new insights into the STEM crisis can be achieved by examining the ways in which the problem has been constructed in and through policy. As was noted by Goodrum and Rennie (2007), despite many initiatives aimed at addressing the STEM crisis, trends in decreasing participation continued. It is suggested here that these trends persist because blaming teachers, teacher quality and poor pedagogy as the primary reason for students turning away frames the crisis only as one of supply. Framing the crisis as one of supply takes the notion of strong labour market demand for granted, and as such, places teachers as the primary site of action, when instead, the primary site of action could be strengthening the political efforts to firstly understand, then to clearly articulate domestic labour market demand for STEM qualified graduates.

Reading the crisis as one of demand also invokes the agency of students which is otherwise marginalised in reading the crisis as one of supply. In a supply crisis, students are positioned as victims of poor teaching that fails to inspire students to take up opportunities in the sciences. In a demand crisis, students are positioned as active entrepreneurs of the self, making choices to invest (or otherwise) in commodified curricula choices, so as to improve their chances of securing employment in the 'new economy' (Adkins, 2005). In addition, reading the crisis as one of demand allows for actions and agency of institutions in the supply-side of the crisis to be interrogated. These actions reveal that paradoxically, despite calls for increased participation in 'enabling' STEM subjects such as Chemistry, and the imperative of the widening participation agenda encouraging more low SES students to study at university, Chemistry as a secondary school subject, and as part of the curriculum hierarchy, is used to maintain positional advantage for schools and universities alike in the context of a marketised education sector. The aspirations and choices of students are mediated by these institutional habituses, and as such, access to the Innovation agenda, and the security and opportunity it promises, remains out of reach for many students who are already exposed to structural and financial disadvantage.

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Appendices

Appendix 1 Ethics approval (DET: 10/243984)

Appendix 2 Ethics approval (JCU: H3866)

Appendix 3 Sample Interview Guide: Students

Appendix 4 Sample Interview Guide: Teachers/Administrators

Queensland Government

Appendix 1 Ethics Approval (Department of Education and Training – 10/243984)

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Appendix 2 Ethics Approval (James Cook University – H3866)

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Appendix 3 Sample Interview Guide: Students

Question	***Purpose***
Theme: Transitions & Capitals	
So how long have you been attending x school?	These questions are designed to capture data related to ways in which social and cultural capitals may act upon transitional junctures.
Which subjects did you study throughout years 11 & 12?	
Did anyone help you to make your subject selection choices? If so, who - parents/friends/school staff?	
Do you remember having to do a SET plan? Do you remember what this involved?	
So did that take you half an hour or a couple of weeks?	
So at school, you would have done some things to help you make your decisions.	
Did your parents have to be involved in this process? What did they have to do?	
So, I guess you might have taken some materials like these home? Was there anyone you discussed these materials with at home, or did you mainly discuss them with someone at school?	
So, once you had finished your SET plan, did you look at again between then and now?	
Did you change your SET plan at any time over your senior? Why did you change it?	
Do you think that writing a SET plan was a useful or helpful thing for you to do? Why? Why not?	
Theme: Aspirations	
So now, you are almost finished year 12, do you have an idea about what you might do next? Has anyone in the school been asking you what you are going to do next?	These questions are designed to capture data related to choice and factors that may be affected student choices and aspirations.
Do you remember what you put down as your goals when you wrote your SET plan? Do you current plans match those you wrote down back in 2008?	
When you selected your subjects for years 11 & 12 were you thinking ahead to a specific career pathway?	
You selected chemistry as one of your subjects. Why did you choose to study chemistry?	
Did any of your older family members or friends study chemistry when they were at school?	
Have there been factors that you have found helpful to you in your study of chemistry? If yes, what are they?	
Tell me about your experience of studying chemistry.	
Did you have the same teacher for Years 11 & 12?	
How did you find the theory work? What do you think about the topics and concepts that you covered?	
How did you find the lab work?	
How did you find the assessment? What kinds of assessment did you do?	
Did you have friends who were studying Chemistry with you?	
Did you have a study group for Chemistry?	

Did you get any help outside of your teacher and friends? Is yes, from whom?	
Have there been factors that have made the study of Chemistry difficult? If yes, what are they?	
When you think about the topics you covered, do you think that the Chemistry you learned in senior will be of use to you in the future? In what ways?	
If you had to talk to the current Year 10s about doing Chemistry, what would you tell them?	

Appendix 4 Sample Interview Guide: Teachers/Administrators

Could you tell me a little bit about your teaching background? How long have you been a teacher? How long have been in the Head of Department role? How long have you been at this particular school?

How did the SET planning process look in 2008 compared to what happens now in 2010?

Tell me about how students receive guidance through the SET planning process

Tell me about the workload in the senior school that is associated with SET planning.

Does the school receive any practical and/or financial support towards mediating the SET planning process for students?

Do you think there is value in the SET planning process?

Do you think it could be mediated more effectively? If so, how?

What do you think about the role that SET plans plays or could play in relation to students with an interest in the sciences, and in particular chemistry?

Tell me about how students receive guidance through the sciences.