Mapping the Policy Environment on Primary STEM Education

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Abstract

The Government of Australia STEM policies leading to school-based implementation have been studied. The purpose has been to understand the Government's policy design and quality in leading to implementation. Recently, Government Primary STEM Education policy dimensions, for example, the action to require pre-service primary teacher specialisation with a priority in STEM have been administered with sparse academic research. Further, this policy action lacked a coordinated framework, which was administered in tension rather than harmony for school-based implementation nation-wide.

To analyse and evaluate policy quality, this study used an exploratory and integrative qualitative methodology to flexibly and logically analyse Government policy documents and conduct an interview with a leading National Government Executive administrator on Primary STEM Education policy formulated for school-based implementation. The analysis relied on four coding methods: *word, line, axial*, and *thematic* informing a Conceptual Framework and rationalizing policy quality. Since no prior framework was identified, a Conceptual Framework is an outcome of this study, which comprises four aspects. Through the four aspects of: the international STEM policy environment, context (which is the Government of Australia Executive Administration), policy dimensions, and policy attributes, three priority policies were analysed and the quality critiqued. The Conceptual Framework has been the basis to present the study's outcome of three priority policies and view policy quality as being in tension, rather than harmony. These policies: *Policy 1: Specialist STEM teachers*, *Policy 2: Students learning to code*, and *Policy 3: School partnerships with STEM organisations* are considered in tension because of a lack of or inconsistencies in sustained: National Government leadership across National agendas to State and Territory agendas, non-government STEM partnerships, and an evidence-based framework. Meanwhile, a priority policy has had government statements of being an all-encompassing and coordinated whole-of-government approach to implementation

by all schools through National agendas and prime ministerial leadership. The outcomes of this study show that policy is not all-encompassing nor coordinated across the National, States, and Territories, which is an inefficient and ineffective policy by design. The implications for teachers, teacher educators, and policy makers is to engage with policy design through an evidence-based framework to improve quality that impacts practice. For further research, an evidence-based STEM Enterprise framework had been recommended by the OACS (2014), and which was not identified by this study. Thus, the study recommendation is that an all-encompassing and coordinated evidence-based policy framework be implemented and relied on to design and develop a quality Primary STEM Education policy to impact school-based practices by the Government of Australia.

Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

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Contents

List of Abbreviations, Acronym, and Initialisms

The following abbreviations have been used for the names of these States and Territories, where appropriate:

Australian Capital Territory (ACT)

New South Wales (NSW)

Northern Territory (NT)

Queensland (QLD)

South Australia (SA)

Tasmania (TAS)

Victoria (VIC)

Western Australia (WA)

All currencies detailed are in Australian Dollars (AUD) unless otherwise stated.

Acronym/ Initialism	Explanation
ABS	Australian Bureau of Statistics
AC	Australian Curriculum
ACARA	Australian Curriculum, Assessment and Certification Authority
ACER	Australian Council for Educational Research
ACOLA	Australian Council of Learned Academies
ACS	Australian Chief Scientist. Notably, the retired Australian Chief Scientist
AG	The Government of Australia, the Australian Government, or The Commonwealth of Governments to Australia as formed by the various National and State government based elections to administer on the election promised policies (or policy platforms) within the national interests to Australia, which is the context of this study
AiGroup	The Australian Industry Group
AITSL	Australian Institute for Teaching and School Leadership
APEC	Asia-Pacific Economic Cooperation
ACT:	Australian Capital Territory Government Executive Agencies and Ministries including: Chief Minister, Treasury & Economic Development Directorate (ACTCMTEDD) Treasury (ACTT) Education Directorate (ACTED) Teacher Quality Institute (ACTTQI)
CSC	Commonwealth Science Council
CSIRO	Commonwealth Science and Industry Research Organisation
COAGP:	National Government Council of Australian Governments Portfolio Agencies and Ministries (COAGP) including: Council of Australian Governments (COAG) Education Council (EC) Education Services Australia (ESA)

	Australian Curriculum, Assessment & Reporting Authority (ACARA)
ETP:	National Government Education and Training Portfolio Agencies and Ministries including: Minister for Education & Training (MET) Department of Education & Training (DET) Australian Research Council (ARC) Australian Institute of Aboriginal & Torres Strait Islander Studies (AIATSS) Australian Institute for Teaching & School Leadership (AITSL)
EU	European Union
IEA	International Education Authority
IIS:	National Government Industry, Innovation & Science Portfolio Agencies and Ministries (IIS) including: Minister for IIS (MIIS) Department for IIS (DIIS) Commonwealth Science Council (CSC) Innovation & Science Australia (ISA) Australia's Chief Scientist (ACS) Office Australia Chief Scientist (OACS) STEM Advisory Group (STEMAG)
ISA	Innovation and Science Australia Committee
MDEGYA	Melbourne Declaration of the Educational Goals for Young Australians
NAPLAN NAP-SL	National Assessment Program - Literacy and Numeracy, which is The National Assessment Program by the direction of the Education Council. NAP-SL is the "first National Assessment Program - science literacy (NAP-SL) of Year 6 students occurred in 2003 with successive assessments conducted in 2006, 2009, 2012 and 2015. This is the only sample assessment that focuses entirely on Year 6 students. This is because the Ministerial Council for Education, Early Childhood Development and Youth Affairs (MCEECDYA, now known as the Education Council) agreed to use the Programme for

	International Student Assessment (PISA) as the National measure of performance for science literacy among secondary students." (ACARA, 2016, para.1)
NCA	The National Commission of Audit
NT	Northern Territory Government Executive Agencies and Ministries (NT) Chief Minister & Cabinet (NTCMC) Department of the Chief Minister & Cabinet NT(DCMC) Department of Treasury & Finance (NTDTF) Department of Education (NTDOE) NT Board of Studies (NTBOS) Teacher Registration Board (NTTRB)
NSW:	New South Wales Government Executive Agencies and Ministries including: Premier & Cabinet (NSWPC) Department of the Premier & Cabinet (NSWDPC) Treasury (NSWT) Department of Finance, Services and Innovation (NSWDFSI) Chief Scientist & Engineer (NSWCSE) Office of the Australian Chief Scientist & Engineer (NSWOCSE) Minister of Education (NSWME) Department of Education (& Communities) (NSWDOE) Education Standards Authority (NSWESA) (formerly BOSTES)
NTBOS	Northern Territory Board of Studies
OACS	Office of the Australian Chief Scientist
OECD	Organisation for Economic Cooperative Development
PC	Productivity Commission of Australia
PIRLS	Progress in International Reading Literacy Study
PISA	Programme for International Student Assessment
PM	Prime Minister (of Australia)

PMCP:	National Government Prime Minister & Cabinet Portfolio Agencies and Ministries (PMCP)
	Prime Minister & Cabinet Ministries(PMC)
	Department of the Australian Prime Minister and Cabinet (DPMC)
QLD:	Queensland Government Executive Agencies and Ministries including:
	Premier & Cabinet (QLDPC)
	Department of the Premier & Cabinet (QLDDPC)
	Department of Treasury (QLDDT)
	Minister for Innovation, Science & the Digital Economy (QLDMISDE)
	Department of Science, Information Technology & Innovation (QLDDSITI)
	QLD Chief Scientist (QLDCS)
	QLD Chief Scientist Office (QLDCSO)
	Minister for Education and Training (QLDMET)
	Department of Education & Training (QLDDET)
	QLD Curriculum & Assessment Authority (QLDCAA)
	QLD College of Teachers (QLDCT)
QUT	Queensland University of Technology
SA:	South Australian Government Executive Agencies and Ministries including:
	Premier & Cabinet (SAPC)
	Department of Premier & Cabinet (SADPC)
	Department of Treasury & Finance (SADTF)
	Department for State Development (SADSD)
	Chief Scientist (SACS)
	Minister for Education & Child Development (SAMECD)
	Department for Education & Child Development (SADECD)
	Teachers Registration Board of South Australia (SATRBSA)
STEM	Science, Technology, Engineering, and Mathematics
TAS:	Tasmanian Government Executive Agencies and Ministries including:
	Premier & Cabinet (TASPC)

	Department of the Premier & Cabinet (TASDPC)
	Department of Treasury & Finance (TASDTF)
	Minister for Education and Training (TASMET)
	Department of Education (TASDE)
	Teachers Registration Board (TASTRB)
	Professional Learning Institute (TASPLT)
TEMAG	Teacher Education Ministerial Advisory Group
TIMSS	Trends in International Mathematics and Science Study
TP	The National Treasury Portfolio Agencies and Ministries(TP) including:
	The Treasurer (T)
	The Department of Treasury (DT)
	Productivity Commission (PC)
UNESCO	United Nations Educational, Scientific and Cultural Organization
UoA	University of Adelaide
VC	Victorian Curriculum
VIC:	Victorian Government Executive Agencies and Ministries including:
	Premier & Cabinet (VICPC)
	Department of the Premier & Cabinet (VICDPC)
	Department of Treasury & Finance (VICDTF)
	Department of Economic Development, Jobs, Transport & Resources (VICDEDJTR)
	Lead Scientist (VICLS)
	Minister for Education and Training (VICMET)
	Department of Education & Training (VICDET)
	Vic Curriculum & Assessment Authority (VICCAA)
	Vic Institute of Teaching (VICIT)
WA:	Western Australian Government Executive Agencies and Ministries including:
	Premier & Cabinet (WAPC)
	Department of Premier & Cabinet(WADPC)

Chief Scientist (WACS)

Chief Scientist Office (WACSO)

Department of Treasury & Finance (WADTF)

Minister for Education (WAME)

Department of Education (WADE)

School Curriculum & Standards Authority (WASCSA)

Teacher Registration Board of WA (WATRBWA)

List of Tables

7.2	TASDE Specialist STEM Teachers Professional Development Program
7.3	TASDET (2016) STEM Education Fund Allocation
7.4	Initial estimates of in-kind funding for STEM programs
8.1	Case-study Coded Dataset

List of Figures

Number	Title
1.1	Study Conceptual Framework
4.1	Treasury DET Budget 2016-2017
4.2	TASDE Program on Specialist STEM Teachers
4.3	TASDE (2016) STEM Education Fund Allocation
4.4	Initial Estimates of In-Kind Funding for STEM Programs
5.1	DET 2017-2018 Budget Statement On Project 1.7 Digital Literacy And STEM
5.2	ACARA Australian Curriculum Project 1.1 Funds Allocation
5.3	Tasmanian Budget Department Of Education 2017-2018
7.1	Conceptual Framework

List of Appendices

Number	Title
1	Students' 2015 Pisa Averaged Achievement Results on the First 26 Nations/Regions
2	TIMSS 2015 Mathematics performance trend by year four students in Hong Kong/ Trends in TIMMS Mathematics Grade Four Performances by Gender in Hong Kong
3	PISA 2015 key findings for Singapore
4	The Government of Australia Federal System
5	Online Key Term/Word Search Results to Data Collection
6	Context Map
7	Generic List of the Types of STEM Policy Documents (Data) Collected for Analysis
8	Data Sample: Word Method Coded Dataset
9	Data Sample: Line Method Coded Dataset
10	Data Sample: Axial Method Coded Dataset
11	Thematic Method Questioning Framework
12	Data Sample: Thematic Method Coded Dataset
13	Case-Study Interview Protocol
14	Case-Study Dataset
15	Policy 2: Students Learning to Code
16	Policy 3: School Partnerships with STEM Organisations
17	NT Dataset: Policy 1
18	QLD Dataset: Policy 1
19	NSW Dataset: Policy 1
20	VIC Dataset: Policy 1
21	WA Dataset: Policy 1
22	ACT Dataset: Policy 1
23	SA Dataset: Policy 1
24	TAS Dataset: Policy 1

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<center>**Chapter 1**</center>

<center>**Mapping a STEM Policy Environment**</center>

This chapter outlines the study and features the definitions of the key terms, a background to the research, and the research purpose and questions. The Conceptual Framework of four aspects that underpin the methodological approach to the analysis, representation of the analysed data findings, and the study contribution is also presented. Finally, the 10 chapters are listed, which form the thesis.

STEM, STEM Education, and Primary STEM Education Defined

In this study, the acronym of Science, Technology, Engineering and Mathematics (STEM) is a transdiscipline (Sanders, 2009), whereby it has been argued that Science (S) and Mathematics (M) are the two foundation or theoretical disciplines, and Technology (T) and Engineering (E) are the two practical disciplines deriving from these two foundations of S (to a greater extent) and M (also see, de Vries, 2011; Lawrence, 2010). In addition to this, Education extends the construct leading to STEM Education, which involves transdisciplinary learning and teaching focused on the theoretical and practical basis, or the understandings and skills of STEM and its impact on cultural, social, and economic development (OACS, 2013). Primary STEM Education is an area of STEM Education as the school-based transdisciplinary learning and teaching of STEM with primary aged students, which has been explored.

Study Background

Various Governments have priority policies listed in agendas for a formalised STEM Education across the Australian schooling system. National and international research acknowledges that Government policy-based support is important for influencing learning and teaching quality,

beginning in pre-school and continuing across the schooling years to tertiary and/or vocational graduates (see, Aubusson, 2011; Blackley, & Howell, 2015; Bybee, 2013; Caprile, Palmen, Sanz, & Dente, 2015; Freeman, Marginson, & Tytler, 2015; Gough, 2015; Henriksen, 2015; Zollman, 2012). STEM Education is seen as contributing to economic, and to a lesser extent cultural and social development (Euryodice, 2011; OACS, 2014; OECD, 2016a; UNESCO, 2017a). The international, National, and State/Territory Governments through their approach to STEM Education in policy agendas are key to supporting these economic and social developments (Kramer, Tallant, Goldberger, & Lund, 2015) and in-turn with influencing learning and teaching quality.

Thesis Aim

The aim of this thesis is to examine and understand the Governments of Australia STEM Education policies leading to school-based Primary STEM Education. The objective is to frame and rationalize how a policy has been designed for school-based practices, by exploring and explaining official Government policy texts with relation to Primary STEM Education. On review of the research and by the data analysis, three priority policies have been framed through five dimensions. The policy fidelity from the National to the State and Territory Governments has also been framed as all encompassing, and coordinated. Thus, the purpose of this study is to examine, and contribute a conceptual framework on the quality of Primary STEM Education policy by the Governments of Australia.

Thesis Rationale

Primary STEM Education research informing policy has been sparse (Rosicka, 2016) in Australia. While, Government commissioned, industry, and sector research-reports have often depicted student performance as declining in Science and Mathematics literacies when compared

to OECD countries or year-on-year changes (see, Thomson, De Bortoli, & Underwood, 2017). Such research has often framed Primary STEM Education in relation to secondary, tertiary, and vocational knowledges, skills, and understandings of core science(s) and mathematics disciplines with regard to an inter-disciplinary practice for students' future employability (see, The Australian Industry Group, 2017; Lyons, Quinn, Rizk, Anderson, Hubber, Kenny, Sparrow, West, & Wilson, 2012; Siekmann, & Korbel, 2016; Tytler, Osborne, Williams, Tytler, Cripps, Tomei, & Forgasz, 2008). As a consequence of such research, Government policies to influence Primary STEM Education learning and teaching quality in Australian schools have been developed and implemented.

A study of the Australian policy context creates an opportunity to consider whether Government policy is, as had been suggested by some, limited (OECD, 2015a), discontinuous (OACS, 2014) and fragmented (Freeman, 2013). Since, Primary STEM Education policy limitation, discontinuity, and fragmentation has sparse evidence from a methodical investigation, the research underpinning this study links Government policy with practice by contributing a conceptual policy framework to support this link being evidence-based.

The Governments of Australia are the context of this study and have been explained as complex and dynamic, partly due to the political nature of Governments and how policy is administered (Althaus, Bridgman, & Davis, 2014) and the links with a global STEM policy-based ecosystem (Kramer, et al, 2015) or environment of the OECD developed nations. However, as suggested by previous research in this field, there is a need for a policy framework that informs the research-based approach to policy for practice-based implementation (OACS, 2013). This thesis therefore offers a research-based response on policy quality.

Research Questions

The overarching research question that has been directing this study is: How is Primary STEM Education policy designed for school-based implementation? In order to assist in answering this question, these three sub-questions have been posed:

1. What are the priority policies?

2. What is the policy fidelity?

3. How is Primary STEM Education policy framed for practice?

In addressing this question and the sub-questions, policy texts as public communications and documents including: agendas, budgets, communiques, plans, press releases, reports, and strategies by the National and State/Territory Executive part of the Governments of Australia have been analysed across a date range of 2008 to mid-2017. This date range is based on the date shown in the texts, which when using key search terms were collected as the data for analysis from official Government websites, at the time of this study.

These texts have been collected and analysed based on ten key search words/terms, such as Primary STEM Education (one search term), which were derived from the research questions. In the analysis, four qualitative data coding methods of: word, line, axial, and then thematic were used so that the Government policy context could be logically explored and framed. By these methods, the reality of the 'Government policy to school-based practice' has been presented and rationalized in accord with the Conceptual Framework described next.

Conceptual Framework

In seeking to answer the research questions, a Conceptual Framework has been developed, which was informed by the reviewed research (see Chapter 2) and the methodological approach (see Chapter 3). A Conceptual Framework guides the development and assessment of a Primary STEM Education policy in this instance or policy development and assessment more generally. Further, the Conceptual Framework is the basis to view this study. Overall, in this Conceptual Framework the policy dimensions and attributes can inform the quality of a policy. Figure 1.1 is a visual representation of the Conceptual Framework guiding the study, which is shown next. The development of this framework is explained in Chapter 3.

Figure 1.1

Study Conceptual Framework

Policy Quality Conceptual Framework

STEM ENVIRONMENT
The international government policy quality research informing the priority policy-based actions in Australia

POLICY CONTEXT
Australian Government priority listed policies for practice-based implementation

POLICY DIMENSIONS:
1. PRIORITY
2. PURPOSE
3. RESEARCH
4. INITIATIVE & BUDGET
5. EVALUATIVE MEASURE

Interacting to implementation

POLICY ATTRIBUTES:
1. ALIGNMENT
2. COHERENCE
3. CONTINUITY
4. FOCUS
5. SCALE

This Conceptual Framework serves two purposes. Firstly, the framework illustrates how to map a Government STEM and STEM Education policy in both the international environment and the Australian (National and State/Territory) context. Secondly, through the methodological approach in applying the framework, the results about a policy 'in-action' are made evident and used to inform a notion of "quality" about these policies. The above Conceptual Framework shows the interplay between four crucial aspects of this study, Government STEM policy: environment; context; dimensions; and attributes that are necessary in understanding policy quality within implementation. These four aspects are outlined next.

STEM policy environment.

The policy environment is the first aspect of the Conceptual Framework, and is the international or global STEM ecosystem (Kramer, et al., 2015) comprising the OECD member Governments' STEM and STEM Education policies for school-based implementation. This is a global system or network with policies framed through:

1. industry-based research reports from different sectors as well as partnership-based initiatives (e.g., BHP Billiton, the EU, Microsoft, UNESCO, and the World Bank),

2. academic research; and,

3. Government commissioned research,

to address the impacting trends linking global, National and State/Territory current and future social and economic developments. Through these sector reports, initiatives, and research, the policies by OECD member Governments have been compared and relied on to base and progress this study. Understanding these international governmental policies provides an insight into STEM Education policy globally. Within this international environment, the highly developed nations of the OECD have STEM Education policies that inform the context, and a review is in Chapter 2.

Policy context.

The second aspect of the Conceptual Framework is the policy context, which is situated within the policy environment. The policy context is framed through the National and State/Territory Executive ministries and agencies that produce, process, and present (Althaus, et al., 2014) or administer priority Primary STEM Education policy for school-based implementation in Australia. This context has been defined as an all-encompassing, collaborative and whole-of-government approach (OACS, 2013) to policy leading to implementation. This context is explored by analyzing online sourced Government policy texts. These texts are the data used to frame the policy dimensions and attributes, and to provide suggestions as to the quality of such policy. Through defining, exploring and framing the context, how each minister and agency administers policy through to implementation becomes evident.

Along with the international policy environment, this context references itself through such things as the:

1. OECD Governments' STEM and STEM Education policy agendas and planned actions;

2. Governments of Australia prioritised STEM policy agendas (for example, the National Innovation and Science Agenda (NISA) (DPMC, 2015) and planned actions and strategies (for example, the National STEM Education School Strategy (NSESS) (EC, 2015)); and,

3. Governments of Australia STEM policy agendas, and the documented actions or strategies by the Governments of the six States and two Territories.

In framing the context, the ministries and agencies that have been found as administering policy for practice-based implementation have become the data sources, and their policy texts forming the coded data sets (see the methodology in Chapter 3, and the findings in Chapters 4

to 7). These texts have been the basis for explaining and commenting on the policy fidelity, as it has been existing over the various National, State and Territory Governments of Australia.

Policy dimensions.

Policy dimensions is the third aspect to the Conceptual Framework, which has been defined directly by the context. Based on the methodology explained in Chapter 3, five dimensions are the resulting thematic codes that have been used to frame a policy in administration by the context in leading to implementation. These five dimensions are the:

1. **Priority:** as the policy (above all, or in concert with others) that has been developed and highly ranked for immediate action to address a particular issue (or can also be termed a challenge, and an opportunity) in communication and documentation, and details the:

   i. *Action* that is designed for implementation by the context stated as an all-encompassing and coordinated approach. For example, requiring that pre-service primary teachers choose to graduate with a specialisation in STEM (DPMC, 2015); and,

   ii. *Issue* that is addressed by this Action through implementation by this prior stated approach. For example, data indicates 40% of year six students have the opportunity to study science in their class less than once a week, and 21% reported that they studied science hardly ever (Hackling, Murcia, West, & Anderson, 2013). With this low level of Science Education (and similar with Mathematics), this research outcome is one information source on the issue of future national, social and economic development; thus influencing the quality of the future supply of highly skilled STEM professionals, and

development of a scientifically literate society in comparison to the highly developed OECD nations (OACS, 2012).

2. **Purpose**: of a priority listed policy from the action and issue that is made contextually evident as detailed by a:

    i.   *Rationale* statement as to why this is a priority policy (i.e., the research basis of the policy leading to implementation). For example, research on *The Victorian Government Primary Mathematics Specialists Initiative* (PMSI) whereby specialist teachers have been working with a generalist in-service teacher, has evidence on the improvement of students' interest and performance in Mathematics along with their teachers' confidence to teach mathematics (Victorian Department of Education and Early Childhood Development (VICDEECD), 2014); and,

    ii.   *Objective* that is stated, which this policy is aiming for on implementation. For example, each primary school in Australia to have access to an inspiring specialist STEM teacher that has a direct and sustained positive impact on students' interest and academic performance in STEM and STEM Education (by 2020) (e.g., OACS, 2012; SADECD, 2016).

3. **Research**: consideration and the extent that academic and commissioned research that has been relied on to develop and progress a priority listed policy including the:

    i.   *Citation* in the policy communications and texts; and,

    ii.   *References* listed with regard to extent that findings and recommendations are relied on to develop a quality policy on implementation;

4. **Initiative and budget**: of a priority listed policy that is made evident as to the approach of all-encompassing and coordinated in relation to the:

      i.   *Projects* that have been planned and budgeted for implementation with regard to Primary STEM Education by schools. For example, the PMSI (VICDECD, 2014).

      ii.   *Funds* that have been allocated from the national budget to a state/territory budget for a new (or scaling an effective) project or program to be implemented to address an issue and reflects the action. For example, the details of the funding allocation to implement the prior stated PMSI within the National and corresponding within State/Territory budgets.

5. **Evaluative measure**: of a priority listed policy that is made textually evident by the approach in terms of the:

      i.   *Outcome(s)* both expected and unexpected that are then used to inform the further development of policy across each of the five Dimensions (i.e., the priority rationale and outcomes) through specific qualifying factors (to measure over various periods). For example: "By 2020 there will be 500 primary teachers with a STEM specialisation" (SADECD, 2016, p.7); and,

      ii.   *Timeline* that is realistic for the evidence by research for the outcomes of the policy in terms of school-based implementation (as suggested, for example, in the quote above).

Combined these five dimensions make evident a priority policy in administration. Each dimension comprises a category and two classification descriptors, which together, illustrate the details or content of a priority 'Primary STEM Education policy', and were the codes used in the analysis forming the datasets on the three found policies (Policy 1, 2, and 3) by the methodology of this study, which is described in Chapter 3. The three priority policies examined by these five dimensions are presented in Chapters 4 to 6.

Policy attributes.

The policy attributes forms the fourth and final aspect of the Conceptual Framework. Based on the reviewed research and further informed by the analysis of the data explained in Chapter 3, five policy attributes were the additional thematic codes used and framed quality of the administered policy. As part of the findings of this study, the policy fidelity is understood with these five attributes:

1. **Alignment** between each dimension (i.e., the: priority, purpose, research, initiative and budget, and finally the evaluative measure) such that similar State and Territory Government policies are designed for coordinated implementation;

2. **Coherence** between each of these dimensions to develop and implement such that the policy forms a coherent 'whole';

3. **Continuity** between each of the dimensions in terms of development and implementation of the policy over the various terms or for longer terms of Governments;

4. **Focus** between each of the dimensions with relation to how the policy appropriately responds to the practice-based needs; and,

5. **Scale** between each dimension with particular emphasis as to how the policy is developed for implementation across the context with respect to the environment (i.e., what is the nature of 'scaling up'?).

With these five policy attributes interacting with each dimension of the three found priority policies, the fidelity is made evident, and is presented in Chapter 7. Therefore, these attributes are the coded categories, and when each are connected to each dimension of a policy are used to illustrate the Primary STEM Education policy fidelity in leading to implementation. As indicated, these attributes were identified through the reviewed research presented in Chapter 2 and the methodology explained in Chapter 3. The three framed priority policies examined

through the five dimensions and the associated attributes are suggested as limited in quality, which is discussed in Chapter 9.

In summary, this Conceptual Framework is used to frame a priority policy in administration within the context leading to school-based implementation, and how it might be developed and implemented.

Thesis Layout

This thesis has 10 chapters and an overview of the contents in each is as follows:

1. Chapter 1 has outlined the initial context and purpose of the research, which listed the research questions and introduced the conceptual framework of the study;

2. Chapter 2 offers a review of the literature with particular regard to leading OECD Governments' STEM Education policies through which an overview of the international policy environment is explored;

3. Chapter 3 describes in detail the research methodology and explains the Australian policy context in terms of the data types and forms, and methods used to collect and analyse the data with respect to the conceptual framework;

4. Chapter 4 is the first of three priority Primary STEM Education policies coded and framed by the methodology explained in Chapter 3. This chapter reports on the analysis that led to the formulation of Policy 1: Specialist STEM Teachers, which is presented through the five prior introduced dimensions;

5. Chapter 5 presents the findings of the second framed priority Primary STEM Education policy, Policy 2: Students Learning to Code;

6. Chapter 6 is the third and final chapter based on data analysis that resulted in Policy 3: School partnerships with STEM organisations, also framed by the five dimensions.

7. Chapter 7 is the further analysis of the three preceding chapters and uses Policy 1 as an indicative case to explain policy fidelity;

8. Chapter 8 is a case-study based on an in-depth interview with a National Executive STEM policy leader and researcher who made prime ministerial recommendations around Policy 1, Specialist STEM teachers. This chapter offers further analysis and juxtaposition to the data findings into policy quality through the reality of working within the context;

9. Chapter 9 is a discussion of the findings about the policy quality between the Governments of Australia based on the Conceptual Framework; and finally,

10. Chapter 10 concludes the study to outline the contribution of the findings on policy quality, more generally across Government and its associated bureaucracies.

Chapter Close

This chapter has introduced the research project that underpins this thesis on the quality of Government of Australia priority Primary STEM Education policy. The thesis has been aiming to understand these policies, and does so by contributing with a research-based approach to framing a Governments of Australia priority Primary STEM Education policy. The following chapter is a review of OECD governments' STEM Education policies and their links to school-based Primary STEM Education as the international STEM policy environment.

Chapter 2

The International STEM Policy Environment

This chapter is the overview of some of the key international policies by governments that have a national interest in STEM and STEM Education. A review of eight Organisation for Economic Cooperation and Development (OECD) nations whose governments have prioritized STEM and STEM Education policies for improving practice is presented. International assessment data, the research recommendations that have been made to governments, and the educational policies of these OECD member governments have been reviewed. As represented in Chapter 1 by the CF of Figure 1.1, this chapter is establishing the international STEM policy environment as the first aspect framing this study.

Background

A STEM Enterprise requires government investment in STEM Education and Research with "a 'social licence' that is part of its 'compact' with society" (OACS, 2013, p.3) because "STEM has and will continue to provide for everyone" (OACS, 2013 p.5). The OACS recommended that the Commonwealth/National Government lead and centralise the policy-based administration of a STEM Enterprise (i.e., Education, Research, Innovation) by a formalized and scientific-based framework. Further, this framework is to be used to research an all-encompassing and coordinated whole-of-government approach to policy leading to a Science-based STEM Education (by prioritising teaching quality) across the schooling system (i.e., from K-12) for all students (OACS, 2012). Thus, the policies of the leading OECD international governments is a necessary reference to inform on the policy environment, including the administration of STEM Education policy by the Governments of Australia.

In summary, the National Executive Government had been advised to frame and coordinate the federated government system to produce, process, and present (Althaus, et al, 2014) or administer a research-based and interconnected STEM Enterprise by policies leading to

implementation, which has had to include those of STEM Education (Freeman, 2013; OACS, 2013). On review, this comparative international review of studies examining government STEM Education polices has been relied on to inform and compare with those of the Governments of Australia, since they:

> Could be usefully applied to the formation and maintenance of a STEM skills workforce and for increasing Australia's productivity and international competitiveness. (Marginson, Tytler, Freeman, & Roberts, 2013, p.10)

On review of the research, a broader scan of the academic literature subsequently located that there were eight highly developed OECD international nations with government led STEM Education policies for a similar purpose. These eight have been reviewed with regard to the policies about Primary STEM Education, which begins by the need to understand the role and ranking system of the OECD as explained next.

The Organisation for Economic Cooperative Development (OECD)

Internationally, the OECD was formed to provide governments with cooperative policy research recommendations to member and partner governments. The mission statement of the OECD has been to encourage policies that can globally improve economic and social development, *(Better Policies for Better Lives*, OECD, 2011). One way in which the OECD has achieved this has been with its member and partner governments' Education Ministries, who have funded and governed an international assessment and evaluation program, The Programme for International Student Assessment, PISA.

PISA is an evidence-based assessment framework comprising tests (and questionnaires), completed by 15-year-old students who were in their final year of formal schooling (OECD, 2016a; 2018). The assessment was conducted every three years, focused on Mathematics, Science or Reading and included questionnaires completed by participating school principals,

teachers, and parents/carers. In 2015, over 540,000 students from 72 countries completed PISA (OECD, 2018).

Since PISA's inception (in 2000) the OECD has iteratively aimed to improve the definition, framework, and terms-of-reference to be a significant source of research used when making and representing governmental STEM policy that supports education, or more specifically STEM Education, in national schooling systems (OECD, 2015b). The OECD's main objective for PISA in 2015, was to assess the extent to which a student was engaged with science-related issues and with the ideas of science, as a reflective citizen (OECD, 2013). In 2015, PISA contextualised this objective through the term scientific literacy, defined as:

> A scientifically literate person who is willing to engage in reasoned discourse about
> science and technology. (OECD, 2013, p. 7)

The OECD publically ranked and longitudinally represented data in reference to this definition of scientific literacy, which for the 2015 assessment was released on December 6, 2016. The data for each participating nation's performance can be used for comparison and justification of OECD's policy recommendations and subsequently analysed by governments to inform and to frame national and state/territory/provincial priority STEM Education policy, an example of which is shown in Appendix 1.

Based on the 2016 PISA data, the average performance of Australian students had declined with -6 in science, and -8 in mathematics, when compared to PISA in 2012. This decline in score averages was higher than that calculated for the international student average score of performance, which was -1 for Science and Mathematics in 2016. This assessment data of scientific and mathematical literacy has been relied on by the OECD in making policy recommendations to member governments.

The OECD's research and recommendations have been 'trusted' by many governments for providing evidence for, and rationale in STEM policy making. Member and partner governments repeatedly cite OECD's research across their STEM policy contexts when:

1. determining STEM issues to address;

2. prioritising issues in STEM Education with supportive actions;

3. defining STEM Education in the national vision, plan, and strategy;

4. formulating initiatives and allocating budgets; and,

5. evaluating initiatives and spent budgets in supporting STEM and STEM Education in schools, based on formalised policies (OECD, 2016a; 2016b; 2018).

Nations with PISA student performances that had evidence of improvements in Science and/or Maths comparison to Australia included (in alphabetical order):

1. Canada

2. China—Hong Kong Region

3. Finland

4. Japan

5. Singapore

6. Republic of Korea (South Korea)

The government STEM policies of each of these nations can be used to compare the STEM policies of the Government of Australia. Reviewing these policies has been limited by the extent to which these governments have STEM policies communicated and documented in English, and publically available online. For example, Japan on review had limited STEM policy research that was available in or easily translated into English by the Researcher. China, Finland, and South Korea have had government policies that were often not readily translatable into English and hence limited this review. With its multiple official languages, Singapore has also been limited to those documents available in English for this review of government STEM Education policy.

There are other OECD member countries such as The United Kingdom (U.K.) and The United States of America (U.S.A), which do not have evidence of comparative improvements to Australia. The U.K. and the U.S.A do become useful to compare to Australia because of their membership within the OECD and reference in research, and so have been considered in this review of policy.

Along with the OECD PISA assessment data, the International Association for the Evaluation of Educational Achievement (IEA)'s Trends in International Mathematics and Science Study (TIMSS) assessment data has been a reference source in government policy and academic research on STEM Education, which has been reviewed next.

The International Association for the Evaluation of Educational Achievement (IEA)

Prior to the establishment of the OECD, the IEA was the first international policy-based research organisation to research and recommend on educational policies to governments (IEA, 2018). The IEA aimed at supporting literacy, mathematics, and science-based education in schools. With over twenty years of data, the IEA has also become the largest scaled international assessment of mathematics and science educational outcomes within national schooling systems. The IEA's TIMSS assessment framework has, since 1995, tested students who are in year four and eight, every four years, in Mathematics and Science.

The TIMSS Mathematics and Science assessments were developed through an international consensus process with involvement by international experts. The IEA aimed to provide a longitudinal and international database of evidence for use by policy makers in governments to support education in schools, which has been relied on in STEM Education policy and research. Along with the OECD, governments and education ministries have used TIMSS results, and IEA recommendations to:

1. locate issues for support;

2. support and implement curricula;

3. measure the impact of policy initiatives;

4. identify gaps in learning resources and opportunities;

5. train researchers and teachers in assessment and evaluation; and,

6. measure the effectiveness of educational environments within a global context
    (IEA, 2018).

In conjunction with the OECD, governments have also regarded the IEA as a 'relied on' big-data source that held to an evidence-base to inform governments on a STEM Education policy, based on Science and Mathematics assessment data, but without a similar or defined assessment framework in place for Technology and Engineering, or STEM.

THE OECD and IEA Assessment Data informing Government STEM Education Policy

On review, government STEM Education commissioned research and policy documents often cite students' performance outcomes in Science and Mathematics in PISA, and TIMSS assessment data. For example, the Government of Canada's initiative of a *STEM Learning Framework* (Let's Talk Science, 2017) cited TIMSS 2015 Science and Mathematics assessment data research as the only cited reference listed in this document. At this point international assessment data on: STEM, Technology (other than inclusion as part of the Science Literacy assessment framework by the OECD in 2015), and Engineering had not yet been made evident by the OECD and the IEA to inform STEM Education research and policy on Primary STEM Education for practice-based implementation.

With this background, a review of eight developed OECD nations (as listed above) are reviewed to portray government STEM policy environments and are presented in alphabetical order next. On review, policy relating to Primary STEM Education is informed from Science and Mathematics student academic performance in PISA and IEA assessments. Although, national assessment frameworks were also referenced, but to a much lesser extent.

Developments in STEM Education Policy by Country

   Canada.

Framed through the national Science, Technology and Innovation strategy, STEM Education is a priority in government policy agendas for the purpose of pursing a higher STEM Education and the higher paying careers in these four fields (Canadian Minister of Industry, 2014). Through such agendas, the national government has substantially funded and framed initiatives to a national charitable organization, Let's Talk Science. One Let's Talk Science funded initiative is, *Canada 2067 STEM Learning Framework: An Invitation to Contribute* (Draft framework) (Let's Talk Science, 2017), which is:

> The result of a lengthy process that has involved extensive research and expert consultations. This effort began with a review of over thirty international and Canadian reports on STEM education published since 2007. The reviewed reports focused mainly on STEM education at the primary and secondary levels in developed western countries in Europe, North America and Australia. They were selected for analysis based on their purpose, namely providing policy advice to governments about how to improve student engagement and achievement in STEM. They include reports supported by a variety of intergovernmental organizations such as the Organization for Economic Cooperation and Development (OECD), STEM-focused industry association, parliamentary committees, scientific bodies such as the Royal Society, and government education departments. (Let's Talk Science, 2017, p. 2)

The final framework was to be completed in mid-2018 and was not available the time of this review at the end of 2018.

The Government of Canada has progressively made STEM Education a national priority in policy agendas through the initiatives, projects and programs of Let's Talk Science, such as:

> Canada 2067, an initiative of Let's Talk Science. This unique initiative aims to spark and convene conversations among Canadians for the purpose of developing a new vision for STEM learning in Canada. (Parkin & Urban, 2017, p. 3)

which has indirectly defined STEM as:

> The acronym STEM stands for Science, Technology, Engineering, and Mathematics, but it has come to be understood as also including a diverse set of skills, characteristics, and ways of thinking about (and solving) problems that are critical to success in today's increasingly global economy and society. The foundations of STEM learning are associated with "competencies," a term which generally encompasses knowledge, skills and attitudes. STEM competencies include but are not limited to an understanding of scientific methods, numeracy, digital literacy, effective communication and creative problem-solving. (Let's Talk Science, 2018a, p. 12)

Further, school-based STEM Education has also been defined as Science-based with:

> STEM is inclusive: Everyone can be included and engaged in science by linking daily personal experiences to science, regardless of where they live, how they live or what language they speak.
>
> Science crosses subjects: Let's Talk Science supports a multi-disciplinary approach to science engagement and we use big ideas like energy as well as focused concepts like magnetism to show the many connections that can be made across traditional subject areas.

Science develops literacy skills: Language and literacy skills are integral to knowing and doing science. Reading, writing and speaking are all essential to comprehending and communicating scientific issues and ideas.

Science develops numeracy skills: The skills of sorting and classifying, estimating and counting, measuring, graphing, collecting data and analyzing are frequently used when doing science.

Science develops general and technical skills: Conducting science investigations and explorations involves the use of inquiry skills. Science also requires using technical skills, such as doing a titration in chemistry or using a spring scale in physics.

Science is powerful: As we think about the future that lies ahead and the global issues that must be resolved such as climate change and global access to food, drinking water and health care it becomes even clearer why STEM is fundamental to life in the 21st Century. (Let's Talk Science, 2018b, para. 6).

Essentially STEM Education has been defined as Science and Mathematics based, with Technology and Engineering as applications of these two.

The purpose for a STEM Education was noted to:

Canadians acknowledge the aspirations and capabilities of younger generations and look to the country's strong and diverse education systems to help prepare them for the future. This learning roadmap summarizes what was learned through the Canada 2067 process about how educators and community partners believe that teaching and learning should evolve in the coming years to ensure that Canadian youth are equipped to meet the challenges of an ever more complex and technologically intensive world. (Let's Talk Science, 2018a, p. 3)

A vision to STEM Education was stated, and is:

> Students graduate with doors open to diverse careers, with the capacity to be active and informed citizens, and with the full range of skills needed to navigate an increasingly complex and competitive world. (Let's Talk Science, 2018a, p.4)
>
> All students develop the full range of skills needed to navigate an increasingly complex world and have equal opportunity to study and pursue diverse career paths. (Let's Talk Science, 2018c, p. 1)

Through this initiative, *Canada 2067*, is a 'national conversation' with STEM partnerships with many diverse organisations, which have included a universities, companies, not-for-profit foundations, and schools. Programs would be framed and funded in order to enable children and youth to understand STEM, and its practical application as a term for interconnected practices within schools.

Of all the OECD nations participating in the PISA 2015 assessment, Canada had the largest STEM tertiary education population, but with an on average lower percentage rate of tertiary STEM Education completion (OECD, 2016a). Similar with most OECD nations, the secondary and tertiary student population interested in, and with a STEM Education in Canada has significant differences in their: socio-economic status, location, gender participation, and performance-based achievements, which has been a persistent trend at a higher than average rate (OECD, 2016a, 2018). For example, and again similar with many of the reviewed developed nations, females in Canada were more likely to have completed tertiary teacher education and/or science teacher education than men, with 16% of females compared to 5% males. Females, had on average a significantly lower completion and participation rate in engineering, manufacturing, and construction (OECD, 2016a). Such differences were linked as issues on tertiary qualified females with an on average earnings as significantly less (about three quarters less) than males, who have been earning more in Technology and Engineering disciplines compared to teaching including science teaching (OECD, 2016a) for policy to address. In part, the Government of Canada has responded, by including 'Primary STEM Education' as part of a formalised STEM Education policy

framework led by the national government, which is considered next.

Leading to and through, *Canada 2067*, a unique STEM Education policy was to be implemented in order to support the nation's future economic development (The Government of Canada, 2015). The commissioned research-based charitable organization, Let's Talk Science, was also the organisation supported with a policy-based initiative with a (CAD) $12.5 million budget to be allocated over five years for primary school-based implementation. Through a school-based learning and teaching Science program, the objective of this initiative was to align and scale the exposure and interest to STEM by students, and notably girls, in schools across Canada.

Further, formalised government and non-government (including corporate and university) partnerships was the mechanism this national policy initiative was to be administered (The Government of Canada, 2015). This national policy initiative was intended to also cohere and continue to progress Canada's many disconnected or fragmented Education policies by the national, provinces and territories governments, which were reportedly designed for a different era rather than '21st Century thinkers' (The Government of Canada, 2015). Prior to this policy initiative, the Government of Canada had Education policy that was autonomously administered by the provinces and territories with little national involvement (Weinrib & Jones, 2015).

Let's Talk Science, was supported by the Government of Canada to improve the policy fidelity (i.e., coherence and implementation) by the ten provinces and three territories and away from administering concurrent and varying versions, which was considered inefficient in addressing related issues. By nationally scaling and centralising this science-based program, and then generalising it for learning and teaching 'STEM Education' in schools across Canada (see Ritz & Fan, 2015; The Government of Canada, 2015; Weinrib & Jones, 2015) this national policy initiative was the first attempt in a 'new strategic approach' to policy administration.

Review of the research into the influence of this approach within school-based STEM learning and teaching practices indicates that while the research has been sparse, there has been variances within the approach with the:

1. cancellation of national government funding for STEM Education initiatives causing a ripple like effect to the provinces and territories' ministries of education to continue on within the extent of funding program(s) (Clark, 2014);

2. requirement for continuity within the government to lead the policy quality across the administration into practice-based implementation. For example, policy leadership focusing on the initiative and budget has a corresponding curriculum, curriculum learning and teaching resources, and teacher support with the program (Clark, 2014);

3. limited research on the STEM Education workforce including on the quality and supply of Science and Mathematics teachers to implement the program (Kitchenham & Chasteauneuf, 2010); and,

4. over reliance on PISA and TIMSS student performance assessment data as the predominant research source cited and referenced by the Government of Canada on the issues to address through the initiatives and budgets stated in national policy initiative, which include the decline in and differences between student interest and performance in STEM and STEM Education (see, Parkin & Urban 2017).

With these findings on government policy, the government has since scaled up the Science program of "Let's Talk Science" and has continued to be involved in subsequent policy development along with support from sector-based partnerships.

The current policy context following evaluative research and public consultation, has framed six themes or pillars for future research to measure by 2023, which include:

1. The number of STEM teacher vacancies is matched by appropriate enrolment and graduation rates of teacher candidates with a specialization in STEM.

2. More STEM-based teaching is incorporated into teacher education programs.

3. The teaching profession is showcased to STEM students to attract more teachers with a STEM background. Pre-service teachers are trained to facilitate interdisciplinary, experiential, inquiry- and competency-based learning and mentored during their practicum experiences by teachers versed in these approaches – the way in which pre-service teachers are trained models this shift to these approaches.

4. Raise the percentage of primary and secondary school science, mathematics and computer science teachers who have specialized subject-specific pedagogical training related to these disciplines to international averages. (Let's Talk Science, 2018b, p. 6)

The first listed objective to increase specialist primary Science and Mathematics teachers was linked to student international TIMSS assessment performances in Science and Mathematics and the extent of time on and quality of teaching STEM by schools (Let's Talk Science, 2018b), rather than national workforce data. The IEA (2016) reported that in Canada there has been no national curriculum, or teacher education and training framework, and only the national coordination of the policy to support school-based implementation (Mullis, Martin, Goh, & Cotter, 2016). Further, a review of the Ontario Ministry of Education (OME) (2018) website featured a provincial rather than a national curriculum with separate learning areas such as Science and Technology. A STEM learning and teaching strategy for elementary or primary education was not found (OME, 2018).

In summary, government policy-based support for Primary STEM Education is from many independent or discrete national, provincial and territory governments still in action, and limited in reference to predominately international rather than academic national/provincial/territory research. While, the vision was to increase student understanding and skills in STEM through a Science-based program with specialist primary science and mathematics teachers through a national government centralizing and partnership approach, the policy implementation was limited by the change in focus to national government

leadership, funding reductions to programs, differing curriculum and research on the national workforce.

China—Hong Kong region.

China, alongside Singapore and South Korea, has been listed as amongst the higher-achieving nations by the IEA and OECD's assessment results. China's student performance results have been based on four participating regions, Hong Kong, Macao, Shanghai, and Taipei. China was one of the top five participating nations (or its represented regions), which has achieved both a high level, and improved equity in educational outcomes by the assessed student cohort (OECD, 2016a; Mullis et al., 2016). This section has focused on Hong Kong, one of the most consistent OECD and PISA participating partners representing China with research and government policy available on STEM and in particular STEM Education, which was in English.

In Hong Kong STEM Education has been defined by an increasingly decentralised government approach to policy, which has defined STEM as:

> …an acronym that refers to the academic disciplines of Science, Technology, Engineering and Mathematics collectively. The promotion of STEM Education aligns with the worldwide education trend of equipping students to meet the changes and challenges in our society and around the world with rapid economic, scientific and technological developments. In the curriculum context of Hong Kong, STEM Education is promoted through Science, Technology and Mathematics Education. (Hong Kong Education Directorate Bureau (HKEDB), 2016a, para. 1)

This definition has STEM Education promoted without Engineering Education, which is similar across these OECD nations. A vision for STEM Education was not identified, although connection with an international world-view on STEM to meet the challenges of rapid economic, scientific and technological developments, with a limited regard to Engineering was made.

The Hong Kong Education Directorate Bureau (HKEDB) has stated that the national

curriculum is the practice-based mechanism to promote STEM, as academic disciplines. The

purpose is that:

> STEM education was first proposed in the 2015 Policy Address and further supported in
> the 2016 Policy Address. Apart from cultivating students' interest in Science,
> Technology and Mathematics, and developing among them a solid knowledge base, we
> aim to strengthen students' ability to integrate and apply knowledge and skills across
> different STEM disciplines, and to nurture their creativity, collaboration and problem
> solving skills, as well as to foster their innovation and entrepreneurial spirit as required
> in the 21st century. Through the promotion of STEM education in schools, we aim to
> nurture a versatile pool of talents with different sets and levels of skills to enhance
> the[ir] competitiveness. (HKEDB, 2016b, p. i)

With regard to this government, the rationale and objective is to nurture a 'skilled pool of

talents for the purpose of enhancing national competitiveness' through a national curriculum.

The HKEDB has funded research, which has informed this national policy, along with the

research of the IEA and OECD (2015c). According to the IEA, Hong Kong students'

performances in mathematics have shown consistently and significantly high achievement. In

2015 (the sixth TIMSS assessment) students were ranked a close second (615) to Singapore

(618), followed by Korea (608), Chinese Taipei (597) and Japan (593) in the grade four

assessment (Mullis, Martin, Foy, & Hooper, 2016). Additionally, grade four students in Hong

Kong consistently improved (Mullis, et al., 2016). Although, grade four gender differences

were evident with boys significantly outperforming girls in the TIMSS 2015 assessment data

(Mullis, et al., 2016). This male outperformance indicated a persistent gender gap and an

improvement by both genders over time. These results are included in Appendix 2.

Such PISA and TIMSS results have suggested that the presented and subsequently

implemented national policy initiatives may have had a positive impact (e.g., Schleicher,

2015). As stated, the HKEDB has been responsible for the policy actions of the Government

on STEM Education, and has progressed policy initiatives with regard to OECD

membership and PISA assessment results with:

> The EDB will renew and enrich the curricula and learning activities of Science, Technology and Mathematics, and enhance the training of teachers, thereby allowing primary and secondary students to fully unleash their potential in innovation. (The Government of Hong Kong, 2015, para. 3)

In response, the HKEDB framed and reported on six action-based strategies as follows:

1. renew the curricula of Science, Technology and Mathematics KLAs;

2. enrich the learning activities for students;

3. provide learning and teaching resources;

4. enhance professional development of schools and teachers;

5. strengthen partnerships with community key players; and,

6. conduct, review and disseminate good practices (HKEDB, 2016a).

These six strategic policy-based actions were similar with those by the governments of South Korea and Singapore by focusing on the national curricula, teacher education, and professional development, albeit within the context of secondary rather than primary schooling. Comparatively, Hong Kong, South Korea and Singapore have had similar positive results and trends in PISA assessments. Uniquely, one action within the Hong Kong national curriculum was to integrate Liberal Arts with Mathematics as one interdisciplinary core KLA, which was call integrated Liberal Arts. The area of Liberal Arts that was integrated was language, which was Chinese and English. The purpose for these six strategies was to educate for 21st century skills. On comparison, the academic research and government policy on Primary STEM Education policy was less extensive.

On review, the HKEDB has framed a comprehensive and coordinated Primary STEM Education policy. For example, primary schools in Hong Kong were provided with a one- off grant for the Promotion of STEM Education funded by the HKEDB (2016b) in 2015. The aim was to promote STEM Education in order to cultivate students' learning interest, enhance their capacity to innovate, and develop their creativity and problem-solving skills. The terms of the HKEDB grant included:

1. Updating and enriching relevant curriculum and learning activities by building on existing curriculum development, and releasing a one-off grant for the promotion of STEM Education to all primary schools (2015/16 school year total HK $100,000 per school). The grant aimed to strengthen schools' capacity to continue improving the planning and organisation of STEM-related learning activities for students' learning of science and technology.

2. STEM Education promoted in a holistic and coherent manner, including enriching students' learning activities.

3. STEM resources for learning and teaching (e.g. teaching aids, consumables and teaching & learning resource materials), and/or upgrading some existing resources for the implementation of school-based STEM-related activities, including projects and competitions.

4. Enhance teacher professional development.

This once-off grant was the only policy initiative produced by the government intended specifically for school-based Primary STEM Education, which was noted at the time of this review.

The priority listed Primary STEM Education-related initiatives were evident in the 2016 and 2017 Policy Addresses:

> …The supplementary document on "Computational Thinking – Coding Education" will be completed soon for use by schools. For the professional development of teachers, starting from the current school year, HKEDB will arrange a series of intensive training programmes for the leadership tier and middle managers of all primary and secondary schools to enhance their capacity in planning and implementing school-based STEM-related activities… To provide more opportunities for students to apply what they have learnt and to enable the sharing of experiences among peers, we will collaborate with tertiary institutions and other relevant organisations to arrange more large-scale quality activities for students, e.g. education fairs related to science and technology. (Hong Kong Education Directorate Bureau (HKEDB), 36/2017, p. 12)

The government policy with regard to Primary STEM Education had added Coding Education by a supplementary document outlining professional development for school leaders and middle managers. Government collaboration with STEM partnerships and schools was necessary for scaling opportunities for students to apply their learning in Science and Technology.

International assessment data has also informed the policy framing of STEM+, the next step in STEM Education policy (e.g., HKEDB, 2016a; Hong Kong Policy Research Institute, 2017). In this policy, the national government has focussed on STEM related Key Learning Areas (KLAs), and the integration of STEM in the curricula (HKEDB, 2016b). Primary STEM Education policy approaches seemingly have limited initiatives that focus on addressing the performance differences in PISA and TIMSS assessments between males and females.

In summary, policy support for Primary STEM Education by this government was first evident in a national education ministry 2015 Policy Address by the Hong Kong Education Directorate Bureau (HKEDB) CEO. In that address (HKEDB, 2015) the STEM policy purpose was to cultivate students' interest in Science, Technology and Mathematics, and develop a solid knowledge base across the 21st Century skills that support the economy. The HKEB had aimed to strengthen students' ability to integrate and apply knowledge and skills across different STEM disciplines, and to nurture students' creativity, collaboration and problem solving, innovation and entrepreneurial spirit (skills) for economic development (HKEDB, 2016a). The HKEDB considered STEM Education in schools as a way of building a flexible talent pool to enhance global competitiveness. Primary STEM Education policy approaches seemingly had limited initiatives to address issues on gender differences, and cultural-socio economic equity or access to a STEM Education but rather adopted a broad-based approach evident by the 'one-off and conditional grant' of $100,000 HK to primary schools for STEM Education. Policy actions were focused on the various elements within Primary STEM Education including Coding, integrating the Arts, Mathematics and English, a national curriculum to integrate Science, Mathematics, and Technology without the

inclusion of Engineering, resources, and in-service professional development.

Finland.

The Government of Finland has developed an all-encompassing and coordinated policy context by a whole-of government approach to both social and economic development, which has had an indirect priority on STEM and STEM Education through its aim:

> …to make Finland a modern and inspiring learning leading country. (Finish Ministry of Education and Culture (FMEC), 2016a, para. 1)

The Finnish school system has legislated for a universal and uniform nine years of compulsory basic education and to make education an equitable right of all citizens since 1968. Within the national government, the Finish Ministry of Education and Culture (FMEC) (2017a) has been responsible for Education, Science, Sport, and Youth policies and hence in framing STEM and STEM Education policies.

The FMEC (2017a) fulfils this responsibility, together, with the:

1. Finnish National Agency of Education (FNAE), an agency under the Ministry of Education that is tasked with the implementation of policy to the education sector; and,

2. Finnish Education Evaluation Centre (FEEC), an independent government agency that is responsible for the national evaluation of education, and to form governmental representation to the education sector.

The Government of Finland does not use the acronym, STEM or STEM Education in national policy documents. One reason to account for that maybe (as noted in the 2013 ACOLA project) is that the government (at that time) did not consider that STEM-related educational issues were important priorities at the national level and therefore "little policy has been intended for an education to prepare a future STEM workforce" (Dobson, 2013, p. 2). The reason cited in the report was that a STEM workforce had been framed and supported following World War Two, unlike most other nations at that time, to make a change from the main industry of timber manufacturing to engineering for building international war-ships.

Even though governments of Finland do not refer to STEM and STEM Education in policy documents (Dobson, 2013) there was evidence of a STEM Education vision and strategy from the national government. One policy initiative entitled, *Tulevaisuuden peruskoulu*, (UNESCO, 2015, p.11) was to address issues such as:

1. support students' motivation and enjoyment in school;

2. reduce gender and social-cultural economic performance differences; and,

3. assess the current situation of basic education and examine the reasons for the drop in learning outcomes. (UNESCO, 2015, p. 9)

These issues were linked with STEM Education and future career interests through tertiary qualifications to progress social and economic development.

The 2015 PISA scores showed scientific literacy in Finland was lower by 32 points than the calibrated 2006 level, when the focus was last on Science. The mean scores in scientific literacy also highlighted that 15-year-olds in Finland ranked third among the OECD countries, to retain a highly ranked position of participating nations (OECD, 2015d). In comparison, mathematical literacy has remained unchanged. In Finland, the impact of socio-economic background and gender on students' results in Mathematics was on average lower compared to other OECD countries. Overall, PISA results have varied geographically, for example, between Northern and Eastern Finland, and by gender-boys' skills being on average lower than females- in Mathematics and Science (OECD, 2015d; 2018). Explanations for these declines were linked to recent economic instability in Finland, which experienced: funding cuts to education, identified inequitable government support between schools, and an aging teaching workforce in need of contemporary STEM Education and training.

Government commissioned research described youth as disinterested in STEM and STEM Education and attributed this to a lack of awareness about the potential career possibilities available to students who study STEM areas, and/or about the Finnish nation's innovations in these fields (FMEC, 2016b; 2016c). As one action, the FMEC made an online national

call for researchers:

> The only element that raises concern in this assessment is the poor performance of
>
> boys. I have invited the researchers to find solutions for this weak point in our
>
> educational environment,' says Minister of Education Sanni Grahn-Laasonen. (FMEC,
>
> 2017b, p. 1)

Research has been driving the education system in Finland and how policy was framed to inform and address issues with learning and teaching in schools. The PISA 2015 nationally assessed scores augmented such research and subsequent policy to address concerns on the extent of equality in STEM Education, especially attributed to boys in remote areas of Finland, a rising unemployment rate among youth, and interest in tertiary STEM Education and careers, which has been similar to most developed nations.

Government has been an active member of the European Union (EU) (including the EU STEM Coalition) and other STEM partnerships, that have informed STEM policies and STEM Education across the EU. STEM skills in STEM Education were to some extent defined by the Government of Finland while an active participant of the EU. Whereby, the EU had defined STEM Education outcomes as those STEM skills "expected to be held by people with a tertiary-education level degree in the subjects of Science, Technology, Engineering and Maths" (EU, 2015, p. 1). These outcomes were linked with STEM Education and future career interests through tertiary qualifications to progress social and economic development in Finland as an active member of the EU, as follows:

1. Numeracy and the ability to generate, understand and analyse empirical data including critical analysis.

2. An understanding of scientific and mathematical principles.

3. The ability to apply a systematic and critical assessment of complex problems with an emphasis on solving them.

4. Applying the theoretical knowledge of the subject to practical problems.

5. The ability to communicate scientific issues to stakeholders and others.

6. Ingenuity, logical reasoning and practical intelligence. (EU, 2015 p.16).

Government has collaborated in international governmental STEM policy and education initiatives for children and youth. *Science on Stage Finland*, has been a part of the EU STEM policy initiative supporting Science, Mathematics, and Technology education in Europe (Eurydice, 2011), which originated from LUMA (which is defined next). Every two years, since its launch in 2000, *Science on Stage Finland,* has produced an online national selection process for teachers to represent Finland in the European Science on Stage festival (FNAE, 2016).

LUMA Centre Finland (LUMA) (the Finnish terms for the natural Sciences and Mathematics), has been the Government policy-based STEM Education initiative that has been evaluated and scaled over time since 1996 (FMEC, 2016). LUMA, described as a global STEM ecosystem has evolved by strategic STEM partnerships and based on academic research, by this vision for STEM Education:

> To reach a high level of know how in science and technology among pupils, students and teachers and to ensure a sufficient number of science and technology professionals all across Finland. (LUMA, 2014, p. 1)

Informing Finland's government policies is LUMA's evaluative research, the European Union (EU), the IEA, and the OECD.

MOOC.fi has been one coding course offered online as a STEM learning and teaching project (LUMA, 2017). MOOC.fi has been offered to interested students and teachers, to address concerns about social and economic development in 'contemporary STEM skills in Finland and elsewhere'. As stated, LUMA has been a long-standing and significant national government STEM Education policy initiative since 1996. Initially, LUMA was a science program and project designed by the FNAE, which over time has been developed and redefined to hold a STEM Education vision and strategy supported by global partnerships. The Science Education Centre LUMA was established in 2003 with the University of Helsinki in order to continue and expand the original project and has become an international collaboration with the EU in STEM Education (University of Helsinki, 2018). The main

goals were to promote science and technology education throughout Finland. To achieve these goals, LUMA Centres have been established in ten universities within Finland. The LUMA Advisory Board was formed and is comprised of representatives from teacher associations, industry federations, and science centres, who together are responsible for the National LUMA Strategy (University of Helsinki, 2018).

LUMA has been the Government of Finland's policy-based initiative with these objectives to:

1. increase the number of students and youth that study STEM subjects;

2. raise awareness by students and youth about STEM Education and careers; and,

3. increase the number of qualified teachers along with the quality of teaching in Mathematics, Natural Sciences, and Technology (EU, 2015).

LUMA has been defining and contributing to the international STEM Education policy environment in partnerships with STEM organisations, based on a research approach through four collaborating universities.

Partnerships with STEM organisations have since supported a centralising of STEM Education via the LUMA Centre in Finland (EU STEM Coalition, 2017) with 13 regional LUMA centres within Finnish universities. A formalised and research-based framework has informed this policy to connect with schools using local communities of practices to interact within a national and international environment of governments and sectors (to include nations within the EU and China) in developing STEM Education, which has been defined as follows:

> The current LUMA ecosystem is a social innovation in which universities, schools, teachers, students, guardians, and industry are collaborating to engage all children and young people from age 3 to 19 in math, science, and technology and supporting research-oriented teachers at all levels for life-long learning. The LUMA Centre Finland promotes and fosters both national and international collaboration between educational institutions from kindergarten to universities, the business sector, educational administration, science museums and centers, teachers' associations, and

the media, as well as all other relevant organizations. The aim of the LUMA is

mathematics, science and technology for all. (EU STEM Coalition, 2017, para. 1)

LUMA has comprised the research-based 'learning communities', which directly interacts with this environment and with government partnership including with the FNEB as well as international companies, such as IBM.

The national schooling system has maintained policy alignment through a long standing framework on national government administered policies supported through multi- and cross-sector collaborations. These policies have been replicated internationally as for example, Finland's policy on maintaining a high quality and valued teaching profession with autonomous school-based practices and a professional-based incentive system as the basis for high quality school-based learning and teaching in (STEM) Education. Governments in Finland have been lauded for successfully developing and implementing quality policy as evidence by the improvements in learning and teaching practice, which is in contrast to those of other well-developed OECD nations (e.g. Salhberg, 2010, 2011a, 2016; Schleicher, 2017). Finland has become one of the most equitable and consistently highly ranked educational achieving nations as per the research by the IEA and OECD (FMEC, 2006). Additionally, teaching is a popular and valued profession in this society and promoted as such, even though most OECD governments have not adopted many of its inherent features (e.g. Sahlberg, 2011b, 2016).

The numbers of applicants to teach in Finland are significantly higher than the intake limits set for teacher education programs. The profession has been nationally envisaged, framed, and supported to value teaching as a critical profession to society by:

1. Well incentivised framework of remuneration, teacher education, and career development structure.

2. Content focussed in all professional development programs for building a specialised teaching workforce.

3. Supports by and with a coherent national curriculum, featuring administration

      services, and learning resources.

4.   A reduction to the teaching time performed in classrooms by teachers for time on research, and lesson planning to develop and implement effective pedagogy.

5.   Limited use of assessment across the schooling environment that may promote competitiveness (FMEC, 2016b).

To register and practice, teachers require a Master's degree and higher academic achievers are encouraged to teach in lower performing schools (Sahlberg, 2010).

Teachers are also involved in determining the teaching methods, teaching materials, assessment frameworks, and classroom curriculum - often in cooperation with peer teachers. Notably all primary teachers major in education sciences (FMEC, 2006). Therefore, Finnish teachers are considered to be highly educated and resourced and to have contributed significantly to students' high achievements in international assessments following from the professional status afforded by the (STEM) policy environment.

Finnish teachers influence the development of national education policy and are not evaluated through external or formal measures. For example, in 2011 the Government of Finland implemented a five-year policy plan to improve school-based Science and Mathematics Education. The policy was formulated to address research-raised issues on students':

1.   performances, interests and participation; and,

2.   completion rates by female, indigenous, and low-socio economic students.

As a result, the government redefined the national curriculum (FMEC, 2016a; 2016b). The FNAE completed a review and then implemented a 'new' national core curriculum for the schooling system. The local education authorities had the autonomy to implement a local curriculum based on this 'new' national core curriculum, which occurred in 2016. Schools then established a classroom-based curriculum (in autumn 2016 for grades 1 – 6) with teacher support for its implementation. This 2016 curriculum implementation process involved the:

1. Development of schools as learning communities.

2. Promotion of student autonomy in studying and in school life.

3. Emphasis on the joy of learning within a collaborative atmosphere using a phenomenological approach to discipline content.

The 2016-released national curriculum categorised seven learning areas with related competencies defined for interactional learning and teaching in school-based subjects:

1. ICT-skills;

2. multi-literacy;

3. thinking and learning to learn;

4. entrepreneurial and work life skills;

5. participation and building sustainable future;

6. cultural literacy, communication and expression; and,

7. managing daily life, taking care of oneself and others.

Each of these learning and teaching areas were written so that their learning objectives included competence goals. The traditional school subjects were to remain, although with less differentiated boundaries with the intention of establishing an inter-contextual understanding in practice between subjects and the seven learning areas. Hence, a STEM Education is implied within these learning areas and approach to the 'new' curriculum to address issues on future social and economic development.

Along with this 2016 curriculum was the implementation of a formative assessment framework for all schools. This national approach to formative assessment to implement as assessment for learning, and assessment as learning in order to evaluate students' learning. The intention of this initiative was to enable students to understand and analyse their own learning processes, and become wholly self-responsible learners, over time (FNAE, 2016).

Overall, the FNAE has been responsible for producing all of the materials to support implementation of this curriculum and the assessment framework using a national website.

Alongside these projects, the FNAE has conducted research, and funded projects including numerous training courses on STEM professional development for both primary and secondary teachers. Notably, the LUMA Centre (Finland's national STEM Education network) has continually received funding from the FMEC and the FNAE. Government funding has supported the implementation of a STEM development program, which has included research-based teaching methods, tools, resources and teacher training, for in-service STEM teachers (LUMA, 2014). Pre-service and in-service teacher STEM Education and Training programs have included primary and secondary level teachers as well as early childhood educators such as kindergarten teachers. The evaluation of this national scaled program has had government-supported research projects framed around it with annual data collection over a six-year period, which began in 2016.

In summary, a research-based government (STEM) policy context has been framed, which has relied on LUMA to scale a government policy initiative. Through LUMA, the government has a research-base, a STEM partnership approach, membership of the EU and STEM Coalition on STEM policies within STEM Education through a whole-of-governments approach. The government had research-based actions and initiatives to address research informed issues such as cultural access and student interest in STEM. These actions include an international open access website with content comprising innovations and research in Finnish Mathematics, Science and Technology, an online international Science and Coding course (*Climate.now*, *MOOC.fi),* and a national curricular with support and resources for STEM learning and teaching (e.g. Eurydice, 2011; LUMA Centre Finland, 2014, FMEC, 2016a). In particular, Finland has a model or context of policy supporting a high quality teaching profession, which has been recommended as an exemplar for replication to all OECD developed governments to improve the quality of school-based STEM Education.

Japan.

A Government of Japan definition on STEM and STEM Education or a framed vision were not located during this review. Although, STEM Education policy was alluded to within this prime ministerial speech at the 13th Science and Technology in Society (STS) forum Annual Meeting held in Kyoto, as:

> Call it "Society 5.0," where science and technology play even more key roles in tackling challenges like ageing, sluggish productivity growth and enhancing well-being of humans, and that is what my government has chosen to aim for as a long-term strategy. A long, long time ago, we were all hunters, which was "Society 1.0. We then developed an agrarian society, "Society 2.0." "Society 3.0" was industrialization. And then the information age came, which ushered in "Society 4.0. In contrast, under "Society 5.0," technologies of sensing, robotics, communication, big data and cloud computing all merge to solve the problems previously deemed unsolvable ... [by focussing on] ... the power of women. (Prime Minister Shinzo Abe, October 2, 2016)

This speech reiterated the issues addressed by Prime Minister Shinzo Abe when chairing the G7 Summit in Ise-Shima, 2016, in leading actions on two initiatives the: G7 Guiding Principles for Capacity Building of Women and Girls, and WINDS -The Women's Initiative in Developing STEM Careers (Ministry of Foreign Affairs Japan, 2016). These two initiatives stated how STEM Careers and STEM Education were, in principle, to be support by the G7 nations to address issues on gender-based disparities, and the extent of contemporary technology skills for economic development in Japan and among the G7 nations. Agreed to were several international actions for national implementation that included STEM careers and STEM Education, as highlighted by the following Declaration:

> ...We launch a G7 initiative, Women's Initiative in Developing STEM Career (WINDS), to catalyze global momentum to promote the advancement of women in STEM fields and

> careers, in partnership with the OECD, UNWomen, and other international agencies and
>
> stakeholder. (G7 Ise-Shima Summit, 26-27 May 2016, p. 14)

These initiatives were to be actioned by the Ministry of Education, Culture, Sports, and Science and Technology of Japan (JMEXT) and were to align through to a school-based STEM Education. However, a review of these two policies, as described by the Prime Minister, was unsuccessful in locating similar references within the policy communications or documents by the JMEXT, which does not reference the term STEM Education. Education policies have been administered by the JMEXT, but carried no reference to the Prime Minister's G7 STEM policy declaration to the issues, actions, initiatives, or the budgets to fund programs for school-based implementation.

The Fukushima Daiichi nuclear energy accident as a result of the Great East Japan Earthquake of March 11, in 2011, combined with the economic impacts from the Global Financial Crisis (GFC), had a major impact on Japan and its policy agenda. Longer-term policies were abruptly revised to address the immediate issue for restoring the nation's energy supply, safety, and standards (Prime Minister Shinzo Abe, 2013). The budget was revised and reallocated away from education and to the energy industry to address these issues (Prime Minister Shinzo Abe, 2013). By 2015, the national government was in a position to reprioritise the policy agenda and refocus on education in schools. Cited commissioned research into the national framework, standards, and budgets for policies were then prioritized to support a more flexible and autonomous school-based STEM Education (e.g., JMEXT, 2015a).

Research by the OECD (2015) noted issues on learning performance and teacher quality in Japan as:

> Japan is among the top PISA 2012 performers in mathematics, science and reading…across PISA cycles…The impact of socio-economic background on student performance is below the average across OECD countries. In compulsory education (from age 6 to age 15) school choice is limited. In 2011, Japan increased the total number of study hours in primary and lower secondary education, in order to reduce dependence on private education resources…Japan faces challenges facilitating the transition from school to work in a context of globalisation and a decreasing working-age population. Measures to increase participation of women in the labour market [are needed to]…improve the utilisation of high quality human capital. Other challenges include ensuring that the increase in study hours for students at schools does not weaken the overall quality of the teaching provided. To deliver quality teaching, teachers need opportunities to improve professionally. Engaging local communities in children's education is also a high priority…as well as to secure funds to achieve the targets established by the government. (OECD, 2015e, p. 3-5)

The OECD research raised issues for Japan appeared similar to the nations reviewed in this study in terms of socio-economic performance differences, gender disparity, and the quality of teaching in Science and Mathematics.

The OECD reported on several policy actions in Japan as:

> School curricula from primary to upper secondary levels (Courses of Study) were revised in 2008/09 with the goal of fostering a zest for life in students. The current Courses of Study aim to develop in students [a] solid fundamental knowledge and skills, the ability to think, make decisions and express themselves in order to solve problems using these knowledge and skills, and the attitude to learn proactively.

Their objectives include strengthening the curriculum in such subjects as languages, mathematics and science, and increasing study hours in class.

Japan introduced the Teacher License Renewal Environment in 2009. Under this system, teachers must renew their teaching licences by participating in at least 30 hours of professional development programmes every 10 years to improve their knowledge and practices.

Starting in 2015, the National Center for Teachers' Development is working to develop new teacher training programmes to help strengthen problem-solving and collaborative work among teachers.

After the earthquake in 2011, the OECD Tohoku School project was created to support local innovations to foster resilience, creativity and 21st century skills in 100 students from the affected region. The project is managed by Fukushima University, with the support of the OECD. The project is seen as a good example of transforming education by project-based learning on a real-life issue, with bottom-up initiatives, leadership and ownership. The project aims to scale up and explore how local innovations can be developed around the world to find solutions for challenges in the world of 2030.

(OECD, 2015e, p. 10)

These actions appear to support autonomy in practice by including teacher problem solving and collaboration to practice project learning on innovations on 'real-life' issues. School-based STEM project learning was to occur by partnerships as bottom-up initiatives. Other than this OECD data, limited research was located on these policies and their actions.

Japan's contemporary schooling system has been framed by the Japanese Central Council for
Education's (JCCE) research, documented in two reports, which defined and framed a 21st
century model of Education, by:

> …compiling two reports on The Model for Japanese Education in the Perspective of the
> 21st Century (Findings) which made a range of proposals premised on nurturing "zest
> for life" in children, and the necessity to focus on education that matches the abilities
> and personality of the individual to realize self-fulfillment and a richness of spirit.
> (JMEXTa, 2013, para.18)

To build on this framework, the National Commission on Educational Reform of Japan
(JNCER) was set up within the Cabinet with the aim of rebuilding Education and structuring
its schooling system in line with the JCCE's research and recommendations (JMEXT,
2013a). Based on the JNCER's recommendations, an Act in Education was enacted in
December 2006, following the JNCER presenting four reports, one of which made
recommendations about STEM Education in schools.

In response to this report, the national executive government endorsed its *Second Basic Plan*
for the *Promotion of Education* by its Cabinet and formalised a five-year plan (Plan) that took
effect from 2013 until 2017 (JMEXT, 2013b). This Plan consisted of three parts and aimed to
support three skills needed in Japan's society. These skills were framed based on the
challenges to resolve the energy and infrastructure related impacts from the Great East Japan
Earthquake: independence; collaboration; and, creativity (JMEXT, 2013b).

Five priority actions were then included and defined (JMEXT, 2015b) for school-based
implementation, which were:

1. To improve the capacities and abilities of teachers with initiatives to support teacher
    training, recruitment to secure qualified and talented teachers, enhancement of in-
    service teacher education that includes induction training, and to encourage

collaboration between the boards of education and universities. A system for renewing teacher certification was also introduced, requiring teachers to renew their licenses every 10 years.

2. Conduct a National Assessment of Academic Ability and regular nation-wide surveys.

3. Develop human resources from science and mathematics backgrounds that are capable of creating new values and of working internationally.

4. Establish Super Global High Schools that educate for wide-ranging knowledge and international abilities, including problem-solving skills.

5. Build safety nets for learning that ensures learning opportunities for all those motivated to learn.

These five priorities, emerging from this most recent plan, could be seen as focusing on: teacher quality; development of human resources in Science and Mathematics; national assessment, skills development highlighting problem solving; and, generic safety nets for learners. In this way, the government's policy has intended to connect to STEM Education in schools. Although, the Plan seems disconnected to the Prime Minister's G7 Summit announcement that STEM Education is to focus on females progressing in STEM careers, and technology development within the schooling system.

In summary, two policies with initiatives to support female STEM Education in primary schools in order to begin to develop student interest in, and progress into, STEM careers for economic development were noted. These policies as documents did not appear (in English) to be part of the online policy database by the government to inform school-based implementation by the JMEXT. The Government of Japan was noted to not have had a formalized STEM and STEM Education policy framework. A framed national STEM policy agenda that links with STEM Education was evident by the JMEXT, although there does not

appear to be actions associated with the G7 policy-based declarations. A reason for this policy disconnection was attributed to a horrible natural disaster with a requirement and effort to reprioritise policies for a corresponding nation-wide recovery, which has limited this government's ability to connect with school-based STEM Education.

Singapore.

A definition of STEM Education by the Government of Singapore was not observed during this review. Although, a definition by a government-supported education agency was noted, which is as follows:

> Although STEM Education has many interpretations, many support it as a "belief that promotes the teaching of STEM concepts, principles, and techniques in an integrated approach." When discussing STEM Education, it often only refers to activities and experiences in the core subject areas of math and science; seldom does it refer to the "technology and engineering" areas, the "T&E" of STEM. If true STEM integration is to occur, teachers must have a good basic understanding of the concepts and practices associated with technology and engineering. The importance of teaching "engineering" in primary and secondary education today has been clearly shown in the recent release of the Next Generation Science Standards (NGSS) in the U.S. In the NGSS, they make a commitment to integrate engineering design into the structure of science education by raising "engineering design" to the same level as scientific inquiry. (Singapore National Institute of Education (SNIE), 2016, para. 1)

This definition featured in a professional development program for in-service teachers by the Singapore National Institute of Education (SNIE). The fact that STEM Education is often undefined, or undefined on Technology and Engineering in policy is made clear by the SNIE, and seems a disconnection occurring within this context of Singapore. Rather than regard national policy, the SNIE has in-turn connected practice with a focus on primary and secondary STEM Education by citing and referencing the U.S.A NGSS policy.

Singapore was the highest performing country in both the 2015 PISA and TIMSS Science and Mathematics assessments. Students in Singapore have consistently improved on national average scores with a reduction in variance across the years. Singaporean students achieved, in Mathematics and Scientific Literacy in PISA 2015, scores of 564 and 556 points respectively (Thomson, De Bortoli, & Underwood, 2016), as the highest ranked nation (refer to Appendix 3). In 2015 PISA assessments, Singapore's students enjoyed learning science more than the international average (OECD, 2016a) to be one of the highest scoring nations in this category. Student enjoyment has been attributed to how Science (and Mathematics) government policy, approach and context have supported teaching quality through:

1.   professional standards of teaching science and mathematics in schools; and,

2.   a comprehensive framework that has embedded: principles, frames-of-references, resources and materials, remuneration, teacher education and ongoing professional development (CPD), reasonable working hours, and personnel supports (Schleicher, 2018).

The Government of Singapore's policy framework and coordinated approach has been, along with Finland, considered an exemplar for international governments to regard by the OECD. The context has evidently improved students' performance and interest in STEM Education through policy actions aimed at improving Science and Mathematics teaching quality.

Governments in Singapore have framed STEM Education by making it a policy priority that supported a national schooling system with explicit value for a Science based nation to further development. Through policy development and implementation, the educational outcomes of citizens through the schooling system contributes to future national development. Singapore has a well-regarded education system as it is seen to produce longer-term and sustained outcomes of successful economic and social development (The World

Bank, 2015). Government has also considered itself successful in accommodating the individual student and autonomous education practices by schools (Singapore Ministry of Education (SMOE), 2015).

The national STEM policy agenda has included five priorities as actions in relation to STEM Education (SMOE, 2015), which were:

1. developing leadership in schools;

2. investing in quality teaching by well-incentivised conditions to recruit and retain teachers including: salaries that are competitive and benchmarked to the qualification standards of professions in the labour market; free teacher training tuition; and, a full salary during pre-teacher placements and training;

3. school infrastructure that has been built to enhance quality teaching includes lesson observation classrooms with one-way mirrors where teachers can authentically observe school classrooms with their peers;

4. developing ICT resources and materials to transform learning by supporting pedagogy and curriculum/assessment development. A third government plan has been implemented that aimed to achieve further integration of ICT into the national curriculum and assessment, pedagogical approach, and enable students' self-directed learning. Schools were allocated grants for ICT that had flexibility in the purchase of resources. Some examples of how schools spent these allocated government funds for STEM Education by schools included: Data loggers as resources in schools for measuring the pH of school *Ecoponds* in biology; and,

5. an assessment framework on learning and teaching STEM by schools, The School Excellence Model (SEM), a nationally designed online self-assessment completed annually by all schools (administered by the SMOE).

Further initiatives by the SMOE included a framework focused on partnerships with families and STEM organisations within schools. For example:

> In 2013, the Ministry of Education (MOE) introduced Applied Learning Programmes (ALP) and Learning for Life Programmes (LLP) to enhance learning for every student…, catering for a wide range of interests and strengths across our school system. To further strengthen the development of ALPs and LLPs in schools through partnership with the community, a new community resource network – named Community of Pathfinders in Action (COMPACT) – has been set up. Schools can tap on the network's… This is in line with MOE's efforts to enable every school to be a good school in its own right…
>
> A COMPACT will be made up of many well-established individuals in various fields including Languages, Humanities, Business and Enterprise, Aesthetics -Media & the Arts, Sports, Youth Leadership, and Science, Technology, Engineering and Mathematics (STEM). Pathfinders can link our schools with the wider industry and community to enable students to make connection of what they will learn in school with the various fields that they will encounter beyond the school setting. The network will provide a structured and broad-based approach to enhance community-school partnership. It will add to the work of our various existing partners…, they can also motivate and stretch the imagination of our students to develop their interests and strengths and pursue excellence in the different fields. This will help students appreciate the diverse career choices and multiple pathways available, and give them invaluable opportunities to meet successful individuals whose work and life values they can learn from. (SMOE, 2015, p. a-1)

The purpose or objective of this initiative was to increase students' interest in STEM as a transdiscipline by definition. Overall, the purpose for these actions by SMOE results from STEM Education policy that had cited research recommending students learning 21st century skills in order to contribute to economic development in the future.

The SMOE specified that learning 21st century skills in schools comprised STEM knowledge, skills, and social-values. The SMOE research had also regarded international research, which featured U.K. and U.S.A female's experiences and interests in STEM Education to inform the policies for implementation. Limited national-based studies were identified on teaching STEM's impact on girls' attitudes towards STEM and the construction of STEM-related identities. Only one study was cited and funded by the SMOE on this topic. This study analysed the data on the Singapore Committee for United Nations Women, *Girls to Pioneer* program.

Similar with most OECD governments, this program was initiated to promote more girls aged between 10-15 in STEM and STEM Education. Girls participating in this study were recruited from schools or private centres (e.g. after school study centres) that had signed up for this program (SNIE, 2018). The findings from this research were yet to be published during the time of this thesis. Other than this research, there was limited other SMOE commissioned and referenced research located with regard to STEM Education focused on Primary STEM Education by schools. Similar to other of these OECD nations, Singapore has policy-based initiatives focused on an after-school or informal programs rather than on formal or school-based programs.

In summary, government policy focussed on school-based Primary STEM Education was limited. Most of the STEM Education initiatives implemented were to address and prevent international research raised issue which included Finland, U.K and the U.S.A (reviewed further on), or informal educational programs. Policy-based actions and programs to increase students' interest in STEM careers and a STEM Education have been based on international policy actions rather than national cited research (i.e. SMOE, 2015). The assessment-based data including the OECD and IEA policy recommendations on Technology (T) and Engineering (E) was insignificant. The Technology and Engineering elements of STEM had not been defined and supported to the same extent as Science (S) and Mathematics (M), which is similar across these nations. This is because OECD and IEA assessment framing has

focussed on Science and Mathematics, rather than on Technology and Engineering. Therefore, the focus on Science and Mathematics is what and how this government's STEM policy presents, which contradicts the prior quoted SNIE definition and statement on STEM Education and tends to perpetuate across each reviewed government so far.

On review, the context has an inherent disconnection with various agencies, which have referenced international policies, and the limited extent of a research-base evident. The OECD and IEA assessment data have informed policies, which is on Science and Mathematics, rather than Technology, Engineering, or STEM as a transdiscipline, which is similar to most developed OECD governments in this review (see Schleicher, 2018; Schleicher & Zoido, 2016). This limited definition and focus on Technology, Engineering and STEM is evident by how the initiatives, which have included the education and training of specialist STEM teachers in Science and Mathematics are framed. Thus, a STEM Education focussed on Science and Mathematics suggests a limit to the extent to which 'STEM' issues are addressed.

Republic of Korea (South Korea).

The Government of South Korea has shifted from STEM to a STEAM policy context. In this context, STEAM Education policies are Science-based and to its applications in Technology, Engineering, Mathematics and the Liberal-Arts for solving problems every day (Korean Ministry of Education Science and Technology (KMEST), 2011a; 2011b; 2012a; 2013; 2014; 2015). In policy, STEAM has differed to STEM in terms of broadening, expanding and integrating Science, Technology, ICT, Engineering, Mathematics, and now the Liberal Arts — for economic creativity and social happiness (KMEST, 2011c). These disciplines and discipline-areas were determined to form the foundation of educational outcomes by students on completion of a free education.

Reviewed in this study, the policies were unclear about a formal definition on the acronym or term STEAM Education including Liberal Arts. Although, several 'STEAM' labelled initiatives have been implemented in schools, two of which are:

1. the Free Semester: one-semester free in middle schools to enhance the creativity, happiness, and well-being of students during which students are encouraged to develop key competencies through experience-based activities (e.g., discussions, science labs, project-based learning) and activities (e.g., career exploration, theme-based learning, fine arts/physical activities, club activities). The Free Semester was implemented in 2016 by all middle schools to increase and sustain students' interest in STEAM Education (KMEST, 2016); and,

2. the 2015 Revised National Curriculum was in order to frame STEAM Education for learning and teaching practices. The aim was for learning outcomes in creativity, and other 21st Century skills classified to the Liberal Arts, with an integrative teaching approach to these disciplines. The curriculum was reframed to support autonomous and integrated pedagogical practices between the Liberal Arts and Sciences in schools. A national software (SW) language education framework was added to support the national vision and goal that all students develop a common national SW language. This national curriculum was planned for school- based implementation with government support in 2017.

The revised curriculum was linked to a national assessment framework to evaluate student outcomes in Science, Mathematics, and the Arts. The results of which were then relied on to stream students into one of two disciplines (Science/Maths or Liberal Arts). Students were limited by their choice in study across the schooling system. Thus, the development of a STEAM Education policy (rather than STEM) occurred focused on Science and Mathematics where the Liberal Arts provide an alternative.

These actions were to address the following issues:

1. the public's concerns about the school-based STEM Education or teaching quality in the free public schooling system. Korea has had a higher percentage of students attending informal STEM Education programs for improving students' academic achievement in Science and Mathematics in order to progress within these streamed

disciplines that has been occurring across system of schooling (OECD, 2015a). For example, this nation has had a significantly higher student-to-teacher ratio, where on average there were 32.4 students per teacher in middle schools compared to the OECD international average ratio of 24 (OECD, 2015a). In light of this, concerns were about students' academic ability in assessments and future career choices being limited by the teaching quality in a high student-teacher ratio classroom environment. Families have utilised informal STEM Education providers to improve students' academic abilities for the teaching quality that will lead to those the higher economic reliable careers relied on by being streamed to the subjects of Science and Mathematics rather than the Arts. In doing so, participation in informal STEM Education is considered to have made a significant contribution to Korea's higher rankings in international (and national) assessments rather than the schooling system (Schleicher, 2018); and,

2. international comparative research highlighting a trend toward lower affective outcomes in the 21st Century skills by students when compared to Western nation's students (OECD, 2015a). Nationally raised concerns were about students' interest in STEM and the future impact on national development in relation to a market-based international STEM economy and society.

These two issues were addressed in part by the STEAM Education policies as determined by the KMEST (who redefined the 2015 national curriculum).

While, a STEAM Education vision statement is to a:

> Creative Economy and People's Happiness through Science, Technology and ICT.
>
> (Korean Ministry of Science, ICT and Future Planning, 2016, para. 1)

This vision was framed to the STEAM Education strategy from, *The Second Basic Plan for foster[ing] and support[ing[human resources in science and technology 2011-2015* (KMEST, 2011a). The vision and strategy by a STEAM Education is for a creative economy, which is similar with those reviewed nations for an innovative economy (i.e., China-Hong Kong Region, and the U.S.A further on).

Students' academic achievement has consistently ranked within the top nations in IEA and OECD assessments in all three tested areas (i.e., OECD, 2015a), which has been attributed to the nature of government policy (Schleicher & Zoido, 2016). The Education Law enacted, in 1949, a Science-based education aimed at national development, which has had coordinated government support balancing for both economic and social-cultural outcomes. Since, STEAM Education has become integral in the approach to addressing national issues in Science, to continue its development (Korean Ministry of Education Science and Technology (i.e., KMEST, 2011a).

As stated, the OECD (2016a) noted that there were issues to address on the cultural and socio-economic differences to the extent of equity and access originating from STEM Education policies implemented across the schooling system. Over several policy agendas, The Korean Ministry of Education (KMOE) in conjunction with the Korean Ministry and Science, ICT and Future Planning (KMSIP) or KMEST (KMOE and KMSIP combined) created what government researchers termed a STEAM Education (e.g., Jho, Hong, & Song, 2016; Shin, 2013), with associated actions, initiatives, and allocated funds to projects and programs for school-based implementation. Unfortunately, in terms of this review, these policies were inaccessible in English from the official website of the Government of South Korea, and the KMEST. Hence, the following review is sourced from researchers, and two related-but limited in content-government English based policy reports.

In order to support economic and socio-cultural development, the STEAM Education policy objective includes:

1. realising 21st Century skills in number and quality focussed on Technology as ICT and Engineering; and,

2. increasing the level of student interest in STEM Education and STEM careers (see Lee, Park, & Kim, 2013).

The second objective coincides with national research that illustrates a significant decline in the number of students in tertiary Science and Engineering Education, and a disproportionate and unsustainable shift to a career path in medicine (apparently a non-STEM profession) and law (KMEST, 2016). The KMEST has informed these policy objectives to form actions that influence students' interest in careers and tertiary Science, Technology and Engineering; and away from medicine, law (Jho, et al., 2016), and according to academic research outcomes (see also Shin & Han, 2011; Son, Jung, Kwon, Kim, & Kim, 2012).

As stated, a policy action was for a national software language whereby the KMOE (2016) has a priority on compulsory school-based software education (SW). The action was that students compulsorily learn a national software language or coding, which was to be trialled across a cohort of schools with evaluation on the outcomes to occur over certain periods. This compulsory coding curriculum was to be scaled up based on evaluative research to realise two outcomes and an associated timeline, which were to:

1.   develop and implement programming tools, and in-service teacher training; and,

2.   a timeline of 2015 and 2016 in researching the outcomes in 1,128 schools.

The KMOE (2016) has shown a policy action on compulsory SW that seems limited in addressing the issues of high teacher ratios and students' interest in STEM Education within the free schooling system. Also, the KMOE has implemented evaluative research on this action, which in time can further establish on whether these two issues persist over the measured time frames of 2015 and 2016. However, a search for such research was not identified at the time of this review.

The mandated SW action contrasts to the research and the support for autonomy across the schooling system (i.e., OECD, 2015a; Schleicher, 2018). The Korea Foundation for the Advancement of Science and Creativity (2013) research has regarded the cultural, social, and economic issues, and the international environment. Some researchers have stated concerns that mandated coding in schools would have an insignificant impact on students' interest in STEM (Lee, 2017) by limiting student choice.

Traditionally, South Korea's policy approach to the schooling system has been described as highly autocratic in terms of how policies were defined and then nationally represented by governments (Kang, 2015). The context is based on a Confucian belief embedded into the national culture that instilled learning performances by persistent effort and hard work, to collectively form the nation's development (Lee, Kim, & Byun, 2012). One STEAM policy initiative was the autonomous teaching of STEAM in schools (see Lim, & Oh, 2015; Lim, Kim, & Lee, 2014; Noh, & Paik, 2014). The purpose of autonomous teaching was to foster individual giftedness, talent, and creativity in schools (KMEST, 2011a). This initiative is a shift away from the Confucian tradition and appears to reference those in Western defined cultures such as The U.K. and The U.S.A. In contrast, non-government partnerships such as with Microsoft have occurred to implement the action on compulsory SW Education, which shows a mix of the Western with the Confucian-belief system framing policy. The actions of assessment for student streaming, and compulsory student learning of the SW are suggested as limiting with regard to the issues of improving teaching autonomy, and student interest in STEM careers and a tertiary STEM Education to progress social and economic development.

In summary, South Korea has a STEAM Education policy context. STEAM Education in schools has closely referenced the OECD's research and recommendations to ultimately support and address similar developmental economic and social-cultural issues, and visions held by the developed OECD nations, such as climate change, scientific literacy, and economic innovation and entrepreneurship. In South Korea, the priority issues have been the interest for and low career participation (e.g. as evidenced by the low number PhD levels to meet the project future demand by the Technology and Engineering sectors of the national economy, away from medicine and law (see Jho, et al., 2015; Jon & Chung, 2015)). To address such issues, one action was the mandated software education by schools, on which evaluative research was currently unavailable and given the contrary academic research on the limited improvement outcomes on mandated policy-based actions following implementation.

The United Kingdom (U.K.).

The Government of The U.K. through, *The Lords Select Committee Report* (2012),

recommended Parliament:

> Formulate and apply a standard definition of STEM Education … [that is] … derived from
>
> a statement of the competencies and skills that a graduate should possess and the
>
> characteristics that a STEM course should contain, including direct STEM content. (The
>
> Lords Select Committee, 2012, para. 15; para. 23)

This report described STEM Education, as:

> The acronym "STEM" encompasses a group of disciplines that teach the skills required
>
> for a high-tech economy. What this means in practice, and how this definition relates to
>
> specific courses in higher education institutions (HEIs), is a more complex matter and
>
> the definition varies across the HE sector and Government. (The Lords Select
>
> Committee, 2012. para. 9)

This description was sourced from the Department for Business, Innovation and Skills

(UKBIS), and the Higher Education Statistics Agency (UKHESA). In contrast, The U.K.

Department for Education (UKDE) (2016) has a strategy focused on prioritising Science and

Mathematics Education, and increasing the of content and rigour in the four disciplines rather

than a defined STEM Education strategy.

Research informing national policy agendas included, The Royal Society, which published its

recommendations for improving the support for Science Education in schools, using the term

STEM Education (The Royal Society, 2014). The Committee Chairs reported that Science

and Mathematics were the foundations to economic prosperity and forecasted that one

million new Science, Technology, and Engineering professionals would be required in The

U.K. by 2020 (The Royal Society, 2014). The Head Teacher member of the Committee,

recommended that STEM Education be valued and to reframe the teaching profession, which

is chronically undervalued (The Royal Society, 2014). Previously, in an open letter

(Beddington & Rothwell, 2012) to the Prime Minister, the Royal Society recommended an

integrated approach to STEM Education 'from age four to twenty-four' by 'at least

supporting specialist trained Mathematics and Science teachers in primary schools'. The

purpose was that:

> In science and mathematics, there is a fortunate coincidence between the intellectual
>
> and cultural needs of the individual and the economic needs of the nation. (The Royal
>
> Society, 2014, p. 4)

The national government has had Science and Mathematics raised as the evidence-based

imposts to social and economic development, and hence the need to progress these areas

through policy.

Interestingly, The *STEM Cohesion Programme* (Program) was established and evaluated by

the UKDE for coordinating those stakeholders responsible for policy support with STEM

Education in schools. The Program was divided into 11 action programs (APs) and

corresponded to the key areas of STEM Education (UKDE, 2010, p. 1). The evaluation report

identified that the limited definition of STEM and STEM Education within the related

enrichment activities supported by government meant these activities lacked alignment and

cohesion across those framed in policy. In addition, the executive government presented at

least two national initiatives to further support STEM Education without a clarification on the

definition of either STEM or STEM Education to align policy with practice by the various

stakeholders. Without a definition, these subsequent initiatives again appear to have a limited

policy alignment and cohesion.

The policy documents detailed two issues that government had prioritised as actions for implementation:

1. preventing The U.K.'s standard of education from falling further behind that of other developed countries; and,

2. resolving inequities identified within the population with lower learning performances and who were living concentrated in disadvantaged areas (UKDE, 2016).

Following up on these two policy issues, key STEM-related initiatives were to be processed by the executive through the 2016 Education policy white paper, which set out, to enable:

1. Equitable support and access to use of resources.
2. Infrastructure to allow (support) a self-improving school-led administration to flourish.
3. A system that is school-led and supports the development and practice of professional autonomy, based on evidence, in Education.
4. To strengthen and reframe accreditation, along with supports to access to teacher education and professional training that is evidence and subject knowledge-based (STEM subjects), by a working group set up by the Department. (UKDE, 2016, para. 1)

The executive government also proposed new laws for Education that established a new funding model and defined teaching standards to support schools (UKDE, 2016). STEM Education had remained undefined by the executive government within these actions to support issues of students' educational access and equity, autonomous schools of practice, teacher professional standards, and evidence-based practice.

Despite that, statutory organisations and government departments had constructed several definitions (e.g., UKDE, 2010), for example:

> STEM is the acronym for science, technology, engineering and maths. The government's STEM programme aims to increase young people's STEM skills in order to provide employers with the skills needed for a 21st-century workforce and ensure the UK's place as a leader of science-based research and development. Many organisations are involved in working to inspire and engage young people in STEM. As a result, the STEM Cohesion Programme was created as a means of coordinating the wide range of expertise and resources available. (UKDE, 2010, p. i)

This UKDE definition related to students obtaining STEM skills in order to provide employers with a 21st-century capable workforce, and ensure international leadership in science. This definition is similar to the 2012 Lords Select Committee, which classified and specified STEM skills and competencies. In contrast, the National Executive's (UKDE, & The Rt Hon Nicky Morgan, 2016) white paper did not refer to STEM skills, and instead referred to teaching STEM subject knowledge, as distinct disciplines, in schools. The Government of The U.K. has evidence of limited alignment, cohesion, and continuity with regard to the definition of STEM and STEM Education in policy.

In light of this, the national executive government released *The South Asian* method of teaching Mathematics late in 2016. This initiative was reported to be 'rolled out to 8,000 primary schools in England' and was to address students' trends in PISA scores and research indicating declining interest and take-up in STEM Education and careers by children and youth (UKDE & Minister Nick Gibb, 2016). The action was that all primary schools would implement the Maths Mastery method with government funds as framed by the policy. The purpose for this action was that the method has been used in Shanghai, Singapore, and Hong Kong—the highest scoring nations in PISA assessments. This initiative was tested in several

schools across England, after a teacher exchange program between England and Shanghai, as a network of Maths hubs in 2014. No research was evident on the test results within this school-based implementation at the time of this review.

An allocation of £41 million was budgeted to train specialist mathematics teachers by 35 school-led centres in Mathematics teaching over four years (UKDE & Minister Nick Gibb, 2016). The objectives of the policy included to increase STEM Education and career take up in the future, and that all students continue to study Mathematics to the age of 18 (UKDFE, 2016). In this context, a policy on improving students' Mathematics achievement with specialist-trained teachers was based on PISA assessment data using a more 'successful' international policy-based program.

Science and Mathematics have been part of government policies, and along with ten years of intense STEM and STEM Education research and programs in The U.K. The research suggested that due to the vast number of STEM initiatives, there was a limited understanding of where or how the greatest impacts have been achieved, or an ability to point to where across the schooling system youth have been limited from taking up subjects leading to Engineering careers (Royal Academy of Engineering (RAE), 2016). The Academy, grouped each issue into seven categories to conclude that unless all were addressed, then there would likely be limitations in the outcomes to increasing the number of youth choosing an Engineering career (RAE, 2016). This was despite The Academy's map of STEM Education identifying over 600 organisations involved in supporting a school-based Engineering Education, and the prior stated forecast for one million Engineers.

The Academy's analysis showed that there were very few areas where there was no support to encourage youth towards engineering or STEM, or in improving their attainment in STEM subjects. However, there were key areas where the scale and pace of activity were insufficient

to achieve the intended outcomes of STEM policies (RAE, 2016). In addition, there was a lack of evaluation or evidence of impact across many programs to allow consideration of whether or not any significant effect on achievement in STEM subjects was realised (RAE, 2016) by government policy. The Academy classified seven key areas where STEM policy actions needed to be addressed by a whole-of-government approach to STEM Education in schools (relating to engineering), which included:

1. improving teaching and learning;

2. greatening STEM support in primary schools;

3. widening access to under-represented groups;

4. increasing support for teachers of STEM subjects;

5. coordinating enrichment activities to reduce duplication of effort and reach schools that are currently underserved; and,

6. improving the understanding of, and attitudes towards engineering among young people, their influencers and the public.

In summary, substantial STEM Education programs have been framed with significant budgets, which define a disciplined approach to learning and teaching Science and Mathematics in schools. While, the research recommendations proposed national policy agendas to the executive government for resolving and improving Technology and Engineering, these recommendations were limited in value without a national definition of STEM and STEM Education or a policy-based framework by the agencies of this government.

The United States of America (U.S.A.).

In The U.S.A, STEM and STEM Education were two terms coined and used across national policy agendas, and various Governments of The U.S.A. (Bybee, 2013). Definitions of these terms have continued to evolve as for example in this description of the USA context:

In education, even among experts in the field, definitions and understandings of what

STEM Education means differ. According to a report by the National Academies Press

(2014), *STEM Integration in K-12 Education: Status, Prospects, and an Agenda for*

Research, in educational practice and in research, the term integrated is used loosely

and is typically not carefully distinguished from related terms such as connected,

unified, interdisciplinary, multidisciplinary, cross-disciplinary, or transdisciplinary.

Defining integrated STEM Education is further complicated by the fact that qualities can

be reflected at more than one level at the same time: in the student's thinking or

behavior, in the teacher's instruction, in the curriculum, between and among teachers

themselves, or in larger units of the education system, such as the organization of an

entire school. (Bybee, 2013 p. 23)

In light of the ambiguity about what is STEM Education, particularly an integrated STEM

Education, instruction remains typically stove-piped in current practice. STEM

Education is guided by a traditional path to a future career in discipline-segregated

pathways that places "Math as part of the basics, Science as important but secondary,

and Technology and Engineering as supplementary add-ons that are only appropriate

'later' and for 'some students." (U.S.A. Department of Education, Office of Innovation

and Improvement (USADEOII), 2016, p. 3).

A vision for STEM and STEM Education was located in the Committee on Science,

Technology, Engineering and Maths Education (CoSTEM) that was established in 2011:

Strategic vision: A future where: The United States has a well-qualified and increasingly

diverse STEM workforce able to lead innovation in STEM-related industries and to fulfill

CoSTEM agency workforce needs; American students have access to excellent P-12,

postsecondary, and informal STEM Education and learning opportunities; and Federal

STEM Education programs are based on evidence and coordinated for maximum impact

in priority areas. (CoSTEM, 2013, p. 8)

This vision was framed with a strategy in *STEM 2026 A Vision for Innovation in STEM*

Education (USADEOII, 2016), which comprised of six interconnecting components:

1. Engaged and networked communities of practice [CoP];

2. Accessible learning activities that invite intentional play and risk;

3. Educational experiences that include interdisciplinary approaches to solving

   "grand challenges";

4. Flexible and inclusive learning spaces supported by innovative technologies;

5. Innovative and accessible measures of learning; and,

6. Societal and cultural images and environments that promote diversity and

   opportunity in STEM. (USADEOII, 2016, p. 6)

The actions leading to realizing this vision were explained as:

Actions of multiple stakeholder groups and the development of CoP that can support

the integration and institutionalization of innovative teaching and learning practices

within local organizational and cultural contexts. CoP actively engage key stakeholder

groups in a process of collective learning that is structured around a shared mission.

Through regular interaction, these groups of people build relationships, jointly

implement activities, and share information with each other that advance. (USADEOII,

2016, p. 6)

Communities of Practices (CoP) were termed as STEM partnerships comprising

governments, industry sectors in STEM, universities, and schools using collaborative

arrangements.

Research raised several challenges, issues and opportunities, such as:

> There is growing concern that the United States is not preparing a sufficient number of students, teachers, and practitioners in the areas of science, technology, engineering, and mathematics (STEM). A large majority of secondary school students fail to reach proficiency in math and science, and many are taught by teachers lacking adequate subject matter knowledge.
>
> When compared to other nations, the math and science achievement of U.S. pupils and the rate of STEM degree attainment appear inconsistent with a nation considered the world leader in scientific innovation. In a recent international assessment of 15-year-old students, the U.S. ranked 28th in math literacy and 24th in science literacy. Moreover, the U.S. ranks 20th among all nations in the proportion of 24-year-olds who earn degrees in natural science or engineering.
>
> A 2005 study by the Government Accountability Office [GOA] found that 207 distinct federal STEM Education programs were appropriated nearly $3 billion in FY2004. Nearly three-quarters of those funds and nearly half of the STEM programs were in two agencies: the National Institutes of Health and the National Science Foundation. Still, the study concluded that these programs are highly decentralized and require better coordination. Though uncovering many individual programs, a 2007 inventory compiled by the American Competitiveness Council also put the federal STEM effort at $3 billion and concurred with many of the GAO findings regarding decentralization and coordination. (Kuenzi, 2008, p. 1)

This research has identified issues of both general and STEM teacher workforce supply, student participation, and lack of quality within STEM Education in The U.S.A (USA).

STEM Education policy agendas are framed based on a concern for the numbers of prepared students and teachers in Science and Mathematics Education (and not Technology and

Engineering) as a result of the number of programs and funds focused in Science and Health-Sciences. Such agendas also consider reversing the trends identified by The National Academies (USANA) (i.e., United States of America National Research Council, 2011) research which showed a significant decline in students' overall interest, cultural and social-economic status differences in the access and equity of resources and support, along with gender differences in STEM Education and careers. Such research had also focused on technology or coding skills in school-based STEM Education. For example:

> High-paying tech jobs across the United States that were unfilled, and by 2018, 51 percent of all STEM jobs are projected to be in computer science-related fields. Computer science and data science are not only important for the tech sector, but for so many industries, including transportation, healthcare, education, and financial services.

> Parents increasingly recognize this need — more than nine of 10 parents surveyed say they want computer science taught at their child's school. However, by some estimates, just one-quarter of all the K-12 schools in the United States offer high-quality computer science with programming and coding and 22 states still do not allow it to count towards high school graduation, even as other advanced economies are making it available for all students.

> Wide disparities exist even for those who do have access to these courses. In addition to course access challenge, media portrayals, classroom curriculum materials, unconscious bias and widely-held stereotypes exacerbate the problem and discourage many of our students from taking these courses. For example, in 2015, only 22 percent of students taking the AP Computer Science exam were girls, and only 13 percent were African-American or Latino students. These statistics mirror the current makeup of some of America's largest and more innovative tech firms in which women comprise

> less than one-third of their technical employees, and African-Americans less than 3
>
> percent. (Obama Whitehouse, 2016a, p. 1)

Extensive national research has identified and informed the actions and issues in several national policy agendas.

Those actions to address the national policy issues included to:

1. improve the quality of teaching in STEM Education;

2. increasing the number and quality of STEM-qualified teachers in STEM Education;

3. ensuring equality of access to STEM resources and teachers;

4. a cross-disciplinary, or an interactionist (e.g. Williams, 2011), approach to teaching STEM;

5. contemporary or 21st Century STEM skills that included scientific literacy, creativity, problem-solving, coding and computational thinking, and innovation;

6. connecting STEM and STEM Education policies between the federal and state governments; and,

7. coding in the curricular across the schooling system (Obama Whitehouse, 2016b; USADEOII, 2016).

Within these seven actions was a focus on the quality and supply of specialist STEM teachers in schools. The USADEOII and CoSTEM have been directly responsible for administering the implementation of these actions across schools nation-wide.

Three budgeted initiatives for school-based implementation have included:

1. Race to the top: Where the first round of the Department of Education's allocated $4.3 billion budget was offered to the U.S.A states to enable, "a competitive preference priority on developing comprehensive strategies to improve

achievement and provide rigorous curricula in STEM subjects; partner with local STEM institutions, businesses, and museums; and broaden participation of women and girls and other groups underrepresented in STEM fields" (USA National Science and Technology Council (USANSTC), 2013, p. 3).

2. No Child left behind: Encompassing The President to host the first-ever White House Science Fair, in 2010, realising Obama's Educate to Innovate policy, which was intended to inspire children to excel in Mathematics and Science. Additionally, The President called on the 200,000 Federal Scientists and Engineers to volunteer in their local communities, in creative ways, to engage with students' learning in STEM subjects (USANSTC, 2013).

3. Keeping teachers in the classroom policy: President Obama (2016a) announced his goal to prepare 100,000 STEM teachers over ten years. This policy was implemented by over 150 organizations and administered by the Carnegie Corporation of New York by a coalition called, 100Kin10 (USANSTC, 2013).

4. Computer Science for All to empower all American students from kindergarten through high school to learn computer science or coding and be equipped with the computational thinking. (Obama White House, 2016c).

These were the priority initiatives in the *Five-year Federal Science, Technology, Engineering, and Mathematics (STEM) Education Strategic Plan* (Plan) (USANATC, 2013), by the Executive Office of the White House of President Obama. This Plan was made to carry out the enacted *America Competes Reauthorization Act of 2010* (Sargent & Shea, 2014) that legislated the terms by which, Science underpinning STEM, would bring about national development. Through this Plan, the national executive government represented a policy agenda to support STEM Education across schools as a system, comprising early childhood learning, education for K-12 students, and Higher Education.

President Obama had prioritised and represented a national STEM and STEM Education vision, plan, and strategy for connection across America's schools, by:

1. STEM organisations engaging with under-represented and low-access groups (e.g. Hispanic female students) for increasing the number of, and improve the quality of, STEM graduates;

2. STEM professionals– namely Scientists and Engineers– to creatively educate children, in order to increase their interest in the field; and,

3. STEM Education and Training to prepare specialist STEM teachers, for improving the quality of STEM Education in schools.

These initiatives were then represented by President Obama during the "Educate to Innovate Campaign for Excellence in … (STEM) Education" (Obama White House, 2010, p. 1) policy campaign with government and non-government STEM partnerships.

The U.S.A. Department of Education has allocated with over USD $250 million of public-private partnership funds to various related projects and programs. The policy specified that five "proven" (White House, 2010, p. 1) partnership models were to be supported in educating 100,000 new Mathematics and Science specialist teachers, by 2015 (United States of America National Economic Council & Office of Science and Technology Policy, 2015). These initiatives did not support educating and training Technology, Engineering, or STEM (as transdisciplinary) teachers. This point of difference in policy also diverges from the 2010 Act and the 2011 Strategy defined on an integrated STEM framework inclusive of STEM Education.

Since STEM and STEM Education were first coined in policy (see, Bybee, 2013; Zollman, 2011), it has been amended by the government in order to clarify STEM Education for school-based implementation to have regard for STEM's role in future national development.

In doing so, 21st-century skills were listed and stipulated as the outcomes of STEM Education within schools (e.g., Sargent & Shea, 2014), in order to increase students' interest, access, and equitable outcomes. For example and yet, in contrast, an amendment was made to the U.S.A Elementary and Secondary Education Act (ESEA) to the definition of STEM Education that added, The Arts (Bonamici, 2013). This amendment was voted in by a joint House-Senate Conference Committee led by Democrat Representative Bonamici (2013) who, in her address to Congress, advocated changing the acronym and term to, Science, Technology, Engineering, The Arts, and Mathematics to form STEAM Education.

The Arts has been a critical discipline alongside STEM because of its inherent standards and principles to those valued skills of 'creativity' to economic innovation and entrepreneurship as the priority 21st-century skills, which have been linked to STEM. Therefore, following that argument, The Arts in STEM to form a STEAM Education, was anticipated as more likely realising the intended objectives recommended by the USANSA on STEM Education for future economic development. Similar recommendations have been made to most of the OECD developed nations such as the EU, China, and Australia to add Arts to STEM Education. However, only one nation has made such a formal STEM policy context change — The Republic of Korea (South Korea), as discussed previously.

In summary, STEM Education in the U.S.A. policy context has evidence of actions on:

1. specialist Science and Mathematics teachers for learning and teaching STEM;

2. a national curriculum, resources, and support for STEM Education;

3. coding or computer programming in schools; and,

4. non-government partnerships to support future economic development.

These four actions were similar between the nations reviewed previously and form part of an international STEM policy environment that connects with school-based practices.

The Government has STEM a vision and strategy (STEM 2026), based on non-government collaboration and cooperation through forming STEM partnerships with CoP models (USADEOII, 2016). Thus, policies address issues such as students' access, achievement, equity, and interest in STEM Education and future career choice to support social and more specifically economic development.

OECD Developed International Government STEM Policy Review Outcomes

The main outcomes from this review of eight OECD ranked international governments' STEM policies with regard to school-based STEM Education learning and teaching practices, are summarised in Table 2.1.

Table 2.1

OECD developed governments' STEM education policies in summary

Country	Definition	Vision	Actions	Summation
Canada	Science based	High skills and knowledge for Social (scientific literary) and Economic (high skills and wages) development	1. Specialist Science and Mathematics teachers, 2 Industry partnerships to support learning and teaching programs/sup -port, 3 Stated a coordinated government led by the national Prime Minister to initiatives & the budget on projects and funding on action1 and 2 (as listed).	Suggested is a range of STEM and STEM education policies are developing by the various national, provincial and territory parts of the government, and progressing toward a national draft STEM Education strategy and framework. A draft strategy, Canada 2067, is the result of a national government initiative and supported science-based organisation, Let's Talk Science, which has been scaled over recent years by evaluative research with regard to STEM Education policy.
China-Hong Kong	Science based	Not evident	1. National curriculum integrated key learning area (KLA) on STEM	Considered is an integrated policy on a national curriculum with professional development, and resources

			2. Teacher professional development on this new KLA 3. Teaching and learning resources on this KLA	for school-wide implementation.
Finland	Science based (e.g. LUMA definition)	High knowledge and skills in science and technology and a sufficient number of qualified professionals	1. National Curriculum 2. Support student interest and enjoyment 3. Reduce gender and social cultural academic performance differences 4. Research the current situation of education in schools	A framed policy context, whereby social and economic development is realised by a whole-of-government approach to regard across all sectors. STEM and STEM Education is framed with government support through a national partnership arrangement by LUMA (originated from a national government initiative and funding supported) collaborative organisation of national universities that has scaled from Science Education to STEM Education based on evaluative research over time as part of an international STEM Education ecosystem of collaborating partnerships.

Japan	Science and Technology based	A high skilled science and technology workforce	1. Support gender equity and participation in STEM and STEM education (National) 2. National Curriculum focus on science and mathematics (JMEXT) 3. Teacher License Renewal Environment (JMEXT) 4. Teacher Education and Training (JMEXT) 5. National assessment on academic ability (JMEXT)	Variation within the STEM policy context between the Prime Minister stated national policies on females, and with the JMEXT on teacher quality, national curriculum focus on science and mathematics and human development skills for innovation, creativity, and problem-solving.
Singapore	Integrated teaching of STEM concepts,	Not evident	1. Leadership in schools 2. Quality teaching	While defining interdisciplinary STEM Education-within the policies. Policy has cohered on

	principles, and techniques		3. ICT resources 4. Quality assurance framework on practice 5. Defining educational content	Science and Mathematics Education with actions on the national curriculum, teacher education and training, and teaching resources to support curricular rather than T and E by the Government of Singapore. This government has evidence to aligned on actioning S and M within a disciplinary practice that is the focus through the presented projects for implementation
South Korea	Undefined on the term STEAM Education to includes the Liberal Arts (or English)	A creative economy and social happiness by Science, Technology and ICT. A national software language	1. High quality and number of 21st Century skills in Japan by a focus on Technology and Engineering skills 2. Increase the level of student interest in STEM Education and Careers by	A varied context that is developing away from a STEM defined policy to STEA (Arts) M (without offering a framed definition for practice-based implementation). The purpose of STEAM Education is to achieve a high quality and number of STEM professionals whom can progress economic development focussed on Engineering and Technology (along with Science and Mathematics) to realise a

			school autonomy 3. Compulsory national software langrage learning by all schools	high quality and quantity of 21st Century skills in South Korea
U.K.	Various definitions that is discipline based for high technology society. Noted to Science and Mathematics	Not evident, but implied in definition as a leader of science based research and development	1. Equity in access to resources 2. Infrastructure 3. Teacher education and training accreditation and access 4. Funding model	Variation on the definition of STEM Education by the actions and funding focussed on Science and Mathematics in national government policies (for example, Teacher Education and Training of specialist mathematics teachers from a purchased program from the Government of Singapore). Limited focus on Technology and Engineering in policy actions.
U.S.A.	Science based	High quality science research and economic development for national competitiveness	1. Increase students access to STEM 2. Support quality STEM teaching with specialist Science and	Variation or incoherence by the policy context with the definition of STEM Education as a transdiscipline with coherence on the disciplines to include projects focussed on specialist science teachers, and coding (Technology) programs in

		Mathematics teachers 3. Learning resources and their access by students 4. STEM partnerships within schools focussed on Science and Mathematics 5. Computer science for all	schools. By comparison, Engineering has had limited delineation by the actions (which is similar with these reviewed OECD countries other than Finland).

On review of this international environment, policy has been framed to address the issues of:

1. student achievement, access, equity, and interest in STEM Education and future choice of career by various informal and formal learning programs, events; and role models;

2. teaching quality within schools in Science and Mathematics by specialist teachers in schools;

3. future economic development as innovation and entrepreneurship by students learning a software language, to code, or computer science; and,

4. contemporary Science practices have raised social-economic impact issues, such as climate change, for public interest and for government policies to address, which has informed STEM Education. STEM Education has been informed to form partnerships with STEM professions and organisations, and to practice project-based or inquiry learning and teaching problem-solving real-world STEM 'bottom-up challenges'.

The first two issues have been noted in reference to PISA assessment data and to a lesser extent through national research on STEM and STEM Education in respect to these policy issues. Such research often raised how 'fit-for-purpose' were these policies in terms of , for example the alignment, coherence, and focus of the actions stated, definitions on STEM and STEM Education, and the nature of the programs funded to support Science, Mathematics or STEM Education. Other than Finland, limited 'fit-for-purpose' or 'policy quality' based on a framework of academic and sector research as an all-encompassing and coordinated approach to implementation was evident. Yet, there was evidence of policy 'borrowing' from international governments to 'bundle and fit' STEM and STEM Education to the initiatives and budgets to address these issues of future social and economic development. While the OECD, IEA and G7 (i.e., Japan) has provided some evidence, there is a need for further research on the nature of the international STEM policy environment and its school-based implementation.

Chapter Close

This chapter has presented a review of the international policy environment in order to contextualise STEM and STEM Education in schools within the international context. The review has been based on the policies of eight highly developed nations of the OECD in order to offer both a comparison and differentiation of the situation. The review gave insights into the respective contexts of STEM and STEM Education in the policy, by these governments, which has helped to frame this study.

The CF for this study and its relation to the Government of Australia STEM policy leading to school-based Primary STEM Education, has been first established (Chapter 1) and links to international governmental organisations, such as the IEA and OECD has now been considered (this chapter). In particular, the OECD has been where most of the developed governments converge to assess, evaluate, and recommend STEM and STEM Education policies within national priority policy agendas. Noted was that policy agendas have included various issues, challenges and opportunities to address and support vision and strategy by a whole-of-

government approach through national administration of STEM (or STEAM) policy, often described as a global ecosystem of STEM policy. The next chapter has the methodological approach for this study.

Chapter 3

Methodology

This chapter describes the methodology of this study. It comprises a description of the context, the collected data, and the analytical methods. The methodology and its limitations are detailed, which includes the analytical outcome of the Conceptual Framework—as shown in Chapter 1 by Figure 1.1. The Chapter has four parts: Part 1: Exploring, defining, and framing the study Context; Part 2: Defining and collecting the data for analysis; Part 3: Analysis of the collected data; and, Part 4: Enhance the data analysis with an in-depth interview—in order to respond to the research question and sub-questions.

Research Aim and Question

As stated in Chapter 1, the purpose of this study is to understand how Government 'Primary STEM Education policy' is formulated for school-based implementation. A research question has been framed with three sub-questions for this purpose, as follows:

1.   How is Primary STEM Education policy designed for school-based implementation?

In order to answer this question, three framed sub-questions are:

    i.   What are the priority policies?

    ii.   What is the policy fidelity?

    iii.   How is Primary STEM Education policy framed for practice?

These questions lead the methodology of this study, which has four iterative parts.

About the Methodology

This study is concerned with understanding the nature or quality of Governments of Australia Primary STEM Education policy for school-based implementation. The methodology is designed in four parts, to generate and analyse online publically accessible and official Government STEM policy texts; and, to complete an in-depth interview using a case-study approach with an experienced National Government STEM policy administrator. In responding to the research question(s), the methodology is shown in Table 3.1.

Table 3.1

The methodology

Part	Strategy	Coding Method/s	
1	Explore, represent, and define the Context, which responds to the research questions.	1. 2. 3.	Word Line Axial
2	Explore, define, and collect data for analysis from the represented and defined Context.	1. 2. 3.	Word Line Axial
3	Analyse the collected data, by category, classify, define, and frame the online sourced and collected data as the analytical approach.	1. 2. 3. 4.	Word Line Axial Thematic
4	Expand and validate the analytical outcomes with an in-depth interview comprising a face-to-face voluntary interview with an experienced 'Primary STEM Education policy' administrator.	1.	Thematic

The methodology (above) is a qualitative approach with four coding methods employed to explore, analyse, and logically frame priority Government of Australia Primary STEM Education policy(s) formulated for school-based implementation. The approach is described as exploratory and integrative (see Dunn, 2015), which is defined in the next section. There are four selected data coding methods, which were used to iteratively and recursively filter, categorise, classify, and logically frame a priority policy from extensive Government texts (see Charmaz, 2014; Clarke, & Braun, 2014), which are explained further on. Finally, an interview, based on case-study methodology (Yin, 2014), is used to add rigor and reliability to the Researcher interpretation of these Government texts.

Methodology rationale.

As stated, this is a qualitative research methodology using an exploratory and integrative approach in a flexible and logical way, which is based on these definitions:

1. Exploratory— a research project is completed with a flexible and pragmatic use of research methods and techniques in order to interpret data and frame outcomes, which inform unique questions that have had little prior research (Jupp, 2006). Exploration is a form of discovery, which is concerned with the development of a rationale derived from data and its analysis rather than forming a hypothesis and framework at the outset of a study.

2. Integrative— the flexible and logical sequencing of discrete methods and techniques, which have been selected from more than one discipline (Dunn, 2015; King, Keohane and Verba, 1994; Yanow, 2014) in order to collect and analyse data from two or more discipline areas of research.

This study is interested in two 'disciplines' based on research questions, which have had little evident available academic research at the time of this study, and are:

1.   Political Science with regard to the study of Government policy; and,

2.   Education with relation to the specific study of school-based Primary STEM Education.

The methods and techniques from each that can be flexibly and generally applied are used and rationalised next. Thus, the two approaches are employed to:

1.   explore for a context and the data that informs about the policy on school-based Primary STEM Education; and,

2.   flexibly and logically integrate methods and techniques valid to both Political Science and Education in order to analyse and frame the data to inform outcomes, which respond to unique research questions without a prior informed hypothesis.

In order to effect an exploratory and integrative study, methodologies from Political Science and Education were reviewed and compared, which could support the two approaches explained above. On review, the Political Science use of Interpretive Policy Analysis (IPA), and Education's use of interpretive coding methods: *word, line, axial,* and *thematic* have employed these approaches to inform this methodology (i.e., IPA) and data analysis (i.e., coding and interpreting the data), which are described next.

Political Science.

 With regard to Political Science derived methodologies and theoretical frameworks, Interpretive Policy Analysis (IPA) has been identified to support policy analysis and the nature of this study (i.e., Exploratory and Integrative approaches). IPA is a methodology, which has been used to flexibly explore an uncertain context, and logically analyse text-based data (i.e., government policy documents, texts, and interviews) using a researcher selected mix and order of coding methods and techniques (Yanow, 2000). Using IPA, a context is explored and defined through the nature of the research question(s) based on the data collected and analysed. Analysed data informs the nature of the studied context, and the research question outcomes to be framed flexibly and iteratively.

As a methodology, IPA has been used to study an under-researched and unframed policy, and is understood to address and impact social and economic issues within a sector of society (i.e., Education, Health, and Social Security). IPA has flexibly accommodated frames of well-being, equity, and economic development from across a range of qualitative and also quantitative methods and techniques (Yanow, 2000). IPA accommodates studies where no predetermined framework is available and enables a researcher to develop a framework through the IPA methodology of data collection and analysis. Using a time and technique appropriate method of measure and/or interpretation, presentation of data outcomes is then possible. In this study, no Political Science framework was identified that supported the nature of the context and research questions. The required framework needs to be based on the quality of the policy dimensions and attributes (see Chapter 1 Figure 1.1), which are derived from the context (i.e. The Government of Australia). The formulation of policy should lead to sector-based (i.e., Education) implementation. Overall, IPA can be used where no prior hypothesis or framework on quality policy design has as yet been determined —thus supporting an exploratory and integrative approach to this study.

As notably described by Dunn (2015) and Yanow (2000, 2014), IPA is to be flexibly used by the order of the research activities, and the selection of coding methods and techniques, which best support the nature of the research question(s) and the type(s) of data collected to analyse policy and frame the quality of the dimensions and attributes for addressing specific cultural, social and economic issues within a sector (i.e., Education) in order to impact or progress social development.

IPA begins by an exploration of the context and for the data to collect (i.e., documents, artifacts, and/or interviews) from interested people and organisations whom are initially unknown and subsequently defined as the context by the researcher. IPA progresses a study by the themes and patterns that emerge from a constant, cumulative and in-depth analysis of the data with regard to a defined context of the study. Qualitative coding methods are flexibly selected and logically used to enable an analysis of government documents and

texts, which inform outcomes on the policy design and quality for specific impact within a social and/or economic sector (i.e., Education) of society. Therefore, IPA is a Political Science methodology enabling flexible exploration for data and insight to inform this study's research questions, and the flexible integration to the approach and selected use of coding methods and techniques with other disciplines (i.e., Education) to support and frame the outcomes of this study (which are explained across the four parts in this Chapter).

Education.

With regard to Education methodologies and on review of the international STEM policy environment, an example of a framed and rationalised Primary STEM Education policy for implementation was not evident. Similar to the rationale for Political Science, an exploratory and an integrative approach in order to flexibly analyse and frame the outcomes with regard to government policy formulation and the actions designed for school-based implementation became necessary and justified. Further, no prior study on this topic with a defined methodology and framework could be identified within the Education research literature.

Notably, Education research methods utilized by this study have predominately relied on Charmaz (2014) to apply four coding methods to complete a flexibly logical and interpretive data analysis, which also supported an exploration for the context and data informing a framed outcome through each research question. As stated, the methodology has four parts that were iteratively and recursively applied to complete this study, and each Education research coding method and their process is described as to how they were commenced and why they were followed to complete this study across the next four parts of this Chapter next.

Part 1: What is the Context?

As shown in Table 3.1 above, Part 1 of the methodology is to explore and integrate the analysis of data using methods from Political Science and Education from an uncertain context, which responds to the research questions through a conceptual framework that was not formed at the commencement of this study.

Open online search of The Government of Australia.

Part 1 of the research began by a search of official Governments of Australia websites to locate the portfolios, ministries and agencies of each National, State, and Territory portfolio, ministry, and agency/department, which have been administering Primary STEM Education policies for school-based implementation. The aim of this first step is to explore, define, and map the Context as the direct source of identified CoPs to collect and analyse data, and to source and conduct an interview. This online search began by using 10 key search 'terms':

1. STEM;

2. STEM policy;

3. STEM Education;

4. STEM (in) schools;

5. Primary STEM Education;

6. Government STEM policy;

7. Australian Government STEM policy;

8. Government STEM Education policy;

9. Government Primary STEM Education policy; and,

10. Australian Government Primary STEM Education policy.

These initial ten key word search terms were derived from the research questions. Various search engines were used including: Google; Google Scholar; and most of the Monash University Library data-bases (e.g., Australian Policies Observatory (APO); Data.gov.au; Informit; Libraries Australia). Numerous National and State/Territory Government websites were accessed and scanned— in particular the http://www.australia.gov.au/ was extensively searched using these key search terms and the search results were filtered and read based on the key search term results. The online search and subsequent analysis of the ten key search term results of official Government websites began by using the word method. The word method is a coding-based analysis of texts and documents based by identifying the existence and frequency of a key search word or term (Charmaz, 2014). Word method is defined as a

flexible qualitative coding method used to filter and select relevant information or data from amongst texts, which respond to the research question. This method was used by forming key words or terms derived from the research question (as indicated above) and then using them as key online search terms to explore the context for this study. The search result to a key search word/term from an official Government website was then highlighted and noted in relation to the source, and the type of data (which is explained further on).

Defining the Context.

Using the word method in this way, the Constitution of Australia (CoA) was located and read in order to define the context. The CoA defined a federal system of National, State, and Territory Governments forming from independent democratic elections of political parties. The federal system is comprised of three parts or interconnecting systems, which discreetly co-exist. Each part functions and organises or governs itself separately in serving for different purposes. The three parts are the:

1. Executive administration to serve on policy administration, and has a:

    i. National (/Federal); and,

    ii. Six States and two Territories.

2. Parliament to serve on policy enactment, which has a:

    i. National; and,

    ii. Six States and two Territories.

3. Judiciary to serve on policy enforcement, which has a:

    i. National; and,

    ii. Six States and two Territories,

This three part federal system of the Governments of Australia is shown in Appendix 4.

In this study, the first part of the federal system of Government, the Executive administration, is the 'Context' as it is responsible for policy administration, rather than enacting (i.e., the Parliament) or enforcing (i.e., the Judiciary) policy. Distinct from the Parliament and Judiciary parts of the Government, the Executive administration (Executive) has been

constitutionally defined to administer all policies or to produce, process and present (Althaus, et al., 2014) policies for school-based implementation.

The Executive produces, processes, and presents (or administers) policies from the Prime Minister (PM) and the Department of the Prime Minister and Cabinet (DPMC), which involves National (Federal) and State/Territory education ministers and agencies. Policies on Primary STEM Education have been administered directly by the National, and the six State and two Territory 'Education and Training portfolios', as follows:

> Australia does not have a single school system. Under the federal political structure, education is the responsibility of the eight states and territories. While schooling across the country has many commonalities, there are a number of differences that affect school operations. The situation is made even more complex by the existence of a substantial and growing non-government school sector, which enrols 33% of all students and encompasses a wide variety of school types. However, in recent years there have been significant steps towards achieving greater national consistency across the eight states and territories. Nevertheless, caution is needed in generalising across the diversity of Australian schooling. School governance and policy in most states and territories has traditionally been highly centralised. Two factors are reducing the degree of centralisation. First, non-government schools are growing rapidly, and while all non-government schools receive some public funding and have to meet registration requirements, they have a large measure of operational autonomy. Second, in the government school sector, there is a growing trend towards devolving decision making to principals and elected school councils or representative boards, though this is still limited in most systems. (Anderson, Gronn, Ingvarson, Jackson, Kleinhenz, McKenzie, Mulford, & Thornton, 2007, p.10)

From this description, the research continued with a similar approach to online website search for relevant data from various National and State/Territory Executive ministers and agencies comprising this context.

The CoA details how the State and Territory governments are responsible for schooling to all children (Australian Bureau of Statistics, 2012). These governments have the main financial responsibility for government schools and also contribute financial support to non-government schools. State and Territory governments:

> regulate school policies and programs, determine curricula, course accreditation, student assessment and awards for all government and non-government schools. State and Territory governments are also responsible for the administration and major funding of vocational education and training (VET) and for legislation relating to the establishment and accreditation of higher education courses.

> The Commonwealth government has special responsibilities in education and training for Aboriginal and Torres Strait Islander peoples, migrants, international partnerships in education, and providing financial assistance for students. It is principally responsible for funding non-government schools and higher education institutions, and provides supplementary funding for government schools and VET.

> EDUCATION REFORM AGENDA

> In 2008, the Council of Australian Governments (COAG) committed to a comprehensive education reform agenda for Australia. The agenda has impacts on education and training policy at all levels as part of broader reforms under the Inter-Governmental Agreement on Federal Financial Relations.

> Under the National Education Agreement, Australian governments have agreed to work together toward the objective that all Australian school students will acquire the knowledge and skills to participate effectively in society and employment in a globalised economy. (Australian Bureau of Statistics, 2012, para. 2-5)

While the States and Territories have CoA defined direct policy responsibility for school-based education, the National government is increasingly involved in framing and funding school-based education through national policy agendas.

Ultimately, no single website, document, or map was located to represent the portfolios, ministry, and agencies within this context to represent how the Governments of Australia have agreed to 'work together' to achieve the objective of the 2008 reform agenda, and so

these sources were subsequently mapped.

Mapping the Context.

In order to show and reference how Primary STEM Education policy is designed by the Context with regard to the responsible administrators by their portfolios, ministry, and departments/agencies, the Executive Government was explored and represented by a map. A map was necessary to visually represent and locate which portfolio, ministry, and agency has been directly administering policy designed for school-based implementation.

Three methods were used in to complete this map. The approach began by using the word method and the same 10 key search terms to once again thoroughly identify and highlight the resulting documents and texts, which were noted on the presenting or publishing ministry, portfolio, and agency. Each notated ministry, portfolio, and agency was then linked by referencing the Government website page entitled, 'Directory' (see https://www.directory.gov.au/portfolios), which was then categorized, recorded website links and formed as a visual map using Excel, an online mind mapping tool (Wisemapping.com) and Power Point in representing the organizational structure of Government designing policy for practice (the approach is explained further on). However, the hierarchy, portfolios, ministries, and departments/agencies were observed to change during the course of this study mostly because of changes made in Government leadership (which is made evident in the following chapters). To ensure currency of the data, this map was constantly updated during the study. Although, the map is static and limited to the data collected and analysed during 2016 and until June 2018. Thus, the Executive as a system that is evidently responsible in the administration of policy designed for school-based implementation was mapped, which is based on those portfolios, portfolio responsible ministries and departments/agencies in their observed hierarchy. The Executive was identified by highlighting the ten key search terms from the texts and documents resulting from the online search results using the following explained word, line, and axial methods by the approach.

As indicated above, the approach to completing this map involved the online scanning and reading of Executive Government websites. The webpages on the various Executive ministries, departments, agencies and portfolios were noted and recorded onto a Microsoft Excel spreadsheet on the type and form of data using the line and axial methods (explained further on), which had contained one or more of the word coded search terms. Specifically, the search results to the key term, *Australian Government Primary STEM Education policy,* were noted because of the relatedness to the research question. A small number of results occurred from this term in comparison with the other key search terms used (as listed above). Overall the number of search outcomes were noted in the thousands (approximately 33,430), which were scanned, filtered, and selected for analysis (see Appendix 5 for the sample of the recorded website search results).

Using Excel, Power Point, and a mind mapping online software tool, *WiseMapping.com*, each were used to record data and to help form a visual map of the Context based on the key search term results. WiseMapping.com is an online cloud based software tool to create and store interactive and http linked mind maps, which can embed web pages, link documents, notate documents, and export maps as SVG, PNG, and JPG, or store data.

As indicated, a 'defined map' of the National, State and Territory Executive ministries and agencies, using these key terms was searched for and unsuccessful. Creating a 'defined map' of the Context was necessary to progress and complete the research. This map was formed using the two additional coding methods, line and axial, to link the resulting online search term texts and documents to the portfolio, ministry, and department/agency. using Microsoft Power Point to construct the representative 'map', Excel to line code the data, and Wisemapping.com to axially code (explained further on) and store the data. With the texts and documents noted with key terms, linkages with the portfolios, ministries, and departments/agencies were necessary to understand how the Government designed policy for school-based implementation. So, the line and axial methods were used to form these linkages, which have been shown in Table 3.1 and are explained next.

The line method is defined as a qualitative coding method used to filter and select relevant information or data from amongst texts. This method was used to determine whether the word coded term was relevant to the study in addressing the research questions, the sentences that had contained one or more of the 10 above listed key search terms were read and highlight if relevant to the research questions. Relevant sentence where highlighted and recorded by copying and pasting this into an Excel document (Charmaz, 2014). The line method was used to establish the meaning and relevance of the highlighted key term/word in the sentence with regard to school-based implementation by the Executive.

These sentences were then notated with a description about and classified in relation to the: portfolio, ministry, and department/agency, and the type or form of data using the axial method using Wisemapping.com (which is explained). The axial coding method is a qualitative coding method used on word and line coded text and then *linking* it to the administering portfolio, ministry, and department/agency of the Executive. In this part, the axial method was used by selecting a word and line coded text or document and noting for the 'source' by linking and relating this data to the representing or responsible National, State or Territory portfolio, ministry, and department/agency to form the Context, which was completed as a 'mind map' with Wisemapping.com and Power Point to form a representative map (Charmaz, 2014). Thus, a search result to a key search word/term and the related meaning by the line coded sentence was linked to an official Government website, portfolio, ministry, and department/agency (through notation and diagrammatic representation of the source for each key word/line).

This mind map on completion in Power Point resulted in a map and is shown in Appendix 6 as the Map of the studied Context, from which the data was defined, collected, and analysed on how policy is designed for school-based implementation.

With regard to the Map shown in Appendix 6, the approach to the axial method informing this map occurred through scanning, reading, and Excel stored word and line coded texts and documents by reading through the search term results, for example, Primary STEM Education, and reading each result using the Word method to highlight the key term and note the:

1. date of the text/document;

2. record of the text/document website link;

3. ministry, and the ministerial delegated agency— The position within the Executive administration as either the National and or State/Territory, for example, the National Minister for Education and Training (MET), and the National Department of Education and Training (DET); or, the Queensland Minister for Education and Training (QLDMET), and the Queensland Department of Education (QLDDET);

4. National and State/Territory minister and agency linked portfolio— i.e., The National Education and Training Portfolio; and,

5. description of the word coded text— for example, a National Prime Minister STEM policy press release, National joint science and education ministerial STEM policy conference, and a QLD Education Department of Education and Training (QLDDET) STEM policy document using the line method to highlight the sentence that the key term was located; and,

6. drawing a linking line from and between each noted portfolio, ministry, and department/agency using the axial method in reference with the Government of Australia website page (as shown above) detailing the organization of Government.

As stated, the results were viewed from an extensive number of National and State/Territory Executive ministerial and agency websites. A search result with a highlighted key word/term was 'downloaded' as either a PDF document, 'screen printed' and saved into a file, or copied and pasted into Microsoft Excel or Word doc and filed based on the source. The http link of

this downloaded text or document was also copied and pasted into Excel and Wisemapping.com. For example, a highlighted text by the Department of the Prime Minister and Cabinet (DPMC) was either downloaded with the http link, or copied and pasted into an Excel spreadsheet and saved into a file, labelled 'National Government-DPMC'. This 'data' was stored on the Monash University secured Google shared drive. The http link was copied and pasted in Wisemapping.com and a note or the document was also recorded to form and show the position (i.e., the National, State, and Territory portfolio, ministry, and department/agency and their hierarchy) on the mind map constituting the Context, which occurred using Microsoft Power Point with the final version shown in Appendix 6.

As stated, the map of the studied Context is shown in Appendix 6. The map includes a description of the Governments of Australia's National, State, and Territory roles and responsibilities for school education derived from the constitution (see Appendix 6). This map is static and not interactive nor updated to reflect the various policy changes of the Government, which may have occurred following the completion data collection in mid-2017 at the time of this study. Ideally, an interactive online map could be produced and maintained of this Context to reflect the dynamic changes of the ministries and agencies, portfolios, and website texts observed, which is a limitation of this study. While, an interactive and updated online open access map of the Context is preferred, it is beyond the limits of this study and is a recommendation in Chapter 9. Thus, this map of the Government Context is the first contribution of this study, since a map was not identified previously to aid in sourcing and collecting data.

Part 1 summary.

In summary, Part 1 of the methodology involved defining and mapping the Context from which to collect and analyse data. This was completed by an online search of official Government websites using ten key search terms, and the results coded by three methods: word, line, and axial. The key search term results were categorized according to the portfolio,

ministry, and department/agency, and mapped using Microsoft Word, Excel, Power Point and Wisemapping.com. The results, organised in Excel and also Wisemapping.com, were around the:

1.   number of results of each of these key terms;

2.   http link; and,

3.   executive portfolio, ministry, department/agency as the 'source' of the accessible webpage text and/or document.

This information was filed and stored in the Monash University secured server. Using this map of the Context as the source for data, the data was then defined by type and form to collected and consequently analyse with regard to the research questions and inform the findings presented in Chapters 4, 5, 6, and 7, which occurred by the approach explained in Part 2 next.

Part 2: What is the Data?

As shown in Table 3.1 above, Part 2 of the methodology is to explore, define, and collect data for analysis from the represented and defined or mapped Context.

Exploring for Government policy data on Primary STEM Education by the mapped Context.

This part began by once again searching the official websites published and now mapped National and State/Territory Executive Government ministries and agencies or the Context. Given that the Context has been defined and mapped, exploration for data enabled omitting the key word 'Government' and thus using 5 instead of 10 key search terms at this point of the study, which are listed as follows:

1.   STEM;

2.   STEM policy;

3.   STEM Education;

4. STEM (in) schools; and,

5. Primary STEM Education.

These five key terms were used to complete an online search of the mapped Context for data to define by type and form to collect and analyse.

Using the word coding method, a third online search was undertaken, which included along with the official Government websites using the following research databases for the period 2015–2017 for a comprehensive and current search for Primary STEM Education policy data:

1. Eric;

2. ProQuest;

3. Google/ Google Scholar;

4. A+ Education;

5. ACER's library catalogue;

6. Education Research Complete; and,

7. Web of Science.

During the search of Government websites, policy texts and documents were often removed, changed, or updated, while the above-listed websites often had Government policy texts and documents that were not identified (i.e., A+ Education). These additional search engines were included to ensure that presented Government policy texts and documents were academically defined, thoroughly searched and located beyond official Government websites. In particular, a Government policy on Primary STEM Education did not exists as an all-encompassing single document (OACS, 2014), but was framed through several interconnecting texts and documents from across the mapped Context. Thus, a definition as to the type and form of a Government policy designed for school-based became the next essential task of this study to complete and progress toward an evidence-based outcome.

In the online searching of these databases, combinations of the five prior listed key-search terms were also used. As stated, the reason for this subsequent online search was for completing a research-based (i.e., derived from data collected and analysed from an extensive search of databases) definition of a Government policy, and for the form and type of policy data to collect and analyse, which is beyond that indicated from initial search of the databases of the Governments of Australia.

Approximately 1,194 policy texts or communications and documents were found by this search, which were constantly reviewed and filtered using the word method to highlight a key term and the line method to read sentences for relatedness to the research questions as described in Part 1 above. The texts with results based on word coding with one or more of these key terms highlighted, and the line coded sentences with relevance to each of the research questions were then axially coded around the following:

1. the number of results to each of these five key terms;

2. the http link;

3. the Context source; and,

4. notes describing how the source of the text is linked to the research question(s).

This information was filed and stored in the Monash University server using Excel, Wisemapping.com, and Word.

Each website of the various mapped National and State/Territory Executive ministries and agencies were re-searched using the same methods and approach explained in the prior Part 1. This was repeated in order to define policy based on the Context by the type and form of data to collect and analyse Primary STEM Education by the Governments of Australia, which has been designed for school-based implementation. Also, this search ensured a thorough and extensive search for policy data by the Context for analysis is completed by this study.

Using primarily the Google search engine and also the prior listed online databases, the five

key above listed search terms had over 1,194 results that were used to complete this

definition and the collection of Government policy data from the Context. To code these

texts and documents Microsoft Excel sheets, Word documents, Wisemapping.com, and

NVivo 10/11 were used and these files have been stored in the Monash University secured

Google cloud-storage server, as follows:

1. web page texts copied and pasted into word documents as tables and/or excel
   spreadsheets;

2. http links;

3. downloaded documents that included pdfs;

4. print screen shots of website pages with texts; and,

5. audio and visual recordings including YouTube site videos.

In summary the form of data for analysis that were sourced are:

1. Audio and video recordings including YouTube links;

2. Pdf documents; and,

3. Webpage texts.

These three forms of online texts and documents or the 'data' were collected and then further

classified and defined based on the type. These online texts were classified by type as either a

STEM policy communication or as a document, to become the main data type used in this

study.

Policy communications.

The first type of data collected was referred to as a STEM policy communication. A STEM

policy communication is a piece of text, visual or audio recording, which was published as an

announcement about a STEM policy by a minister or agency within this STEM context. For

example, the joint media release at the Press Club in December, 2015 by the Prime Minister

(PM) and Minister for Innovation, Industry and Science (MIIS) on *the National Innovation*

and Science Agenda (the NISA). Using Excel and Wisemapping.com, the text of this media release was:

1. categorised as STEM policy data for analysis to collect from within the mapped context; and,

2. classified as a data type by definition as a STEM policy communication.

This was the first type of data, which was collected for subsequent analysis.

The NISA media release was one STEM policy communication identified by searching online websites using the five key terms. To collect a STEM policy communication, each key term that had a search engine result was reviewed by reading and recording by these criteria:

1. a published STEM policy media based communication within the mapped context;

2. informed Primary STEM Education;

3. publically accessible online; and,

4. the Http link.

Each online search result with text featuring all of these criteria were collected and stored for further analysis.

Policy documents.

A policy document was the second and main type of text-based data, which was collected for analysis, based on this definition:

GOVERNMENT INFORMATION (PUBLIC ACCESS) ACT 2009 - SECT 23

What constitutes an agency's policy documents

An agency's "policy documents" are such of the following documents as are used by

the agency in quality with the exercise of those functions of the agency that

affect or are likely to affect rights, privileges or other benefits, or obligations,

penalties or other detriments, to which members of the public are or may

become entitled, eligible, liable or subject (but does not include a legislative

instrument);

(a) a document containing interpretations, rules, guidelines, statements of policy,

practices or precedents,

(b) a document containing particulars of any administrative scheme,

(c) a document containing a statement of the manner, or intended manner, of

administration of any legislative instrument or administrative scheme,

(d) a document describing the procedures to be followed in investigating any

contravention or possible contravention of any legislative instrument or

administrative scheme,

(e) any other document of a similar kind. (AustLII, 2009a, para.1)

A generic list of the types of the collected policy documents is outlined in Appendix 7.

One type of policy document included, *Statements of Expectations* (SoE). A SoE was used by a National portfolio minister to delegate policy priorities to a statutory agency. A SoE was one type of policy document (The National Treasury, 2014) through which a portfolio minister had delegated the administrative responsibility of a Government policy(s) to an agency:

Ministers are able to provide greater clarity about government policies and objectives

relevant to a statutory authority, including the policies and priorities it was expected to

observe in conducting its operations. The Statement of Expectations recognises the

independence of the statutory agency. (National Treasury, n.d, p.1)

For example, The Education Council (EC) has issued SoEs to Education Services Australia (ESA) on STEM Education policy priorities, each of which enable ESA to act an agency of

the Executive National Government through the Council of Australian Governments Portfolio (CAOGP) (EC, 2016) at the time of this study.

The EC's 2016, SoE, set out the ESA's work priorities and requirements, which was to administer the priority policies delegated to the COAGP by the PM and the DPMC. This SoE had four work priorities, which included; to design, develop and deliver curriculum, assessment and professional development services to education agencies. These education agencies were noted and mapped as the Australian Curriculum Assessment and Reporting Authority (ACARA), the Australian Institute for Teaching and School Leadership (AITSL), and the State/Territory Governments (EC, 2016). ESA was to maintain the ACARA website, provide support for the Australian National Curriculum (NC), and support and maintain the AITSL intranet and website with regard to STEM Education policy priorities.

Through this type of data the agencies were able to be linked as the source and their position shown with regard to Primary STEM Education primarily using the axial method and Wisemapping.com. For example, the context shows that both, ACARA and AITSL, are agencies of the National Education and Training portfolio (ET), which have held the delegated policy administration from the Minister of Education and Training. ESA's issued SoE was published or mandated by the Education Council from the COAGP. The COAGP has been a National based and State/Territory Government represented portfolio, which has to some extent used Intergovernmental Agreements (IA) to cohesively administer policies across the National and the State/Territory Governments. Thus, the policy framework through this type of data sourcing became further evident and formed the main data of the analysed datasets explained in Part 3.

A policy document was determined to be an appropriate type of data for analysis since it was the formalised practice in use by the context to influence school-based practice. Therefore, in this study, a STEM policy document was text in a document or online webpage with the detail on how the Government was to coordinate and comprehensively administer a Primary STEM Education policy for school-based implementation.

Part 2 summary.

In summary, this second part entailed defining and collecting the form and type of policy data produced, processed, and published (Althaus et al., 2014) by the Context comprising the main datasets of the analysis. This involved a second online search to include academic databases for policy presented by the Context. As shown in the map and in addition to the academic databases, each National, State, and Territory portfolio, ministry and agency website was re-searched using five key search terms as listed. Five key search terms (noted above) were used derived from the research question(s), and aimed to identify and define the data type to collect for further analysis. The Part 2 outcome is a definition of a Government policy in type and form that is linked to a responsible portfolio, ministry, and department or agency as to the data to collect and analyse. This data by form and type comprises of formalized policy texts published on academic databases and official Government of Australia websites and webpages as, audio and video recordings including YouTube links, webpage texts or screen prints, and pdf documents, which contained one or more of these five key terms. These online texts were classified as either a *STEM policy communication (C)* or a *STEM policy document (D),* which were then ready for Part 3, the main analysis of this collected data.

Part 3: Data Analysis

As shown in Table 3.1 above, Part 3 of the methodology is to analyse the collected data, by categorising, classifying, defining, and framing the online sourced and collected data as the analytical approach. Based on the five key-search terms relied on to define and collect the main data set-out in Part 2, Part 3 of this methodology is the analysis and subsequent

presentation of the outcomes to the three sub-questions and culminating research question. Notably, three priority Primary STEM Education policies were the only policies identified based on the research questions that were comprehensively framed with regard to the mapped Context (i.e., through using the three coding methods in an iterative and recursive way (Charmaz, 2014)) to progress the study with a peer-reviewed and accepted response to each research question. As stated, a formalized STEM policy framework was not located at the time of this study and necessitated the formation of one in order to represent and rationalize a policy administered for school-based implementation.

In Part 3, four coding methods were used to analyse the data defined and collected in Part 2, three Primary STEM Education priority policies were cumulatively identified and then categorized and classified according to descriptors that emerged of five dimensions and five attributes (which is explained in this part). During the analysis, a Primary STEM Education priority policy was framed based on the addition of the thematic method, which supported the development of the Conceptual Framework with five dimensions and five attributes to be derived from the data, and which have been shown in Chapter 1. An overview of the Part 3 analytical approach is presented in Table 3.2. For Part 3, Table 3.2 includes the action, method, technique, and strategy for the analysis of these data, an explanation of approach then follows.

Table 3.2

Data analysis steps

Action	Method	Technique	Strategy
1. Read text and highlight key words	Word (Charmaz, 2014)	Read, highlight and annotate each collected text or document, which had evidence of one or more of the key terms. Each text was read to locate a key term/word, and when identified was highlighted and noted on the published source, date published and the type of text (i.e., a STEM policy communication or documents). Wordcloud.com and Adobe.pdf viewer were used to assist in highlighting, counting and identifying the key terms. For example, the frequency of the term: STEM Education, and Primary STEM Education were highlighted in a text or document was recorded using Wordcloud.com. Frequency was useful for determining the extent that a document/text may be relevant to the analysis in comparison to the documents/texts sourced to collect and analyse, which inform a response to the research questions. Any references to Secondary STEM Education were discarded. Those texts/documents were compared in relation to frequency (number of occurrences of a single term) and extent of occurrence (where all key terms used) and were recorded based on	A heuristic approach to label and classify key words from reading for and noting the frequency and inclusion of key words in the collected data (Charmaz, 2014). To sort through the online search results for the data with relevance to the research questions of this study.

		results. While those documents without the word coded key term STEM and one or more of the four other key terms were removed for further analysis at this point.	
2. Re-read the filtered word coded data and highlighting the sentences, which feature the key term STEM and one or more of the other four terms.	Line (Charmaz, 2014)	Highlighting and labelling the sentences with a highlighted key term/word using Adobe.pdf viewer, Microsoft Excel and Word, and NVivo 10/11. NVivo 10/11 was used to store the collected texts/documents and to categorise highlighted/annotated texts into labelled groups along with similarly using Excel and WiseMapping.com (see below). On reading each sentence with a highlighted word, this sentence was categorised or cut and pasted into Excel and linked to the published source. A note was	To give the highlighted key term some meaning in relation to the Context and research questions.
3. Categorise and classify the word and line coded data in reference to the research question	Axial (Charmaz, 2014)	Re-reading the texts/documents to highlight the paragraph containing the word and line coded data. Each paragraph was then recorded using Microsoft Word, Excel, Wisemapping.com, and NVivo 10/11 software and linked to a noted interpretation of the paragraph text for school-based implementation. Each noted paragraph was grouped. A group was labelled based on the Context source of the text and on the similarities and differences with regard to the	A visual representation of the data by forming and labelling groups to show the similarities in paragraphs to research question(s) where word and line coded texts/documents

		research questions(s). This axially coded data was then progressed for a fourth and final method of coding for analysis.	were linked to the source. The strategy is to group the data in order to visualise the similarities and differences or to identify a pattern(s)/theme
4. Define, represent and explain how the context has designed a Primary STEM Education policy for school-based implementation	Thematic (Charmaz, 2014; Clarke & Braun, 2014)	Using the word, line, and then axial coded data, labelled datasets are formed based on noted themes. A theme is identified and noted based on a recurring pattern across the axially grouped data derived from the research question(s). A pattern(s) was thematically categorised and classified with a descriptor as well as the research question and sub-questions (using Wisemapping.com, Microsoft Excel, Word and Power point, and NVivo 10/11 software and manual notes). This software was used to show and record the thematically framed patterns within the axially coded data. The axial coded data was filtered, reduced, ranked according to National, State and Territory ministry, portfolio, department and agency, and framed into two sets of five thematic categories, which were labelled policy *Dimensions* and	To frame and rationalise a priority Primary STEM Education policy with regard to school-based implementation as designed by the mapped context.

show and rationalise a government policy on Primary STEM Education designed for school-based implementation (Saldana, 2014).

Action 1.

The analysis of the main data into datasets first began using the word method. This data was coded based on the frequency and extent that the five key search terms/words (listed in Part 2) occurred in a text/document. The word method was used first as an initial and inductive approach to the data analysis as described by (Charmaz, 2014). This involved reading all the texts of the collected data. For example, the *National Innovation and Science Agenda* (NISA) was a policy document, which was one of the online key term search results collected for analysis from the Government websites explained in Part 2. This document was read to locate, highlight, and rank one of the five key term/ word, as derived from the research questions. The terms STEM, STEM Education, and Primary STEM Education were ranked highest based on their frequency recorded in a communication or document and the extent to which all five terms were used.

This method was completed either manually using a highlighter, or online using a PDF editing software tool such as Adobe Acrobat. Since there was an extensive number of documents to code, an online software tool was used, which listed and ranked the key words based on their frequency within a text/document, which was WordCloud.com. Wordcloud.com was used to show the frequency and ranking of the five key search terms in this and each text/document. Wordcloud.com is an online software tool, which on entering a series of key terms/words searches through text and documents to highlight, list and rank the frequency of each term/word. This software enabled the extensive texts and documents to be efficiently filtered. A sample of word coded text using this software is shown in Appendix 8.

Microsoft Excel was used to record the text/document with the highest frequency and extent

of highlighted key terms with reference to the published source. For example, the NISA was

word coded and then noted in Excel as linking to the Federal Department of the Prime

Minister and Cabinet (DPMC) in the following manner:

> This publication should be attributed as follows: Commonwealth of Australia,
>
> Department of the Prime Minister and Cabinet, National Innovation and Science Agenda.
>
> (DPMC, 2015, pi)

Subsequently using this method, the Prime Minister and the Minister for Industry, Innovation

and Science were noted as the ministerial sources for the NISA, a STEM policy

communication or public release speech sourced from this link:

https://www.malcolmturnbull.com.au/media/launch-of-the-national-innovation-and-science-

agenda on December 7, 2015.

In Part 2, the DPMC was mapped as part of the context, and comprises the Prime Minister

and selected ministers who frame and set the agenda of the priority policies of the

Government of Australia. The NISA was the most current priority STEM and STEM

Education policy agenda document at the time of this study, based on the ministerial media

and document release date of December 2015. No further agendas were release during the

analysis of this study; however, a prior STEM and STEM agenda was also word coded,

the—*Industry Innovation and Competitiveness Agenda* (NIICA) (DPMC, 2014). Further on

in the analysis, the NISA was noted as building on and introducing new policies as detailed in

the NIICA.

Labels were constructed to link a word coded text/document to the source and type of data. For example, the NISA document was coded, DDPMC1, to represent the:

1. type of data collected, which was a STEM policy document by the first D of DDPMC1;

2. online source and context it was accessed from, which was the Department of the Prime Minister and Cabinet (DPMC) who published the NISA document (see the Map in Appendix 6 with the listed abbreviations); and,

3. number in the DDPMC1 labels the NISA document to distinguish it from amongst the many other texts/documents collected and published by the DPMC.

Labelling helps to identify and link the communication/document from amongst many of those presented by a particular portfolio, ministry, and agency of the Context. The word coded texts were stored using Microsoft Word and Excel files, and saved onto the Monash University secured Google share drive.

This method and the other three methods were conducted to point of saturation. Saturation, (Charmaz, 2014) refers to the point reached when no further variations were able to be identified, and repetition was experienced between the texts and documents. At saturation, a further method (i.e., the line method) was initiated. Saturation, based on variation and repetition, was reached through the process of:

1. reading for similarities and variations;

2. highlighting and noting codes that identified similarities and variances; and,

3. inductive and deductive questions on the similarities and differences in the order and frequency of key terms in a text.

Once all the collected data was analysed to the point of saturation using this method, a second layer of coding occurred using the line method.

Action 2.

The line method was the second coding method used to analyse the data, based on the explanation by (Charmaz, 2014). The technique involved highlighting the sentences from those texts/documents, which had a high frequency of a particular key term and extent of the five word coded key terms. This method was used after the word method to iterate and move the analysis forward once all the key terms in a text or document were highlighted. A text/document with the highest frequency and extent of key terms were re-read and all sentences containing a key term were highlighted and noted. A description was recorded with the highlighted sentence using Microsoft Excel and also Word in order to easily create a classification table from amongst these line coded texts (which is explained further on), which was linked to the responsible Government administrator or publisher (i.e., the portfolio, ministry, and agency), e.g., DDPMC1, and the online link that the communication or document was obtained.

On reading a highlighted sentence, a label was coded based on the relevance to the research question (Saldana, 2016). An example of line analysis is as follows:

> Requiring that new primary school teachers graduate with a subject specialisation, with priority for science, technology, engineering and maths (STEM). (DPMC, 2015, p.5)

This word coded sentence (see Action 1) was further analysed using the line method by cutting and pasting this sentence into a Microsoft Word document or Excel spreadsheet. This sentence was then described to inform a label based on the interpretation for school-based implementation, which was a *priority action*. The line method was used to describe the data in order to form labels, which categorize (dimensions and attributes) and classify (the descriptor of dimensions and attributes) the data. A sample of line code text, as described is in Appendix 9.

In summary, the line method enabled descriptions of a text, which linked with the context and the research questions. The line method was used to:

1.   move or progress the analysis, on from the word method; and,

2.   describe the data with relevance to the research question.

As, shown in Appendix 9, the line method was included to form descriptions, which can inform the labels categorizing and classifying the data with regard to the mapped context and the research questions. Once all the collected data was analysed using this method and saturation was experienced, a third layer of coding occurred to progress the analysis of the data.

Action 3.

To progress the data analysis, the axial method was the third coding method used to categorise, group, and link the data. Axial coding involved a set of procedures to form and make connections between categorised groups or datasets comprising the data (Charmaz, 2014; Strauss & Corbin, 1998). Following Action 1 and 2, axial coding relied on the sentence coded description, the situated paragraph, the context in which it is embedded, and the interactions. The outcome was five interacting policy dimensions and attributes, which were framed as part of the conceptual framework (shown in Chapter 1). Using this method, five dimensions were first framed in order to show an all-encompassing (OACS, 2013) Primary STEM Education Policy within the mapped Context.

Coding and framing the policy dimensions.

Initially, groups were formed by a process of coding the word and line coded texts. This occurred by re-reading these coded texts and highlighting the inherent paragraph. A categorization, and a classification descriptor code was given to each read paragraph based on the interpretation for school-based implementation, which was linked to the publisher of the

text. Through this process five categorisation and ten classification codes were consistently

evident (shown in Table 3.3 below) and formed the main codes.

Table 3.3

Policy dimensions

Context/ Data source		(Minister/Agency/Portfolio): PM/DPMC/National Department of the Prime Minister and Cabinet (DPMC) Data source/type: DPMCD https://www.innovation.gov.au/page/national-innovation-and-science-agenda (pdf)
Category	Classifier	Definition
Priority	Action	An evidence based plan of action that has regarded and benchmarked the international policy environment, which is a priority for school-based implementation. For example: Requiring primary pre-service teacher STEM specialisation. (NISA) (DPMC, 2015, p.5) Administered by the Government of Australia for school-based implementation (i.e., a communication and or document presented by the Prime Minister stating that the, above shown, action is a whole-of-government priority for implementation.
	Issue	The evidence-based and recommended challenge, issue, and/or opportunity to address as a priority to improve or support school-based practices. For example: There are obstacles we need to overcome… School students' maths skills are falling (DPMC, 2015, p.1) that the priority action addresses.
Purpose	Rationale	The evidence-based rationale of the priority policy, which is stated by the Government of Australia. For example: Jobs of the future will require a high level of technological literacy from all workers. Increasing the uptake of STEM subjects by students at school and improving achievement in

		this important area will ensure that all young people are prepared for jobs of the future. (DPMC, 2016, p. 9)
	Objective	A rationale statement included an objective(s), which is to be realised after implementation by an evaluative measure of the priority action through an initiative with a budget in addressing the challenge/issue/opportunity. For example: The education system must equip students to be successful entrepreneurs, hold a number of diverse jobs or work across a number of industries. (DPMC, 2015, p.12)
Research	Cited	The extent and relevance of industry-based research reports, academic research, and government commissioned research-reports or the evidence-base that has informed the determination of a priority policy, which has been cited (and references listed see the next classification descriptor). Evidence by citations include the priority action and issue; purpose rationale and objective; initiative and budget; and evaluative measure (listed in the next category or dimension). For example: Teaching quality accounts for 30 per cent of the variance in student performance…Research has shown that more explicit teaching of literacy and numeracy will result in improved student outcomes. (DPMC, 2016, p.8-9) which on analysis is built on and relied on by the whole-of-government.
	Reference	A public-accessible reference list of the evidence informing a STEM policy, which is inherent in a communication or document. For example: Australian Council of Learned Academies (2013). Snapshots of 23 Science, Technology, Engineering and Mathematics (STEM)

		consultants' reports: Characteristics, lessons, policies and programs. Retrieved from http://www.acolasecretariat.org.au/ACOLA/PDF/SAF02Consul tants/Consultant%20Report%20-%20Snapshots.docx.pdf. (OACS, 2013, p.33) which is administered using a whole-of-government approach.
Initiative & Budget	Project	A planned and budgeted project and/or program for school based implementation that links with the action, issue, purpose, research, and evaluative measure. For example: Publishing employment data such as the number of teachers in a school against each level (graduate, proficient, highly accomplished and lead) of the Australian Professional Standards for Teachers on the My School website. (DPMC, 2016, p.8-9)
	Funds	Ideally, the detailed budget including the allocation of funds to implement the various planned projects of programs. For example: In December 2015, the Government announced funding of $1.1 billion over four years for the National Innovation and Science Agenda. (DIIS, 2016, para.3).
Evaluative Measure	Outcome	The public accessible details on the STEM policy impacts by school-based implementation evaluated by research, which is used to build the evidence-base of priority policies designed for school-based implementation (i.e., to inform and recommend on subsequent policy). For example: The education system will provide all Australians with the capacity and confidence to make informed choices on complex matters where STEM offers options that have ethical, economic or environmental dimensions. The performance of

		our students in STEM disciplines will rank among the best of their international peers. STEM will sit equally alongside citizenship and literacy in the culture and curricula of Australian schools. (OACS, 2013, p.7) which on analysis is evident by a whole-of-government approach.
	Timeline	The stated timeline to evaluate the impacts of a priority STEM policy by school-based implementation, the outcomes of which are used to inform and build on the production, processing, and presentation of a priority policy by the Context. For example: *By 2025*. (OACS, 2013, p.7) which on analysis is evident by a whole-of-government approach.

These categorization and classification codes were framed and labelled policy dimensions, and used as the 'template' (represented by Table 3.3) to derive the final datasets from the axially and thematically (shown in Action 4) coding process. This process was used since no such policy framework was identified during this study, and was necessary in order to represent a priority policy for school-based implementation within the mapped Context.

These five categories formed the initial groups of data-sets, which were then each classified with a description based on the highlighted word, line, and paragraph from one published source and comparing this to another published source, to create a similar or different group within each of the five categories. The five groups with paragraphs were then given a classification description by reading the paragraphs of each group and noting a representative definition for school-based implementation, as shown above in Table 3.3.

Once all the line coded data had been re-read and highlighted on the paragraph with a code, all the codes were grouped and linked based on their similarities and differences using Wisemapping.com. On reading each paragraph, the extent and order was axially noted in

each coded group as shown in Table 3.3 to reflect a priority policy designed for school-based implementation, which was not evident in a single document but from across the collected texts and documents by this method. The five groups were labelled, ordered, and linked as *Policy Dimensions*, which was framed and used to form and link the datasets on the various National/Federal, State, and Territory portfolios, ministries, and agencies. A policy dimension was an axially derived code, comprising of one category and a two classification descriptors, based on the word and line coded texts situated within a paragraph of a communication or document sourced online, with regard to the Context. Wisepmapping.com, and Microsoft Word were used to record each paragraph and assign a code, which described the interpretation for school-based implementation. On completion five categories with inherent classification descriptors of policy dimensions emerged: *Priority, Purpose, Evidence, Initiative and Budget, and the Evaluative Measure*, which were linked to the Context and is depicted in Appendix 10.

Each category represented the interactions of policy-based datasets between a related ministry, agency, and portfolio. For example, the priority policy evident by the Prime Minister (PM), The National Department of the Prime Minister and Cabinet (PM), and the National Prime Minister and Cabinet Portfolio (PMCP). A policy dataset was based on the STEM and STEM Education policy communications and documents from this ministry, agency and portfolio comprising of these five policy dimensions, to show a priority policy for school based implementation from this section of the mapped context. This process was repeated for each 'section' of the mapped context, which formed and inter-linked the groups to frame each policy dimension as a 'template' of a priority policy, following the final thematic method of coding, by the datasets presented in Chapters 4, 5, and 6.

Each category or policy dimension was based, ordered, and interlinked primarily through the National policy priority agendas (e.g., the NISA) with reference to the National, PM, the DPMC, and the DPMCP, which was recorded as the definitive minister, agency, and portfolio to prioritize and delegate a policy for school-based implementation across the Government of Australia.

Coding and framing the policy attributes.

In understanding how The Government of Australia coordinated whole-of-government approach to a priority policy (OACS, 2013), five framed policy attributes were observed in the data and each were coded based on their interaction with the policy dimensions by the National, State, and Territory portfolios, ministries, and agencies. Based on reviewed research (i.e., Freeman, 2013; OACS, 2014) and a comparison of National and State/Territory data, five attributes were observed and coded, which are listed in Table 3.4 next.

Table 3.4

Policy attributes

Attribute	Definition	Strategy
Alignment	The matching of a priority policy specified by the PM, the DPMC, and the DPMCP with the national Education and Training ministers, agencies, and portfolio to the priority policies specified by the state/territory governments through to the state/territory education responsible ministers, agencies, and portfolios (Earley, 2005; Pieters, Dimkov, & Pavlovic, 2013).	Regard the interaction of each policy dimension by each national and state/territory education minister and agency with the concurrent national STEM policy agenda to show alignment for the intended Primary STEM Education learning and teaching practices to occur by school-based implementation.
Coherence	The systematic presentation of mutually reinforcing policies across government departments to create synergies towards achieving agreed objectives and to limit contradictions. Issues of policy coherence may arise between different types of public policies, different levels of government and between different stakeholders. Policy coherence is a process that takes into account the development goals in all policies, which have an impact on school-based Primary STEM Education. The purpose is to minimize inconsistencies between the policies by	Regard the interaction of each policy dimension by each national and state/territory education minister and agency with the concurrent national STEM policy agenda to show coherence by school-based implementation.

	the national, state, and territory governments by creating synergies between their education ministers, agencies and portfolios. The aim is to increase the effectiveness of school-based implementation to address priority issues and achieve objectives (European Commission, 2018).	
Continuity	The evolution of a priority policy from production to implementation, which evolves by evidence-based research to build and develop or change over the longer terms of the Government of Australia (Dunn, 2015). Continuity is required in order to produce incremental shifts that improve, and change the nature of a priority policy, which in turn improves the outcomes on implementation (Cerna, 2013).	Regard the interaction of each policy dimension by each national and state/territory education minister and agency with the concurrent national STEM policy agenda, to show evidence-based continuity of a priority policy by school-based implementation over the longer term regardless of the changes occurring within the Government of Australia, which recursively iterates such a policy across agendas.
Focus	The focal point of a priority policy that has a direct impact on implementation. The extent of focus that a priority policy has on the learning and teaching practices of Primary STEM Education within school-based implementation, rather than a limited focus or indirect focus. For example, a policy that is either based on an extensive evidence-base focussed on Secondary Primary STEM Education, political party values,	Regard the interaction of each policy dimension by each National and State/Territory education ministry and agency with the concurrent national STEM policy agenda, to show the evidence-based focus of each factor with learning and teaching Primary STEM Education through school-based implementation.

	or on industry reports on future economic development (Curtin, 2000).	
Scale	Based on the concept of scalability, policy scale is the ability of a priority policy to be efficacious on a small scale under controlled conditions, and through evaluative measures to be expanded for school-based implementation nation-wide, while retaining effectiveness (Milat, King, Bauman, & Redman, 2013).	Regard the interaction of each policy dimension by each national and state/territory education minister and agency with the concurrent national STEM policy agenda, to show the evidence-based scalability of each factor with learning and teaching Primary STEM Education through implementation by all schools, including efficacious learning and teaching practices/outcomes based on evaluation of the impacts.

By using policy dimensions as the template for grouping each National and State/Territory ministry, agency, and portfolio dataset derived by the word and line coded texts and documentations, each group was compared on the basis of policy fidelity or adherence to a whole-of-government approach of the policy for school-based implementation. In following the action and strategy shown in Table 3.4 above, the approach involved using a questioning framework, which is shown in Appendix 11. This approach coded five policy *attributes* of: *Alignment, Coherence, Continuity, Focus, and Scale* using Wisemapping.com, com to store or link the datasets, and Microsoft Word and Excel to show the coded texts with comparative variances on a policy dimension by a section of the Context.

Policy fidelity was rationalised by comparing the similarities and differences in the datasets to the hierarchical organisation of the mapped context. For example, the PM and the DPMC through the NISA document was noted as the leader of STEM policy with corresponding interaction with the National education ministers and agencies. Then, the National education agencies with the State/Territory education ministers and agencies. In summary, the axial

method involved grouping and inter-linking the data (Charmaz, 2014; Saldana, 2016) to show a visual representation of the data, in order to progress a frame for examining an all-encompassing and coordinated priority policy for school-based implementation by the Governments of Australia. At this point the framed policy dimensions and attributes were thematically coded.

Action 4.

The final layer of analysis, thematic coding was used to rationalize the axial coded datasets. Themes were identified as the priority actions that needed to occur in relation to school-based Primary STEM Education. Three themes were identified; Policy 1: Specialist STEM teachers, Policy 2: Students learning to code, and Policy 3: School partnerships with STEM organisations. These three policies were the persistent themes evident in the policy dimensions and attributes datasets across each of the sections of the mapped Context. The first noted theme was labelled Policy 1: Specialist STEM teachers, and was determined by comparing and contrasting the texts and documents grouped into the policy dimensions and attributes for a theme, which related to the research questions. For example, the National PM, DPMC, and DPMCP was recorded as the minister, agency, and portfolio of the mapped context, which had 'produced, processed, and published' the NISA. The NISA was coded as a framed dataset based on the five policy dimensions, and then linked to the State and Territory Governments using the attributes to understand how policy is designed by The Government of Australia for implementation.

The thematic method was used to rationalise the datasets by identifying themes or patterns, which responded to the research question. This method was used based on the definitions from Strauss (1987) and as explained by Boyatzis (1998), which regarded a flexible and recursive process of inductive and/ deductive questions on the axially coded datasets (Clarke,

& Braun, 2014). The thematic method was a repetitive process to define and describe the connected groups of clusters formed by the axial analysed data (Salana, 2006). For example, with the analysis on the NISA, the thematic method was used to develop an understanding of why the NISA document had prioritised 'requiring pre-service primary teachers graduate with a subject specialisation in STEM'. The questions used during this repetitive process as part of the analysis are shown in Appendix 11.

A phased process (Clarke, & Braun, 2014) was used to rationalise each theme, which were linked with the context to synthesize the data in presenting a response to the research question. In this study, the method involved five activities (Boyatzis, 1998; Klenke, 2016), which included:

1. writing a label that was based on the question— what was this to be labelled by questioning on why this was an action;

2. defining a theme pointing to its essence, for example; the innate characteristic, by questioning about how was this was intended to be defined and why;

3. describing how the theme was realised or experienced in relation to the context and sources of the study by questioning about how was this recognized and why;

4. describing the similarities and variances of the theme by the context and sources of the study—what was to be included and excluded about this, and questioned on why; and,

5. with regard to the research question and three sub-questions, sampling from the data was a representation of three themes, which were objectively synthesized to inform the response by continuous and extensive questioning — what was an example of this, and why?.

NVivo 10/11, Microsoft Word, and a notebook were each used to identify and record a theme.

Through the question protocols shown in the Appendices, three themes or priority policies were rationalized using the axial coded and policy dimensions and attributes, as follows:

1. Specialist STEM Teachers;

2. Students Learning to Code; and

3. School Partnerships with STEM Organisations.

Each policy was noted to have a rank or order of priority, which was linked to the current agenda of the Federal Government at the time of this study. Based on the extent of coded text, Policy 1, then Policy 2, and finally Policy 3 were the predominate themes, which could be formed based on the data. Thus, the outcome of this method were three defined, all-encompassing and relatively coordinated priority Primary STEM Education policies, which were 'in action' across the Governments of Australia for school-based implementation.

Part 3 summary.

In culmination of these methods, three themes were iteratively and recursively defined and framed relying on the axial coded datasets, the outcomes of which are presented in Chapters 4, 5, 6, and 7. Analysis of each of the three policies is presented across Chapters 4, 5, and 6. In each chapter, a priority policy is presented based on the National datasets. In Chapter 7, Policy 1: Specialist STEM teachers is used as the example to present an analysis of a coordinated policy based on the similarities and differences noted by the State and Territory Government datasets with the current National agenda. Thus, the analysis of the online sourced data was completed at this point, and the analysis was furthered with a case-study.

The approach and rationale for completing an interview is explained next.

Part 4: Interview influenced by Case-Study method

As shown in Table 3.1 above, Part 4 of the methodology is to juxtapose and validate the analytical outcomes with an interview relying on a case-study method, comprising a face-to-face voluntary interview with an experienced 'Primary STEM Education policy' administrator. Fitting with the IPA methodology (Yanow, 2014), a final or fifth method and with a third type of data was used to inform the completion of this interview—a single case-study (see, Yin, 2015) as a voluntary semi structured face-to-face interview with a leading National Executive administrator. The purpose of this interview, through case-study method, was to understand the personal insights from a figure central to the whole policy context on the formulation of a Primary STEM Education policy by the Governments of Australia in leading to school-based implementation. An identified leader was selected based on the position held and highest reference from the key word search terms results in the data. The approach has been outlined next in Table 3.5.

Table 3.5

Interview approach

Action	Method	Technique	Strategy
Completed an interview	Single case-study method (Yin, 2015)	Conduct a voluntary semi-structured interview with a national executive STEM policy administrator who is leading on how the context connects to Primary STEM Education. Compare the online sourced policy communication and document using the four coding methods to analyse the data with the directly sourced interview data for validation and to obtain further (juxtaposition) understanding in responding to the research question and sub-questions. Completed an interview from a person located from the online sourced data, who was thematically identified as a direct source to the 'production, processing, and presentation' of Primary STEM Education policy.	Validation of the three inherent themes by categorisation and classification as the policy dimensions, which emerged and their presentation as a priority STEM policy. Understand the quality or attributes of a policy based on the policy dimensions with school-based Primary STEM Education. An explanation by an interview with a direct source that was used to explain how the context links with regard to Primary STEM Education

The purpose for completing an interview using a case-study method was to check that the analytical outcomes from Parts 1, 2, and 3 were:

1.   credible;

2.   dependable; and,

3.   confirmable (Ary, Jacobs, Irvine, & Walker, D, 2018).

To validate and provide a juxtaposition of the online data analysis, a case-study method (see, Yin, 2015) influenced the interview method of data collection and analysis and hence is not regarded to be a case-study as defined by Yin. While missing strategies of notably multiple sources and interviews with this source as framed by Yin, the term interview has been interchangeably used with case-study for want of a better word to explain its purpose. A case-study is indicated because it is the analysis of a particular case of STEM policy, which is Primary STEM Education policy as formulated by the Governments of Australia. The Researcher emphasizes that there is more to case-study methodology than simply studying a case. Thus, elements of case-study methodology were employed in analyzing and framing the lived experience of a senior staff member (Henri— pseudonym) with prime ministerial responsibility on STEM and STEM Education policy of the Government in leading to school-based implementation.

Notably, the thematic method was primarily used to frame, compare and present the outcomes of the transcribed interview data.

A voluntary semi-structured interview was completed with a senior National Executive STEM policy administrator and leader (interviewee), who was identified from the analysis from the online sourced data. The identified interviewee was a National Executive administrator regarded as leader on the National STEM policy. The interview was based on a semi-structured protocol and a consent form, which was sent to and signed for consent by the interviewee and a copy securely stored according the Monash University ethical standards of research conduct, in response to the analysis of the online sourced data (see Appendix 13 for the interview protocol). The interview was conducted over 90 minutes and

the interviewee was allocated a pseudonym (Henri) for publication purposes. The audio-taped and transcribed interview became the basis on which a case-study (Yin, 2015) was created. The interviewee, on completion of the analysis of the transcribed data, was sent a copy to review and make further comments and amendments. On return and further review by the Researcher, final emailed approval from the interviewee to publish the final version of Chapter 8 of the 'case-study' was sought and granted.

The transcribed data was analysed using the same approach as described to the four coding methods, which featured using the thematic method to look for patterns as the themes to the data. These themes were noted as similar with the online data with a recommendation made on Policy 1: Specialist STEM teachers. The thematically coded sample of the interview data transcript using Microsoft Word is shown in Appendix 14. The case-study analytical outcomes are presented in Chapter 8.

Interview data analysis.

The case-study process was completed as follows:

1. transcribed the recorded interview;

2. read this text of the interview as a whole, and made descriptive notes based on the research questions;

3. word coding based on the key search terms found on reading through this text again for what it was about by highlighting each section;

4. re-reading and line coding the highlighted sentences and paragraphs with the key terms and noting themes, using a table format in Microsoft Word as the next source of coded dataset;

5. re-reading and axial coding noting on the relationships within the highlighted sections of text into this dataset in Microsoft Word;

6. re-reading and thematic coding by looking for the patterns within the descriptive codes found within the highlighted sections of text into this final analysed dataset in Microsoft Word;

7. compared the themes with the online sourced and similarly coded datasets; and,

8. presented each theme as the findings of this interview data based on the research questions.

This process was referenced from (Saldana, 2016), and (Yin, 2015).

Monash University Ethics Committee Approval and data storage

This research project involved human subjects to require approval by the appropriate committee of Monash University. Ethical approval was sought for this study and approval granted from the Monash University Human Research Ethics Committee (MUHREC) Research Office, CF16/881 2016000445 in 2016.

All data collected and analysed has been stored on Monash University's secure Google share drive, according to the MUHREC protocol.

Study Limitations

The limitations to this methodology and study are explained next.

This study used qualitative rather than quantitative methods similar to hermeneutic approaches, which have been relied on for policy analysis research (Yanow, 2014). As such, the Context from which the documents were able to be sourced was a limitation. The sourced data was limited to the Executive administration part of the Federal Government, while the parliamentary and judiciary parts, which may have relevant data, were not included by this study. The collected and analysed data was limited to publically accessible on-line National and State/Territory Executive Government ministry and agency website published texts, interviews (recorded as video or audio), and documents according to the methodological resources and a three year time limit afforded to this study. Data that was not publically available as a STEM policy communication or document was not analysed and may have had an impact on the outcomes.

Prior to 2010, all Prime Minister and Cabinet documents only became publicly available once they were more than 30 years old (National Archives of Australia, 2017). Since May 2010, by an approved amendment to the Archives Act 1983, public access to most Government records (including Cabinet records) was to occur after 20 years, instead of 30. This change was to be phased in over the subsequent 10 years until 2020. For example, from 1 January 2017 the Cabinet records for 1992 and 1993 were made available for the first time. The availability and types of STEM policy documents published by the context was limited to the extent of those made available according to this Archives Act.

Due to the complexity, dynamism, and extensive Government ministries, agencies, and portfolios that administer policy Government and without a formalized framework or single policy document detailing an all-encompassing and coordinated priority policy identified by this study, the ability to analyse, and map a priority policy was limited. Nevertheless, a total number of nearly 1200 documents were accessed and analysed in the way outlined in this chapter, and juxtaposed with a case-study on a notable National STEM and STEM Education policy leader. The analysis identified from the data that the National DPMC, EC, DET, Treasury, OACS and the various National and State/Territory education and training agencies had the most relevant text, which contained—*Primary STEM Education,* more-so than agencies such as the National IIS and PC. Due to this complexity and dynamism, those ministries, agencies, and portfolio with extensive and related data relevant to the research questions were relied on, rather than including all related data.

A single case-study by an in-depth interview rather than several case studies was completed, which may be considered a limitation. A single case-study was used due to the prominence and relatedness of the interviewee with the research aim.

This study has sourced data from the Governments of Australia, and reviewed OECD developed international STEM and STEM Education policies, rather than relied on data sourced from school-based practices of Primary STEM Education. This limited 'practice-based' data, was unintentional and occurred because of the intentional interest to understand

Government STEM and STEM Education policy, which has been 'produced, processed, and presented' for school-based implementation.

Summary

In-order to realise the study aim, the methods and approaches described were selected on their ability to collect data linked to the Context and related to school-based Primary STEM Education. The coding methods were selected and applied based on their flexibility and generalisabilty to explore Government websites, and then frame and rationalise a priority Primary STEM Education policy. The methodology is summarised in Table 3.6 next.

Table 3.6 Methodology

summary

Part	Strategy	Methods	Outcomes
Part 1	Define, show and relate the context of this study.	Word Line Axial	Defined and mapped context of the study, comprising the conceptual framework shown in Chapter 1.
Part 2	Define and collect the main data for analysis, which is derived from the Context.	Word Line Axial	Defined the type and form of data to collect and source for analysis as online Governments of Australia STEM policy communications and documents, about school-based Primary STEM Education.
Part 3	Frame and rationalise a priority Primary STEM Education policy for school-based implementation.	Word Line Axial Thematic	Framed five policy dimensions and attributes comprising the conceptual framework (see Chapter 1). Three priority Primary STEM Education policies, and policy fidelity presented in Chapters 4, 5, 6, and 7.
Part 4	Validate and juxtaposition the Part 2 and 3 outcomes with a second form and type of data, and additional analytical method.	Case-study: thematically code a transcribed a face-to-face recorded interview.	Case-study recommendation on and all-encompassing and coordinated Policy 1, presented in Chapter 8.
Overall	Understand the Governments of Australia Primary STEM	Word Line Axial	The Conceptual framework to present three priority Primary STEM Education policies, and

	Education policies for school-based implementation	Thematic Case-study	consider policy fidelity. A recommendation for an all-encompassing and coordinated priority policy framework on specialist STEM teachers for school-based implementation.

Sourced online from official Government websites, the main type of collected data was STEM and Education policy communications and documents, along with a semi-structured voluntary interview with a National Executive administrator about school-based Primary STEM Education. The main data was sourced online from each of the mapped National and State/Territory Executive minister and agency websites. The interview data was collected as a voluntary semi structured face-to-face interview with a noted and referenced National Executive STEM policy administrator using a case-study method. The analysis of the main data relied on strategies drawn from social-science research methodologies for policy and education analysis, which featured four coding methods: word, line, axial, and thematic to inform the outcomes of this study. Then, the analysis of the main data relied on a single case-study (based on Yin, 2015), which was constructed to authenticate and juxtaposition with the online sourced data outcomes.

In summary, the methodology comprised of four main parts, which were completed as:

1. defining and mapping the studied context;

2. defining, sourcing, filtering, and collecting the data;

3. analysing the primary data through four coding methods in an iterative and recursive approach to frame and present three priority Primary STEM Education policies, and their fidelity; and,

4. a case-study method as the basis to conducting and analyzing the interview and recorded interview transcribed data to accord the online sourced data analysis outcomes.

The data analysis was explained as using four coding, and a case-study method, which are as follows:

1. Word to code the data to five key search terms, notably *Primary STEM Education*;

2. Line to code the data, notably with this key terms a description on the sentence content and context;

3. Axial to group and connect the data to identify a pattern(s) to the ministry/agency /portfolio with formalised Primary STEM Education based on the key term/word and sentence content and context;

4. Thematic to define and describe pattern(s) by a categorisation or the five policy dimensions and attributes from the data on this word, line, axial, and thematic methods to parse or code the online sources data; and,

5. in-depth interview using a case-study method with data findings to compare and expand on the online sourced data to the research question response.

Thus, the methodology and the limitations were explained in-order to provide a conceptual framework. This framework has been used to represent and rationalise on an all-encompassing and coordinated priority Primary STEM Education policy, which occurs through the remaining chapters.

Chapter Close

This chapter has explained the methodology and the limitation of this study. Four parts formed the methodology to derive a conceptual framework of a mapped Context, three priority Primary STEM Education policies, and the nature of policy fidelity with regard to school-based Primary STEM Education in Australia. The research approach was an exploratory and integrative approach from two academic research areas (Political Science, and Education). The next three chapters present the analysis of the data through a presentation of each thematically defined Primary STEM Education priority policy. The

first of these is on specialist STEM teachers, Policy 1, which is presented in Chapter 4.

Chapter 4

Specialist STEM Teachers

This chapter is the data analysis of Policy 1: Specialist STEM teachers. As explained in Chapter 3, the online data have been analysed using the word, line, axial, and thematic coding methods. Guided by the research questions, five policy dimensions of *Priority, Purpose, Research, Initiative and budget, and the Evaluative measure* were evident. With examples from the coded data, the chapter sets out the analysis of this policy using these five dimensions.

Background

Following the research questions and the methodology, Policy 1 was found to contain the greatest amount of coded text. The five policy dimensions comprise:

1. *Priority*—*Action and issue*;

2. *Purpose*—*Rationale and objective*;

3. *Research*—Evidence-base by *citation and/or reference*;

4. *Initiative and budget*—For both the *projects/programs and funds*; and,

5. *Evaluative measure*—Of the *outcomes and timelines*.

Together and in this order, these dimensions offer insight into a priority Primary STEM Education policy. In culmination, the dimensions can be viewed as a proxy to the comprehensive nature or otherwise of a policy.

Policy 1: Specialist STEM Teachers

Dimension 1

Priority-action and issue.

Definition.

As indicated from the reviewed research and by the research questions, Specialist STEM teachers is a Government of Australia policy *priority*. *Priority* is a National Executive or DPMC defined and framed *action* to address an evidence-based and raised *issue* to a policy listed within a Government of Australia agenda. For example, the *National Innovation and Science Agenda* (NISA) as the current agenda at the time of this study has the *action* requiring pre-service primary teachers to graduate with a specialization with a priority for the STEM disciplines (DPMC, 2015). The evidence-based *issue*, which this *priority action* addresses, has been noted in Government policy documents as, learning to teach across all subject areas often left learning areas such as Science underdeveloped for primary teachers, which resulted in a lack of confidence in primary teaching Science and also Mathematics (TEMAG, 2014). Thus, a priority policy has begun to be framed by a National agenda *priority action* in response to a research-based *issue* of the Government of Australia, as explained through the following data.

Data.

A sample of the coded data related to Policy 1: the National priority is shown in Table 4.1.

Table 4.1

Coded Dataset: Priority

National Agency	Priority Action	Priority Issue
DPMC	"Requiring that new primary school teachers graduate with a subject specialisation, with priority for science, technology, engineering and maths (STEM) (DPMC, 2015, p. 5)" "Teacher quality…Work with state governments on the area of teacher quality" (DPMC, 2014, p. 47)	"There are obstacles we need to overcome… School students' maths skills are falling" (DPMC, 2015, p. 1) "Election commitment to restore the focus on science and mathematics in primary schools" (DPMC, 2014, p. 47)
OACS	"The Australian Government has announced that all future primary pre-service teachers will be equipped with at least one subject specialisation, including a priority on science and mathematics. In the short term, all primary teachers should have access to specialist STEM teachers as co-teachers, coordinators, mentors, and providers of sustained professional development" (Prinsley & Johnston, 2015, p. 5)	"Graduates report a lack of preparedness to teach STEM (Prinsley & Johnston, 2015, p. 1) Many students entering teacher training courses have not thrived in science, technology or mathematics in their own schooling" (Prinsley & Johnston, 2015, p. 1) "A minority of Australia's primary school teachers have an educational background in a STEM discipline" (Prinsley & Johnston, 2015, p. 5)
EC	"Increasing teacher capacity and STEM teaching quality" (EC, 2015, p. 6)	"Some primary school teachers lack confidence in teaching science and maths" (EC, 2015, p. 8)

National Executive Agencies

The Department of the Prime Minister and Cabinet (DPMC)

As derived by the DPMC, Policy 1 is evident through the document, *The National Innovation and Science Agenda* (NISA). On 7 December 2015, the NISA (DPMC, 2015) was released. On analysis, the NISA was the second Government of Australia policy agenda to present the policy priorities about 'Primary STEM Education'. The NISA comprises the list of priority policies designed to support on the document, *The Industry Innovation and Competitiveness Agenda* (the NIICA) (DPMC, 2014). While, the NIICA was the first identified agenda with priority Primary STEM Education policies, the NISA was the consequent and current priority policy agenda of the Government at the time of this study. Thus, this study has considered the NISA to the NICA, which informs Policy 1.

On analysis, the NISA document described a National policy priority as two inter-reliant classifiers. These priority classifiers were the:

1. *Action*—e.g., to require pre-service teacher specialization with a priority for Science, Technology, Engineering, and Mathematics (STEM) (DPMC, 2015); and,

2. *Issue*—e.g., the election commitment to restore the focus on Science and Mathematics teaching quality in primary schools (DPMC, 2014, p. 47).

Table 4.1 shows that there is an *action* on primary teacher STEM specialization (NISA) that supports and builds on teacher quality (NIICA action) through primary preservice teacher education. Also, the *issues* these actions address were defined in terms of students' declining skills in Science and Mathematics (DPMC, 2015), and restoring the focus on Science and Mathematics in schools (DPMC, 2014) informing this policy. As the basis of this chapter, Policy 1 *dimension* of *priority action and issue* are clear.

These *actions* show the different perspectives on primary specialist teachers as either STEM (as highlighted in NISA) or Science and Mathematics (which was the focus in NIICA), to address *issues* of student skills and teaching quality in primary Science and Mathematics Education. Policy 1 has been framed as specialist STEM teachers by a current *action* to address an *issue* on school-based Primary Science and Mathematics Education (the NISA), with regard to supporting a concurrent *action and is*sue (the NIICA). These *actions and issues* have therefore been established by the DPMC.

The policy dimension of ***Priority*** exists in two National agendas as:

1. *Actions*

    i. requiring that new pre-service primary teachers graduate with a specialization with a priority for the STEM disciplines (NISA) (DPMC, 2015); and,

    ii. working with State and Territory Governments on school-based teaching quality in Science and Mathematics (NIICA) (DPMC, 2014).

2. *Issues*

    i. the declining Science and Mathematics skills of school students (NISA) (DPMC, 2015); and,

    ii. the quality of Science and Mathematics teaching in primary schools (NIICA) (DMPC, 2014).

Similarly through the data, other National Executive agencies were also found, including the OACS.

The Office of the Australian Chief Scientist (OACS)

Analysing the OACS data identified a *priority action* that emerged as:

> The Australian Government has announced that all future primary pre-service
>
> *teachers* will be equipped with at least one subject specialisation, including a priority
>
> on science and mathematics. In the short term, all primary teachers should have
>
> access to specialist STEM teachers as co-teachers, coordinators, mentors, and
>
> providers of sustained professional development. (Prinsley & Johnston, 2015, p. 5)

This data highlights the OACS *priority action* as focusing on specialist STEM teachers as co-teachers, mentors…, which links with the DPMC (i.e., the NISA). The OACS has specified an *action* that all in-service primary teachers should have access to a specialist STEM teacher. The OACS *action* elaborates STEM specialists are school-based mentors and providers of professional development in the short term. The OACS reporting of the Government of Australia announcement includes a priority of specialisation for primary in Science and Mathematics, which is about in-service teachers and their access to specialists. In contrast, the DMPC has an *action* to 'require' pre-service primary teacher specialization with a priority in STEM disciplines. While there is little evidence of explanation for this difference, the OACS has placed more detail around the Government *action*.

The OACS stated several *issues* of support, which are:

1. Graduates report a lack of preparedness to teach STEM. (Prinsley & Johnston, 2015, p. 1)
2. Many students entering teacher training courses have not thrived in science, technology or mathematics in their own schooling. (Prinsley & Johnston, 2015, p. 1)
3. A minority of Australia's primary school teachers have an educational background in a STEM discipline. (Prinsley & Johnston, 2015, p. 5)

Therefore, these *issues* focus on primary teacher STEM Education and Training in relation to:

1. initial preparation of teachers;

2. prior academic achievement of teachers; and,

3. in-service primary teacher current workforce extent of educational background in STEM disciplines.

These *issues* cohere to the DPMC *action*. In comparison, the DPMC has limited coherence with the OACS *issues* by describing *issues* only associated with Science and Mathematics school-based teaching 'quality' and students' skills in these two areas. The NISA Policy 1 *priority* has focused on initial primary teacher education to prioritise for a specialisation in STEM Education, which extends their election commitment beyond Science and Mathematics. Similarly, other National Executive agencies comprised data linked to this policy including the Education Council (EC) of the Council of Australian Governments (COAG). Hence, the EC, which has been administering the *National STEM School Education Strategy* (NSSES) (2015).

The Council of Australian Governments (COAG) with the Education Council (EC)

The EC, *National STEM School Education Strategy* (NSSES) (2015), analysis identified the following *priority action*:

Increasing teacher capacity and STEM teaching quality (2015, p. 6)

However, no further *action* was able to be identified within the EC sourced data. This *action* is similar with that of the DPMC and OACS in terms of 'STEM' teaching quality. In contrast, this *action* of increasing teacher capacity has no further data identified.

While the *issue* was described as:

> Some primary school teachers lack confidence in teaching science and maths
>
> (Education Council, 2015, p. 8)

This *issue* is considered as cohering with the OACS, in terms of a focus on primary teacher confidence. However, this NSSES *issue* is focused on Science and Mathematics teaching, and has limited data on STEM teaching.

Priority: action and issue summary.

As the above data demonstrate, Policy 1 priority has two actions:

1. requiring pre-service primary teachers to graduate with a specialization, with priority in the STEM disciplines and more so Science and Mathematics, rather than also including Technology and Engineering; and

2. working with the State and Territory Governments on school-based Science and Mathematics teaching quality.

The priority *issue* to be addressed by these actions was:

1. effect an election commitment on school-based Science and Mathematics teaching quality;

2. students' declining skills in Science and Mathematics;

3. in-service primary teacher reportedly low levels of confidence to teaching Science and Mathematics; and,

4. In-service primary teacher reported limited educational backgrounds in Science and Mathematics by STEM Education and Training.

The Policy 1 priority action was noted in the current as well as in prior or concurrent National policy agenda of the Government of Australia, at the time of this study. Thus, rather than a

specialist primary STEM teacher, the discipline focus has changed to Science or Mathematics is the first priority action of this Government. The priority is designed to lead to school-based implementation of a Science and Mathematics Education, with limited data and focus on Technology and Engineering Education.

By analysis, two policy priority actions (STEM specialists graduate primary teachers and raising the quality of science and mathematics teaching) support four issues. The consideration of these actions and issues is as follows:

1. the election commitment was linked to a 2013 election policy list (The Coalition, 2014), rather than academic research focused on Science and Mathematics;

2. student's declining skills has focused on only on Science and Mathematics literacy by PISA and achievement by TIMSS assessment data, without similar research on Technology and Engineering;

3. primary teacher confidence levels have been based on reports (i.e., TEMAG, 2014) rather than being informed by contemporary and relevant academic research; and,

4. primary teacher education and training in STEM have been based on reports focused on Science and Mathematics rather academic research or the data on the primary STEM Education and training complexities of this workforce in Australia.

Pre-service primary teacher Science and Mathematics specialisation is the focus of Policy 1. Limited evidence was found on pre-and-in-service primary teacher specialisation on Technology, Engineering, or STEM as a transdisciplinary practice. Limited academic research was also found to have informed these actions and issues. Essentially, Policy 1 is focused on pre-service primary teacher education and training specialisation in Science and Mathematics to address an election commitment, international student academic achievement

and interest data, and Government-commissioned reports on low primary teaching Science and Mathematics capability and capacity.

Dimension 2

Purpose-Rationale and Objective.

Definition.

As indicated, Specialist STEM teachers is a Government of Australia policy priority with a *purpose*. *Purpose* is the DPMC stated *rationale and objective* of a priority policy listed within an agenda. For example, the Government of Australia has a *rationale* of improvement to the quality of life in Australia by more innovation and Science (DPMC, 2015). The *objective* linked with this statement, while often incoherent in policy communications and documents, is to increase innovation and Science learning and teaching quality.

Data.

A sample of the data showing the coded Policy 1: National *purpose* is in Table 4.2.

Table 4.2

Coded Dataset: Purpose

National Agency	Purpose Rationale Statement	Purpose Objective
DPMC	"A more innovative Australia will improve the quality of life of Australians across the country, from our cities and our regions, to our rural and remote communities. Every Australian will benefit from an agenda that puts innovation and science at the heart of government" (DMPC, 2015, p. 5)	"Our education system, therefore, must equip students to be successful entrepreneurs, hold a diverse number of jobs or work across a number of industries" (NISA) (DMPC, 2015, p. 12)
EC	"A renewed national focus on STEM in school education is critical to ensuring that all young Australians are equipped with the necessary STEM skills and knowledge that they will need to succeed. (NSSES) (EC, 2015, p. 4) Quality teaching is the key to lifting student engagement and performance in STEM Education. Teachers need to be equipped with the skills and confidence to support STEM learning. The rapidly changing nature of technology, and the importance of real world approaches to science education, makes this particularly challenging. Evidence suggests that some primary school teachers lack confidence in teaching science and maths, particularly where they have limited expertise in these content areas" (NSSES) (EC, 2015, p.	"Schooling should support the development of skills in cross disciplinary, critical and creative thinking, problem solving and digital technologies, which are essential in all 21st century occupations" (NSSES) (EC, 2015, p. 3) and "Increasing teacher capacity and STEM teaching quality" (EC, 2015, p. 8)
DET	"Reflects the educational priorities of the Australian Government" (DET, 2016a, p.	*Not evident*

National Executive Agencies

The Department of the Prime Minister and Cabinet (DPMC)

A *purpose* statement was highlighted in reference to the NISA and the coded *rationale* was as follows:

> A more innovative Australia will improve the quality of life of Australians across the country, from our cities and our regions, to our rural and remote communities. Every Australian will benefit from an agenda that puts innovation and science at the heart of government. (DMPC, 2015, p. 5)

This text was labelled Policy 1 National DPMC *purpose rationale*. This was the *rationale* coded on the *priority action and issue*. The Policy 1 *purpose* is that more innovation and Science benefits improves the quality of life of all Australians.

The NISA was then analysed for an *objective* derived of this *rationale*. In this document, four sections were noted with *objectives*. Of these four, one referenced STEM Education (the third one) by the title, Talent and Skills. However, an *objective* on the *priority action* and *issue* was unclear within this document and required further comparison.

As shown in Table 4.2, the coded NISA *objectives* from this section of, Talent and Skills, were that primary schools are to equip student to:

1.   be successful entrepreneurs;

2.   hold a diverse number of jobs; and,

3.   work across a number of industries.

Overall then, the Policy 1 *purpose* has the:

1.   ***Rationale*** statement that more innovation and Science benefits and improves the quality of life for all Australians; and,

2.   ***Objective*** for schools to equip students to be successful entrepreneurs, hold a number of diverse jobs, or work across a number of industries.

In understanding the DPMC policy agenda data, the NIICA was also analysed but no similar *purpose rationale* or *objective* was located with regard to this policy.

The Council of Australian Governments (COAG) Education Council (EC)

Expanding on the NISA, the *National STEM School Education Strategy* (NSSES) (EC, 2015), was analysed with regard to a *rationale* linked with to specialist STEM teachers. The *rationale* is that STEM education ensures young Australians will have the necessary STEM skills and knowledge to succeed. In addition, the EC *rationale* is that quality teaching is fundamental to increasing all students' achievement and interest in STEM Education with regard to contemporary practices of Technology and Science. Finally, the *rationale* indicates that some in-service primary teachers with limited content expertise have low confidence in teaching Science and Mathematics.

The EC NSSES objectives, to which this rationale was ascribed to, was that primary schools:

1.   support the development of skills in cross disciplinary, critical and creative thinking, problem solving, and digital technologies; and,

2.   enhance primary STEM teaching capacity and quality needs to increase.

The National Department of Education and Training (DET)

The National Department of Education and Training (DET) has the delegated STEM Education policy responsibility directly from the National Minister of Education and Training (MET). The MET is a member of the COAG EC and the DET is similarly responsible for the policy-based administration of the NSSES. Although, the DET's, *Department of Education and Training Corporate Plan 2016–2020* (DETCP) identified a *purpose* to "reflect [s] the

educational priorities of the Australian Government" (DET, 2016a, p. 6). Therefore, the DET

Policy 1 *purpose* was to link with the *purpose* in the NISA by the DPMC, and within the

NSSES by the EC.

Purpose: rationale and objective summary.

Overall, the policy documents were unclear in terms of a stated purpose and objective in

relation to requiring pre-service primary teachers to graduate with a STEM specialisation. So,

the rationale needed to be inferred from the current and prior National policy agenda along

with the EC, and DET concurrent documents in order to arrive at a rationale and objective for

Policy 1. The rationale is to benefit and better the future lives of young Australians with

innovation in contemporary technologies and scientific practices. The objective is for schools

to develop and increase all students' engagement and performance in STEM so that in the

future all students have the skills and capacities as successful entrepreneurs, to hold a number

of diverse jobs, and work across a number of industries. In addition, schools are to support

the teaching capacity and quality of Primary STEM Education.

This rationale is limited to Innovation and Science, and application to Technology,

Engineering and Mathematics has to be inferred. The objective is limited to students' future

work, for example as successful entrepreneurs in diverse industries and across many jobs.

Specialist STEM teachers are to educate students about Innovation and Science as successful

entrepreneurs of the future national economy.

Dimension 3

Research-Citation and Reference.

Definition.

Research is the evidence-base cited and referenced to a policy within an agenda. For

example, The Foundation for Young Australians in the National NISA agenda (DPMC, 2015)

is noted but is considered as a report rather than academic research. While, a

reference to this citation was not listed, references had been listed in prior agendas.

Data.

Table 4.3 illustrates a sample of the data coded as National *research* for Policy 1.

Table 4.3

Coded Dataset: Research

National Agency	Research Citation	Research References
DPMC	*Not evident* on this policy. However, a highlighted paraphrase as: "The Foundation for Young Australians predicts that today's young people will hold as many as 17 different jobs, in five different careers" (NISA) (DPMC, 2015a, p. 12) Limited or indirect cited paraphrasing noted to the OACS (2014) within the (NIICA) (DPMC, 2014)	*Not evident* (NISA) (DPMC, 2015) Referenced (NIICA) (DPMC, 2014)
PC	*Not evident*	*Not evident*
EC	"Melbourne Declaration on Educational Goals for Young Australians (MDEGFYA, 2008); OACS (2014). (EC, 2015, p. 3); Australian Government, Industry Employment Projections 2015 Report; ABS Perspectives on Education and Training: Australian qualifications in STEM, 2010-11, Cat. 4250.0.55.005; and, PricewaterhouseCoopers (PWC), A Smart Move: future-proofing Australia's workforce by growing skills in STEM (2015)." (NSSES) (EC, 2015, p. 4)	Referenced

National Executive Agencies

The Department of Prime Minister and Cabinet (DPMC)

The NISA document noted *Research* through paraphrase (below), which is a form of

Citation:

> The Foundation for Young Australians predicts that today's young people will hold as
>
> many as 17 different jobs, in five different careers, over the course of their working
>
> lives. (DPMC, 2015, p. 12)

The extent of *research* coded for Policy 1 was this single *citation* from an unreferenced

report. The NISA did not include a *reference* section. Therefore, the evidence was limited to

the paraphrasing of a report. By comparison, the NIICA (DPMC, 2014) evidence was *cited*

and referenced by the OACS (2104). Overall, the policy through the NIICA has an evidence-

base that was limited in academic research terms and largely drew on industry-based and

Government commissioned research reports. For example, reports of the ABS, IEA, OACS,

OECD, and the PC were cited and included in the reference list. The use of a *citation* was

included on the OACS (2014) research report as follows:

> Australia's performance in mathematical literacy in schools has fallen in absolute and
>
> relative terms. Of the countries tested in 2003, only five significantly outperformed
>
> Australia in mathematical literacy. By 2012 we were outperformed by 12 countries.
>
> Around 40 per cent of our Year 7 to 10 mathematics classes are taught without a
>
> qualified mathematics teacher. The paper includes 24 recommendations across a range
>
> of areas, including competitiveness, education and training, research and international
>
> engagement. (DPMC, 2014)

This *citation* was based on the OACS (2014) commissioned *research* rather than academic

research to inform policy within this agenda and indirectly links with Policy1. Academic

research pertaining to primary students' skills or achievement in STEM was not evident.

On analysis, the NIICA reference list included the following samples:

ABS. (2014a). Australian Industry, 2012-13, cat. no. 8155.0. Australian Bureau of

Statistics. Canberra: Commonwealth of Australia.

ABS. (2014b). Australian National Accounts, cat. no. 5206.0. Australian Bureau of

Statistics. Canberra: Commonwealth of Australia.

ABS. (2014h). International Trade in Goods and Services, cat. no. 5368.0. Australian

Bureau of Statistics. Canberra: Commonwealth of Australia.

Cornell University, INSEAD and WIPO. (2014). Global Innovation Index 2014 Report: The

Human Factor in Innovation. Fontainebleau, Ithaca and Geneva: Cornell

University, INSEAD and WIPO.

Governor of New York. (2013, August 28). Governor Cuomo Announces Public-Private

Partnerships to Prepare More Than 6,000 Students for High-Skill Jobs. Retrieved

September 2014, from https://www.governor.ny.gov/press/08282013Students-

for-High-Skill-Jobs.

International Education Advisory Council. (2013). Australia – Educating Globally.

Canberra: Commonwealth of Australia.

OECD. (2012a). Better Skills, Better Jobs, Better Lives: a strategic approach to skills

policies. Paris: OECD.

OECD, ILO, IMF and World Bank Group. (March 2014). Achieving stronger growth by

promoting a more gender-balanced economy. OECD, ILO, IMF and World Bank

Group.

Office of the Chief Scientist. (2014). Science, Technology, Engineering and Mathematics:

Australia's Future. Canberra: Commonwealth of Australia. Productivity

Commission. (2014c). Productivity Update 2014. Canberra: Commonwealth of

Australia.

World Economic Forum. (2014b). The Global Competitiveness Report: 2014-15.

Geneva: World Economic Forum. (DPMC, 2014, p. 94-105)

The NIICA has a list of research-based reports rather than academic research featured within the reference section, thus limiting the influence of *research* on Policy 1. The DPMC NISA and NIICA did not have data that could be coded as academic *research by citation and in a reference section*. However, the NIICA cited and featured a reference section that detailed limited research-based reports that could be attributed to this policy as indicated by the list above.

An online search of Federal agencies with DPMC delegation or commission to conduct research, located the DPMC 'delegated peer-reviewed research agency', which was noted as being the Productivity Commission (PC).

The Productivity Commission (PC)

The Productivity Commission (PC) (one of five agencies within the Treasury Portfolio), research-based documents were analysed. The Treasurer, pursuant to Parts 2 and 3 of the Productivity Commission Act 1998, requested that the PC complete peer-reviewed research into the National evidence base for school education (PC, 2016). However, following application of the four coding methods (see Chapter 3) no *citations or references* on specialist STEM teachers were evident. Overall, this report illustrated that the extent of *research related* to a priority 'Education' policy was limited, which in turn limited the impact on improving school-based teaching quality.

The Council of Australian Governments (COAG) with the Education Council (EC)

The EC's NSSES was analysed with regard to *research* by *citation* and a *reference* section. In the NSSES, two uncited paraphrases were noted:

> Evidence suggests that some primary school teachers lack the confidence in teaching science and maths, particularly where they have limited expertise in these content areas (EC, 2015, p. 8)
>
> Quality teaching is the key to lifting student engagement and performance in STEM Education. Teachers need to be equipped with the skills and confidence to support STEM learning (EC, 2016, p. 8).

A *reference* section was included in the NSSES, and shown in Table 4.3, and similar with the DPMC in featuring non-academic reports.

The EC has paraphrased and included a reference section to suggest that *research* to inform Policy 1 was limited to research-based reports, rather than academic research. In addition, the NSSES reports were predominately from National Government agencies and a financial sector organisation.

Research: citation and reference summary.

The Policy 1 *research*-base was analysed for academic research, with limited findings of National Government agency and financial sector reports. Notably, the OACS (2014) research-based report was specific on the policy priority with the action on specialist STEM teachers and issue of student skills in Mathematics and Science literacy. Also, teacher confidence in Mathematics and Science has been noted from Government commissioned research-based reports (i.e., TEMAG, 2014), rather than academic research. Finally, the PC as the independent research-based Government agency on policy was noted with limited

research. Interestingly, a PC (2016) report on the education system found that priority

policies have had limited research and consequently limited outcomes.

Overall, *Research* was (often without citation or references listed) from Government

commissioned and industry-based research reports, and did not include academic research in

the evidence-base.

Dimension 4

Initiative and Budget-Projects and Funds.

Definition.

The *initiative and budget* is the DPMC statement on the various *projects* and the allocation of

funds to a policy within an agenda. For example, the *initiative* to build on the key measure of

requiring pre-service primary teachers to graduate with a specialization with priority for

STEM or Science and Mathematics through associated or focused *projects* and allocation of

funds from within a detailed budget (DPMC, 2015).

Data.

Table 4.4 offers a sample of the data coded by *initiative and budget* for Policy 1.

Table 4.4

Coded Dataset: Initiative and budget

National Agency	Initiative Project (and Programs)	Budget (Allocation of funds)
DPMC	Unspecified, however noted and attributed to the NIICA policy as a built on and supported policy (NISA) (DMPC, 2015a, p. 5); and, "Working with the States and Territories on a national STEM School Education Strategy." (NISA) (DMPC, 2015, p. 12)	*Not evident* in the imbalanced and bundled $1.1B budget. (NISA) (DPMC, 2015, p. 16)
Treasury	*Not evident* (Treasury, 2016)	$1.2B or $927.6M (imbalanced/bundle) (Treasury, 2016)
DET	"Activities to improve initial teacher education courses in Australia as recommended by the Teacher Education Ministerial Advisory Group (TEMAG) in its 2014 report, *Action Now: Classroom Ready Teachers"* (DET, 2015a, p. 13); and, "The Department and AITSL continue to support implementation of the Government's reforms to improve the capability of the teacher workforce based on the recommendations of the Teacher Education Ministerial Advisory Group (TEMAG) report. In December 2016 all education ministers, through the COAG EC, committed to developing the national Initial Teacher Education and Teacher Workforce Data Strategy to assist with workforce planning and assess the outcomes of initial teacher education" (DET, 2017a, p. 34)	*Not evident* in the $16.9M. (DET, 2015b) (a bundled budget)

National Executive Agencies

The Department of the Prime Minister and Cabinet (DPMC)

The NISA did not include details on a *project* or the *funds* to build on the requirement that pre-service teachers graduate with a STEM specialisation. Although, a set of eight new projects and funds were described in order "to ensure young people have the skills they need for the future" (DPMC 2015, p. 12). However, all eight *projects* shown in the *budget* were unrelated to this 'requirement'. In fact, the NISA allocation of *funds* to these new *projects* and the corresponding *budget* were irreconcilable.

The Treasury's related budget documents were then analysed to identify how (or whether) the DPMC had delegated the NISA with an *initiative and budget* on this priority policy.

National Treasury

Treasury collected budget documents on a linked *initiative and budget* was the National 2016-2017 Budget that had an allocation of $1,200,000, (over four years, from 2018 until 2020) to support Government and non-government schools improve literacy and numeracy, teaching and school leadership—"to lift student outcomes" (National Treasury, 2016, p. 80). Though Figure 4.1 (next) shows that the funds were allocated to the DET over three years and totaled $927,600,000— a 2016-2017 discrepancy of $272,400,000 and one year.

Figure 4.1

National Treasury DET Budget 2016-2017

School Funding — additional funding from 2018

Expense ($m)

	2015–16	2016–17	2017–18	2018–19	2019–20
Department of Education and Training	–	–	102.2	306.1	519.3

The Government will provide an additional $1.2 billion over four years from 2017–18 to provide further funding support for government and non–government schools for the 2018 to 2020 school years. Total school funding will be indexed by an education sector specific index of 3.56 per cent, with an allowance for changes in enrolments.

The additional funding will be based on the principles of being needs based, stable, simple, fair, transparent and is contingent on financial effort by the States and Territories and education reform by all sectors including improving literacy and numeracy, teaching and school leadership, and accountability, to lift student outcomes.

Image retrieved from: http://www.budget.gov.au/2016-17/content/bp2/html/bp2_expense-10.htm

In comparing these *budget* papers, a *project* and allocation of *funds* on pre-service primary teacher specialization with a priority for STEM was unable to be fully identified. Further, how the difference of $272,400,000 (and the loss of one year that was identified within the 2016-2017 document) was to be administered was equally indeterminable. Therefore, analysis shifted to the DET.

The National Department of Education and Training (DET)

An *initiative* of lifting the quality of initial teacher education with a *budget* of $16,900,000 was noted that indirectly linked with the prior shown DPMC and Treasury data listed in Table 4.4. This DET Budget Statement details a *project* for improving pre-service teacher education courses as recommended by TEMAG (Teacher Education Ministerial Advisory Group) (TEMAG), which was formed and commissioned to complete a research-report on teaching quality in Science and Mathematics by an *initiative* within the NIICA.

TEMAG (2014) had 38 recommendations related to the quality of teaching in schools. Of these, Recommendation 18 was that pre-service primary teachers graduate with at least one subject specialisation, prioritising Science, Mathematics or a language. This recommendation did not include an *initiative or budget* with focused programs and allocation of funds for school-based implementation. The DET (2016b) Budget Statement did not have a *budget* to allocate *funds* to this TEMAG recommendation(s), nor was there the evidence to build on the DPMC's NISA requirement that pre-service primary teachers graduate with a specialisation with a priority for STEM. The DET had limited data showing an *initiative and budget* to build on this key measure. Rather, the DET had data to show an *initiative and budget* for lifting innovation in pre-service primary teaching Science and Mathematics programs.

Initiative and Budget: project and funds summary.

The *initiative* to build on the key measures of requiring pre-service primary teacher to graduate with a specialization with a priority in STEM, and to work with the States and Territories on the NSSES had no stated *budget*. Rather, pre-service primary teachers graduate with at least one subject specialisation, prioritising Science, Mathematics or a language was noted within a *budget* of $16.9 million to support the activities recommended by TEMAG. The data shows that there is a limitation and disconnect with the agenda by the *initiative* and *budget*. The DPMC did not specify how the key measure was to be built on or budgeted.

Dimension 5

Evaluative Measure- Outcomes and Timeline.

Definition.

The *evaluative measure* is the DPMC statement on the policy *outcome(s)* and the t*imeline* within an agenda. For example, the Government of Australia has an *evaluative measure* that all pre-service primary teachers have a specialization with a priority for STEM or Science and Mathematics by 2020 based on the current (NISA) agenda (DMPC, 2015).

Data.

Table 4.5 shows a sample of the data coded as *evaluative measure* for Policy 1.

Table 4.5

Coded Dataset: Evaluative Measure

National Agency	Evaluative Measure Outcome(s)	Evaluative Measure Timeline
DPMC	*Not evident* on the action to: "Requiring primary pre-service teacher STEM specialisation" (DPMC, 2015, p. 5)	*Not evident* from the imbalanced budget timeline of: 2015- 2019 (DPMC, 2015, p. 12)
DET	"Classroom readiness includes the ability for new teachers to effectively teach core subject areas, such as literacy, mathematics and science ... We will instruct AITSL to use course accreditation arrangements to require universities to make sure that every new primary teacher graduates with a subject specialisation. Primary teachers with a subject specialisation will complement the teachers they work with by sharing their expertise and skills" (DET, 2015a, p. 8)	*Not evident*
AITSL	"Successfully delivering the Government's response to TEMAG, measured through progress against the agreed work plan" (AITSL, 2016a, p. 3); "The requirement in the accreditation standards that all primary teaching graduates have a subject specialization is being addressed by providers and is mostly unproblematic – although some jurisdictions have concerns to be worked	December 2015 (AITSL, 2016b, p. 1) "A report of our performance against these measures is provided to the Board every six months as part of the company's organisational performance measures … Progress against the work plan is reported to the Minister through the Department of Education and

through." (PTR Consulting Pty Ltd, 2017, p. 4); and,

"The accreditation standards require that all primary teaching graduates have a specialisation in a learning area of the Australian Curriculum. Most authorities and employers see that this has been relatively easily agreed in principle and preparation is underway. Providers generally see that it is their responsibility to structure their course offerings accordingly and for many it is an opportunity and unproblematic. A few jurisdictions regard implementation as an unresolved challenge. There are concerns that the requirement will essentially be interpreted as leading to a greater focus on science, technology, engineering and mathematics (STEM) to the detriment of a broader spread of capabilities; that local needs for skilled generalists in rural and remote areas could be ignored and that state based priorities also need to be taken into account. The overall view however is that any concerns will be settled through further dialogue at the local level and with reference to how other jurisdictions are adapting the accreditation standards." AITSL – TEMAG Evaluation: Stakeholder perspectives on progress. (PTR Consulting Pty Ltd, 2017, p. 12).

Training on a quarterly basis. We also provide a report on progress against the work plan to the AITSL Board at each meeting, as well as to Education Council every six months." (AITSL, 2016c, p. 3)

National Executive Agencies

The Department of the Prime Minister and Cabinet (DPMC)

The NISA stated *evaluative measure* on Policy 1 was analysed. An *evaluative measure* by an *outcome and timeline* was unspecified despite the *action* indirectly informing the *outcome*, as follows:

1. all pre-service primary teacher graduates with a specialization with a priority for STEM; or Science and Mathematics; and,

2. the National Government working with the State and Territory Governments on the area of teaching quality.

An *evaluative measure* is unspecified by the DPMC but could perhaps be inferred by the priority *action and issue* policy dimension. A *timeline* was also inferred by the NISA budget, which was shown as 2015 to 2019.

The National Department for Education and Training (DET)

The DET stated its support for 38 recommendations of TEMAG (2014). In a response document, the DET noted the following:

> The Government will instruct AITSL to develop a framework for the robust and consistent assessment of teacher education students throughout the duration of their course. AITSL will be asked to set clear expectations that assessment must be continuous, based on the Graduate level of the Australian Professional Standards for Teachers, and focused on school student learning. AITSL will also guide universities and schools in how teacher education students should be supported including what they should collect as evidence of their classroom readiness. This will help teaching graduates demonstrate to prospective employers that they have the knowledge and

skills essential for teaching. AITSL will also work closely with states and territories and non-government schools to develop a nationally consistent approach to the induction and support of beginning teachers to make sure they reach their full potential once they enter the profession. Classroom readiness includes the ability for new teachers to effectively teach core subject areas, such as literacy, mathematics and science … We will instruct AITSL to use course accreditation arrangements to require universities to make sure that every new primary teacher graduates with a subject specialisation. Primary teachers with a subject specialisation will complement the teachers they work with by sharing their expertise and skills. This does not mean primary teachers will teach only in their area of specialisation, but rather that their expertise will be available within the school to assist other teachers with the knowledge and expertise to teach the subject effectively. (DET, 2015a, p. 8)

This data shows that the DET had an *outcome* linked to the *action* (shown in Dimension 1 above by the DPMC). By the DET instructing AITSL to frame pre-service primary teacher education course accreditation standards requiring subject specialization, an *outcome* is evident. Although, this teacher education framework is not specific to STEM as transdisciplinary, rather it is subject based and directed at Science and Mathematics. A *timeline* for this instruction has not be found in the DET data.

The Australian Institute for Teaching and School Leadership (AITSL)

AITSL has been the agency responsible for the quality framework of Primary STEM Teacher Education, Training, and Practice. An AITSL *outcome* was stated as follows:

Successfully delivering the Government's response to TEMAG, measured through progress against the agreed work plan. (AITSL, 2016a, p. 3)

AITSL is linked with the *action* on pre-service primary teacher specialisation and has evidence of an *outcome* that is similar with the DET rather than the DPMC. The *outcome* is to deliver the Government's response to TEMAG (2014). This response is measured through progress on an agreed work plan. Thus, the *outcomes* are featured in the AITSL work plan.

The AITSL work plan *outcome* and *timeline* include that:

> Subject specialisation requirements included in course accreditation requirements
> • Timeline – December 2015 (AITSL, 2016b, p. 1)

This *outcome* and *timeline* was reported as completed by AITSL. Therefore, Policy 1 (from an AITSL perspective) has been 'completed'. However, 'completed' was also followed by the 'comment' that:

> Requirements are reflected in the revised accreditation standards and procedures which were endorsed by the Education Council on 11 December 2015. Further work underway to support implementation. (AITSL, 2016b, p. 1)

The AITSL statement of completion suggests that there is further work 'in action' to support school-based implementation of Policy 1, which has been endorsed by the EC. Therefore, State and Territory Government endorsement of the AITSL framework for pre-service primary teacher education courses to require graduate specialisation is complete. Yet, the AITSL framework required further work for implementation. Further work pertains to how the various States' and Territories' teacher registration and professional standards agency frameworks viewed this National framework and had prioritized STEM discipline specialisation.

Further, the process of the *evaluative measure* was also located in the, *Corporate Plan 2017-2020,* and the *Annual Report 2016-2017* with:

> A report of our performance against these measures is provided to the Board every six months as part of the company's organisational performance measures … Progress

against the work plan is reported to the Minister through the Department of Education

and Training on a quarterly basis. We also provide a report on progress against the work

plan to the AITSL Board at each meeting, as well as to Education Council every six

months. (AITSL, 2016c, p. 3)

AITSL has shown an *evaluative measure* by an *outcome*, i.e., delivering the response to

TEMAG on requiring pre-service primary teacher education specialisation in a discipline.

The *timeline* for this *outcome* was based on periodic, quarterly and six monthly, performance

reports to December 2015, which was noted as 'completed' and with 'further work on

implementation'. This timeline of reporting is on an agreed work plan and reported to the

AITSL Board, MDET, DET, and EC. The Government TEMAG response included that the

AITSL and State/Territory education agencies work together - a report of *outcomes* was

summarised in Table 4.5.

Evaluative Measure: outcome and timeline summary.

The *evaluative measure* to effect the key measures of requiring pre-service primary teachers

to graduate with a specialisation with a priority in STEM, and to work with the States and

Territories on teaching quality had no evident *outcome(s)* or *timeline(s)*, and was inferred by

the NISA stated *action* and the *budget* timeline of 2015-2019 (DMPC, 2015). While, the DET

had a statement of inferred *outcomes* directed to AITSL that was focused on pre-service

specialization, but without a priority on STEM nor a timeline evident. AITSL, on these DET

directed outcomes, had evaluated and reported that the "requirement in the accreditation

standards that all primary teaching graduates have a subject specialization is being addressed

by providers and is mostly unproblematic – although some jurisdictions have concerns to be

worked through" (PTR Consulting Pty Ltd, 2017, p. 4), and "a few jurisdictions regard

implementation as an unresolved challenge. There are concerns that the requirement will

essentially be interpreted as leading to a greater focus on science, technology, engineering

and mathematics (STEM) to the detriment of a broader spread of capabilities" (PTR Consulting Pty Ltd, 2017, p. 12). The data shows that there is a limitation and disconnect with the National agenda by the *evaluative measure*. The DPMC did not specify how the key measure was to be evaluated for impact as to the intended *outcomes* and by when through a *timeline* for implementation nation-wide.

Overview of Policy 2

Table 4.6 offers an overview of the data by the five dimensions for Policy 1.

Table 4.6

Policy 1: Specialist STEM Teachers

Australian Government STEM Education Policy Context: Priority Policy Dimensions	
Priority Policy 1: Specialist primary STEM teachers	
1. *Priority*	*Action:* "Requiring that new primary school teachers graduate with a subject specialisation, with priority for STEM or Science and Mathematics" (DPMC, 2015, p. 5) "Teacher quality…Work with state governments on the area of teacher quality" (DPMC, 2014, p. 47) *Issue*: "There are obstacles we need to overcome… School students' maths skills are falling" (DPMC, 2015, p. 1) "Election commitment to restore the focus on science and mathematics in primary schools" (DPMC, 2014, p. 47)
2. *Purpose*	*Rationale*: "A more innovative Australia will improve the quality of life of Australians across the country, from our cities and our regions, to our rural and remote communities. Every Australian will benefit from an agenda that puts innovation and science at the heart of government." (DMPC, 2015, p. 5) *Objective(s)*: *Not evident* and designed to: "Our education system, therefore, must equip students to be successful entrepreneurs, hold a diverse number of jobs or work across a number of industries." (NISA) (DMPC, 2015, p. 12)

3. *Research*	*Citation*: *Not evident* on this policy. However, a highlighted paraphrase as: "The Foundation for Young Australians predicts that today's young people will hold as many as 17 different jobs, in five different careers" (NISA) (DPMC, 2015, p. 12) Limited or indirect cited paraphrasing noted to the OACS (2014) within the (NIICA) (DPMC, 2014) *Referenced*: *Not evident* in the current agenda(NISA) (DPMC, 2015) *Referenced:* Referenced in the prior and concurrent agenda (NIICA) (DPMC, 2014)
4. *Initiative &* *Budget*	*Project(s): Not evident*, however noted and attributed to the NIICA policy as a built on and supported policy (NISA) (DMPC, 2015a, p.5); and, "Working with the States and Territories on a national STEM School Education Strategy." (NISA) (DMPC, 2015, p. 12) *Funds*: *Not evident* from the imbalanced and bundled $1.1B budget. (NISA) (DPMC, 2015, p. 16)
5. *Evaluative* *Measure*	*Outcome(s)*: *Not evident* on the *action* to: "Requiring new primary pre-service teacher specialization with a priority in…STEM" (DPMC, 2015, p. 5) *Timeline(s)*: *Not evident* from the imbalanced budget timeline of: 2015-2019 (DPMC, 2015, p. 12)

Chapter Close

This chapter presented the findings derived of analysis of the five *dimensions* from the online sourced data on the priority policy 1: Specialist STEM Teachers. Briefly, that analysis can be summarized as:

1. *Priority action* to require pre-service primary teachers to choose to graduate with a specialization with a priority in STEM, began by the NISA (DPMC, 2015), which builds on the NIICA action(s) on Science and Mathematics teaching quality (DPMC, 2014). Then, the OACS had a differing action focused and that elaborated on in-service Science and Mathematics teacher specialists. While, the EC had an action to work with the States and Territories on STEM teaching capacity and quality without further explanation evident on pre-and-in-service teaching. The National action has disconnection from the DPMC on pre-service teacher specialization prioritizing in STEM with the OACS on in-service teacher support in Science and Mathematics Education by specialists, and EC unclear on how States and Territories are working on STEM teaching capacity and quality across the primary teaching workforce.

    The linking National *priority issue* is on students' declining skills in Mathematics and Science (i.e., the NISA) based from international assessment data i.e., PISA and TIMMS. Also, to address an election commitment on teaching Science and Mathematics quality in schools (i.e., the NIICA). While, the OACS clarified issues that included graduates report a lack of preparedness to teach STEM, students entering teacher training courses have not thrived in Science, Technology or Mathematics, a minority of primary school teachers have an educational background in a STEM discipline. Alongside, the EC has stated the issue of primary teacher confidence to teach Science and Mathematics. The

Government of Australia action is considered limited and disconnected by the National Government ministries and agencies to the disciplines of Science and Mathematics rather than to STEM, and the teaching workforce of a focus on pre-service teachers by the DPMC and in-service teacher by the OACS. In concert, the issue is considered limited and disconnected by the National Government ministries and agencies to the Science and Mathematics skills of students, and an election commitment to focus on Science and Mathematics teaching quality (DPMC), with the quality and confidence of the teaching workforce in Science, Technology, and Mathematics, rather than to STEM (EC and OACS);

2.   *Purpose* that the DPMC has framed in the NISA is, specialist STEM teachers will support students' innovation and entrepreneurship for an improved quality of life. The *objective* of this *rationale* is that students will have innovation and entrepreneurship skills that improve and benefit quality of life in the future. The EC has rationalized that a renewed National focus on STEM in school education is critical to ensuring that all young Australians are equipped with the necessary STEM skills and knowledge that they will need to succeed, and quality teaching is the key to lifting student engagement and performance in STEM Education. The DET has a purpose of reflecting the Government's priorities with no further evidence of linked objectives. The National Government ministries and agencies have disconnection on the *purpose rationale* specialists to support student's innovation and entrepreneurship (NISA), with a focus on STEM in schools ensures students have the necessary STEM skills and knowledge to succeed (EC), and reflecting the Government's priorities (DET). Similarly, the objective(s) have National Government ministry and agency disconnection, since it was not evident by the DPMC in the NISA;

3. *Research* –base that was paraphrased without a *citation* and not *referenced* in the current National agenda (NISA) on an industry-based research report by The Foundation for Young Australians. Government commissioned and industry-based research reports was cited and referenced in the NIICA (the prior agenda). The evidence-base of Research informing a priority policy is considered limited by the extent or use of academic research, which was not evident in the National data;

4. *Initiative and budget* that was unspecified and irreconcilable. The initiative and budget is considered as limited with the projects and funds on how to require pre-service primary teachers choose to graduate with a specialisation in STEM. While limited, the DET had an indirectly related initiative and budget focused on the Governments' response to TEMAG (2014) on an AITSL university framework to require pre-service primary teacher specialisation with priority to Science and Mathematics; and,

5. *Evaluative measure* that was also not evident and indirectly implied to the NISA action (shown above) and the budget *timeline* of 2015 to 2019. While limited, the DET in direction to AITSL specified *outcomes* on primary teacher specialization without a priority on STEM. AITSL has indirectly related an outcome and timeline of December 2015 on the Governments' response to TEMAG (2014) by an AITSL university framework to require pre-service primary teacher specialisation without statement on the priority to STEM. This evaluative measure was stated as 'complete' with ongoing unresolved work in some States and Territories for implementation. Based on the DET and AITSL data, this evaluative measure is on requiring pre-service primary teacher specialization,

without a priority on STEM and is not according to the implied nationally

presented action.

The next chapter continues with the data findings on a second major theme highlighted as,

Policy 2: *Students learning to code*.

Chapter 5

Students Learning to Code

This chapter is the data analysis of Policy 2*: Students learning to code*. Guided by the research questions, five policy dimensions of *Priority, Purpose, Research, Initiative and budget, and the Evaluative measure* were evident and are used to further examine this policy. Similar to the previous chapter, examples from the coded data sets are the basis of the analysis of Policy 2 through these dimensions.

Background

Policy 2 contained the second largest amount of coded data derived from the publicly available material. The five policy dimensions comprise:

1. *Priority—Action and issue*;

2. *Purpose—Rationale and objective*;

3. *Research*—Evidence-base by *citation and/or reference*;

4. *Initiative and budget*—For both the *projects/programs and funds*; and,

5. *Evaluative measure*—Of the *outcomes and timelines*.

Together and in this order, these dimensions are used as an analytic frame for examining the second priority Primary STEM Education policy.

Policy 2: Students learning to code

Dimension 1

   Priority-Action and Issue

   Definition.

As indicated across the analysed policy documents, Students learning to Code stands out as a Government of Australia policy priority. This is illustrated by, for example, the stated priority *action* that 'all students embrace the digital age by learning coding and computing' (DPMC, 2015). The evidence-based *issue,* which this priority action addresses, was noted in Government policy documents as 'too few students are learning computing in schools' (DPMC, 2015). Thus, this priority policy began to be shaped and framed by the National priority action in response to an issue as explained through the following analysis of the data.

   Data.

A sample of the data showing the coded Policy 2: the National priority is shown in Table 5.1.

Table 5.1

Coded Data set: Priority

National Agency	Priority Action	Priority Issue
DPMC	"Support all Australian students to embrace the digital age by promoting coding and computing in schools (DPMC, 2015, p. 4) Supporting the teaching of computer coding across different year levels in schools "(DPMC, 2015, p.4) "The Government will foster further student engagement with… (STEM)." (DPMC, 2014, p. XIV)	"Too few Australian students are studying science, maths and computing in schools – skills that are critical to prepare students for the jobs of the future" (DPMC, 2015, p. 4) "A key foundational requirement is that we have people with sound basic STEM capabilities." (DPMC, 2014, p. 46)
EC	"The strategy has identified five key areas for national action through which school education has the greatest leverage. Increasing student STEM ability, engagement, participation and aspiration" (EC, 2015, p. 6)	"Students early interest in STEM is not translating to ongoing engagement and participation in STEM Education… they don't necessarily understand the relevance of STEM Education, particularly maths" (EC, 2015, p. 8)
OACS	**"Inspirational Teaching** strong stem teaching at all levels, supported by high quality and relevant teacher training and subject-specific professional	"We need a reliable pipeline of specialist STEM skills; but we also need informed workers, users and consumers who have

development…increased numbers of subject-qualified STEM teachers in Australian schools **Inspired Learning** a core STEM education for all students—encompassing inspirational teaching, inquiry-based learning and critical thinking—placing science literacy alongside numeracy and language proficiency as a priority." (OACS, 2014, p. 20)	curiosity and imagination to be part of the broader STEM economy." (OACS, 2014, p. 23)

National Executive Agencies

The Department of the Prime Minister and Cabinet (DPMC)

As derived of the DPMC (2015), Policy 2 is evident through the document, *The National Innovation and Science Agenda* (NISA), which was the current National STEM policy agenda at the time of this study. As stated in Chapter 4, the NISA has the list of new priority policies intended to support and build on those stated within *The Industry Innovation and Competitiveness Agenda* (the NIICA) (DPMC, 2014). Policy 2 was noted in the NISA and within the NIICA (the NISA had precedence in informing this priority action and issue). The Policy 2 priority action was derived from the relationship between the following two statements:

> Support all Australian students to embrace the digital age by promoting coding and computing in schools. (DPMC, 2015, p. 4)
>
> Supporting the teaching of computer coding across the different year levels. (DPMC, 2015, p. 4)

The *priority action* is therefore to support students to engage with digital technologies by promoting coding and computing in schools. While, the NIICA (DPMC, 2014) noted *action* of supporting the teaching of computer coding, was noted as the action that was 'built on and supported' by this NISA action (DPMC, 2014). This NIICA priority action was to "assist to develop and implement the 'Coding across the curriculum' programme" (DPMC, p. XIV). Interestingly, this NIICA action built on a prior action for "a review of the Australian Curriculum" (DPMC, 2014, p. XIII). Hence, the Policy 2 action of supporting all students to embrace coding in schools is the most current policy priority action to build on all previous STEM policy agendas (i.e., the NIICA, 2014) of the Government of Australia.

The *action* addresses the *issue* often noted as being:

> Too few Australian students are studying science, maths and computing in schools – skills that are critical to prepare students for the jobs of the future. (DPMC, 2015, p. 4)

The stated STEM priority issue focused on Science, Mathematics and Computing rather than Technologies and Engineering. This issue builds on the NIICA issue, (see Table 5.1), relating to the international economic competitiveness of countries through 'essential' STEM skills. This policy has a similar focus on Science and Mathematics as Policy 1: Specialist STEM Teachers. Although, this policy considers Computing an essential STEM skill, without clarifying which of the four disciplines this skill resides. Based on the data (as exemplified in Table 5.1), the Policy 2 *priority issue* is limited in focus to Coding, and has been noted as inherent to the Technologies discipline within STEM Education rather than Science, Mathematics, and Engineering or as a transdiscipline.

The priority that all primary students learn to code is designed to address concerns about future international economic competitiveness of Australia. This *priority action and issue* was determined by the DPMC, and was noted as a new policy in the NISA, building on a

previous policy priority action and issue within the NIICA. Other National Executive agencies were similarly noted in terms of this policy, including the Education Council (EC).

The Council of Australian Governments (COAG) with the Education Council (EC)

Analysis of the EC's STEM Education strategy policy document (NSSES) identified the following Policy 2 action:

> The strategy has identified five key areas for national action through which school education has the greatest leverage. Increasing student STEM ability, engagement, participation and aspiration. (EC, 2015, p. 6)

This data shows the how EC NSSES further prioritised the DPMC policies for school-based implementation of all National agenda actions to five areas. These priority areas were stated to be based on the Melbourne Declaration on Educational Goals for Young Australians (MDEGYA) (2008). The MDEGYA had an action that schooling should support the development of skills in Digital Technologies. Essentially, the EC was therefore prioritising all National policy actions, which included students learning Coding, Computing, and Digital Technologies in schools drawn on the MDEGYA rather than the DPMC. Specifically, the EC *action* was that students were to learn Digital Technologies with increased ability, engagement, participation, and aspiration, rather than Coding specifically.

Furthermore, the EC stated that:

> Students' early interest in STEM is not translating to ongoing engagement and participation in STEM Education … they don't necessarily understand the relevance of STEM Education, particularly maths. (EC, 2015, p. 8)

The EC therefore had a different issue compared to the DPMC; i.e., students' early interest in STEM Education or Mathematics Education largely based on the view that the relevance of STEM was not understood by students. In contrast to the DPMC, the *issue* is the relevance of

STEM and, more so, Mathematics rather than all students learning to Code. While the OACS (2014) report informed both the DPMC and EC in relation to this policy, there are clear differences between these issues. DPMC identifies the issue as relating to skills, while EC identifies the issue as one of relevance and the usefulness of these disciplines areas.

The Office of the Australian Chief Scientist (OACS)

Analysis of the OACS (2014) identified the following priority action:

> **Inspirational Teaching**
>
> - strong STEM teaching at all levels, supported by high quality and relevant teacher training and subject-specific professional development
> - increased numbers of subject-qualified STEM teachers in Australian schools
>
> **Inspired Learning**
>
> - a core STEM education for all students—encompassing inspirational teaching, inquiry-based learning and critical thinking—placing science literacy alongside numeracy and language proficiency as a priority. (OACS, 2014, p. 20)

This data shows the *action* as supporting inspirational STEM teaching by a high quality and relevant Primary STEM Teacher Education and Training, which interacts with inspired STEM learning from a core STEM Education placing Science Literacy as a 'new priority'. This action implies that Coding may be a specialist learning area of a core STEM Education, with a lesser priority compared to Science Literacy, Numeracy, and Language proficiency. The OACS has limited data on students learning to code, and indicates that it forms a part of a core STEM Education by inspirational subject-based specialists whom inspire learning in STEM.

Further, the OACS (2014) stated that a core STEM Education should comprise contemporary content, with a priority for the learning area of Scientific Methods, Philosophy, and History

or Scientific Literacy. This data informed both the DPMC and EC, which derived different actions and issues with:

1. Coding because not all students are learning to code (DPMC, 2015); and,

2. Digital Literacy because not all students understand the relevance of a STEM or Mathematics Education (EC, 2015), but did not define them as a priority.

The OACS noted *issue* was that:

> We need a reliable pipeline of specialist STEM skills; but we also need informed workers, users and consumers who have the curiosity and imagination to be part of the broader STEM economy. (OACS, 2014, p. 23)

This *issue* is similar to the DPMC and EC on increasing STEM skills for future jobs. However, the OACS issue has included the reliability and continuity of the education system to support critical STEM skills in quality and quantity of specialists to support an action that focuses on a core National standard of Science Literacy.

The OACS priority was to support high quality and increased number of inspirational specialist STEM teachers to inspire learning through a core STEM Education of Science Literacy, Numeracy, and proficiency in a Language across the schooling system. The OACS policy priority thus highlighted a difference with the DPMC and EC to preference a core STEM Education and Science Literacy.

Priority: action and issue summary.

As the above data shows, the Policy 2 *priority action* was:

> promoting students to learn coding and computing in schools.

This *action* was led by the DPMC as a whole-of-government approach. The priority *issue* was:

> All students are not learning computing in schools, which is a critical STEM skill for future jobs.

This *issue* is noted as the Policy 2 priority for action by the Government of Australia.

The Policy 2 priority was noted in the NISA and the precedent NIICA priority policies of the Government of Australia, at the time of this study. However, limited data was identified on an action to support inspirational STEM teaching from content and pedagogical specialists who might inspire STEM learning through a core STEM Education placing Science Literacy as a 'new' priority (OACS, 2014). Concurrently, limited data was noted on the continuity and reliability by the STEM Education and Training system to 'supply a high quality and increased number of specialist STEM teachers, and a nationally defined base standard of Science Literacy'.

The DPMC NISA priority had in fact then been reprioritised by the COAG EC to support learning and teaching of Digital Technologies and Mathematics to increase student aspiration, interest, and understanding of the relevance for STEM skills, which in turn was considered to increase STEM skills for future jobs. As stated, increasing student aspiration and interest for a Mathematics Education and learning Digital Technologies had been reprioritised by all Government priorities through the EC based on the MDEGFYA (2008).

Specifically, all students 'will learn to code' was to address the issue that all students were not learning to code and contrasts with students' limited understanding about the relevance for a STEM Education (EC, 2015) and inspired STEM learning by a core STEM Education that prioritises Science Literacy (OACS, 2014). Further, the analysis on the Federal ministry and agency priority actions noted the terms of Coding, Computing, Digital Technologies, and

Scientific Literacy, which have been interpreted in a number of ways resulting in differing actions amongst the DPMC, EC, and OACS and similar diversity in interpretation when implemented by the State and Territory education ministers and agencies. This diversity in interpretation within different levels of Government is explored further in Chapter 7.

Dimension 2

Purpose-Rationale and Objective

Definition.

As indicated, Students learning to code is a Government of Australia policy priority with a purpose. *Purpose* includes the DPMC stated rationale and objective of a priority policy. For example, the Government of Australia had a rationale that coding was a critical skill for all future jobs (DPMC, 2015). Linked with this *rationale*, the *objective* was that Year 5 students would learn to code through online computing challenges. Thus, this priority policy has been further framed by a purpose.

Data.

A sample of the data showing the coded Policy 2: National purpose is presented in Table 5.2.

Table 5.2

Coded Dataset: Purpose

National Agency	Purpose Rationale Statement	Purpose Objective
DPMC	"Science, maths and computing in schools — skills that are critical to prepare our students for the jobs of the future" (DPMC, 2015, p. 4)	"Years 5 and 7s to learn coding through online computing challenges" (DPMC, 2015, p. 13)
EC	"To build on a range of reforms and activities, already underway. It aims to better coordinate and target this effort and sharpen the focus on the key areas where collaborative action will deliver improvements to STEM Education." (EC, 2015, p. 1) "Interrelationship between student aspirations towards STEM careers and engagement in STEM subjects. Mathematical thinking is a fundamental skill that underpins all STEM learning. The sequential nature of mathematical learning means that students who fall off the 'maths pathway' early can struggle to achieve sufficient levels of mathematical literacy" (EC, 2015, p . 8)	"Schooling should support the development of skills in cross-disciplinary, critical and creative thinking, problem solving and digital technologies, which are an essential in all 21st century occupations" (EC, 2015, p. 1)
DET	"Schooling system ensuring young people leave school with the skills they need to succeed" (DET, 2016, p. 14)	"Boosting literacy, numeracy and STEM performance" (DET, 2016, p. 14) "40 Digital Literacy School Grants to be provided" (DET, 2016, p. 33)

National Executive Agencies

The Department of the Prime Minister and Cabinet (DPMC)

A DPMC *Purpose* was noted in the NISA and articulated through a *Rationale* statement as:

> Science, maths and computing in schools — skills that are critical to prepare our students
>
> for the jobs of the future (DPMC, 2015, p. 4)

This data represents the rationale that Computing is a critical skill for jobs in the future. Thus, the policy purpose is that learning to code is an essential skill of all jobs in the future. This *rationale* links with the prior priority of all students learning to code within schools to address concerns about the future supply of workers with STEM skills to progress the National economy.

The policy purpose has an ***Objective*** noted as:

> Years 5 and 7s to learn coding through online computing challenges. (DPMC, 2015, p. 13)

The objective that all Year 5 students would learn to code by online computing challenges linked to the ACARA Australian Curriculum (AC): Digital Technologies curriculum and in-service teacher support by specialist Digital Technologies through a federally funded program, *The Digital Technologies in focus project* (DTiF), for access by all schools, which was evident by the NIICA data.

The Policy 2 purpose that learning to code is essential for a job in the future with regard to Primary STEM Education, is intended to be realised through the *objective* of Year Five (and 7) students learning to code using online computing challenges supported by ACARA in the Digital Technologies curriculum and its associated support for teachers in the DTiF project (ACARA, 2017). As stated, National Executive agencies had data linked to this policy, which included the EC (who had been administering the National STEM School Education Strategy (NSSES, 2015)).

The Council of Australian Governments (COAG) Education Council (EC)

The COAG EC, *National STEM School Education Strategy* (NSSES) (2015) and the policy

rationale was noted as:

> To build on a range of reforms and activities, already underway. It aims to better
>
> coordinate and target this effort and sharpen the focus on the key areas where
>
> collaborative action will deliver improvements to STEM Education. (EC, 2015, p. 1); and,
>
> Interrelationship between student aspirations towards STEM careers and engagement in
>
> STEM subjects. Mathematical thinking is a fundamental skill that underpins all STEM
>
> learning. The sequential nature of mathematical learning means that students who fall
>
> off the 'maths pathway' early can struggle to achieve sufficient levels of mathematical
>
> literacy. (EC, 2015, p. 8)

The EC suggests that Government already has many policy actions in STEM Education so a

coordinated collaboration, and a focusing of these key actions will influence improvements in

STEM Education is the overall purpose. The DPMC priority of Science, Mathematics and

Computing skills being critical has shifted to Mathematical thinking only by the EC and is in

contrast to the DPMC priorities. This EC rationale also contrasts with the OACS for a priority

of Science Education and Scientific Literacy. Hence, the EC policy purpose is framed in

ways that focus on developing and coordinating all Government STEM Education reforms

and activities in ways that can improve school-based STEM Education outcomes, but differs

in emphasis from the other arms of Government and its agencies. This purpose is to reframe

and reprioritize the current range of reforms and activities in ways that may appear to address

'priority policies'. Thus, the DPMC purpose of Coding as an essential skill for future jobs has

been reframed to Mathematical thinking being the essential skill, because the EC appears to

have determined that this skill will lead to a greater improvement in school-based STEM

Education outcomes.

The EC NSSES *objective* underpinning this rationale was attributed as:

> Schooling should support the development of skills in cross disciplinary, critical and creative thinking, problem solving and digital technologies, which are an essential in all 21st century occupations. (EC, 2015, p. 1)

This *objective* is much broader than that of the DPMC and while requiring schools to support student capabilities within Digital Technologies it has taken license to reframe Coding as Digital Technologies.

As stated, the NSSES *priority and purpose* were agreed to by the National and State/Territory Government education ministers drawing on the *Melbourne Declaration on Educations Goals for Young Australians* (MDEGYA) (EC, 2008). The MDEGYA stated the purpose that Digital Technologies are an essential skill for future jobs.

Further analysis (following section) led to an understanding about how the National education department regarded the policy purpose.

The National Department of Education and Training (DET)

A National STEM policy purpose was identified within the *Department of Education and Training Corporate Plan 2016–2020* (DETCP), as the:

> Schooling system ensuring young people leave school with the skills they need to succeed. (DET, 2016a, p. 14)

This *purpose* statement is a *rationale* focused on the education of skills, which provides limited data on students learning to code. Through this DET rationale, 'skills to succeed' are assumed to include Coding and Digital Technologies. However, limited DET data was identified pertaining to a rationale as to why students should learn to code.

An example of such limited data as noted in relation to a DET objective was:

Boosting … STEM performance. (DET, 2016a, p. 14)

The DET objective to boost STEM performance appeared to be linked to the perceived need to increase students' academic achievement in National and international assessment in Science, Mathematics, and to a limited extent Technology (i.e., NAPLAN-SL, NAP-ICTL, PISA, and TIMMS). As an objective, Technology and more-so Engineering have limited focus through these National and international assessments.

Overall, the DET had limited data on the skills necessary to succeed and how to boost STEM performance. Further analysis highlighted the DET (2016) budget statement (which was an indirect objective) as:

40 Digital Literacy School Grants to be provided. (DET, 2016b, p. 33)

This was the extent of data noted in this statement. As an implied objective, 40 digital literacy grants to be allocated to schools is linked to 'boosting STEM performance'. However, this DET allocation of 40 digital literacy grants raises questions as to how they might boost overall STEM performance. The extent of data in, for example, the corporate plan and the budget statements, was limited. Thus, the DET had a limited purpose relating to educating for essential STEM skills including Digital Literacy through 40 Digital Literacy grants as a mechanism for boosting STEM performance.

Purpose: rationale and objective summary.

Policy 2 purpose has a *rationale and objective.* The *rationale* is that Coding is an essential skill of all future jobs. The objective is that Year 5 students learn to code by online coding challenges (i.e., the NISA). This action was linked to the NIICA (DPMC, 2014) action focused on a review of the ACARA AC, which resulted in a newly framed Digital

Technologies curriculum and federally funded program, DTiF, for in-service teacher support from Digital Technologies specialists who would be accessed by all schools (ACARA, 2017).

This *rationale* varies with the EC, which reprioritised policies to those with the greatest impact for improving school-based STEM Education. The greatest impact was considered to be Mathematical Thinking rather than Coding. The EC objective was noted as schools supporting student learning of Digital Technologies.

By contrast, the National DET had limited data pertaining to a purpose for students learning to code. The DET sought to consider the schooling system as enabling students to leave with the skills to succeed by enabling students to learn the skills of Coding and Digital Technologies. The DET objective was to boost STEM performance but there was limited data as to how that might occur. Although, the '40 digital literacy grants for schools' could be seen as implying that boosting digital literacy of 40 schools was an *objective* of this policy. The DET objective considered STEM performance would be boosted by evidence in improved student academic performance in National and international Science and Mathematics assessments by ACARA, PISA, and TIMMS. However, objectives on the academic performance by assessment on students learning to code based on the ACARA Australian Curriculum Digital Technologies learning area was not identified in this National policy purpose data.

Dimension 3

Research-Citation and Reference

Definition.

Research is the research-based citations and references to a policy within a Government agenda. For example, the Government of Australia had paraphrased research by The

Foundation for Young Australians in the National NISA agenda (DPMC, 2015), and for the

purposes of this study was considered as a report rather than academic research. While, a

reference to this citation was not listed, references had been listed in prior agendas. Thus,

students learning to code can be further framed by the nature of the research the Government

of Australia used to inform policy

Data.

A sample of the data showing the coded Policy 2: National research is in Table 5.3.

Table 5.3

Coded Dataset: Research

National Agency	Research Citation	Research References
DPMC	Uncited on this policy. However, a highlighted paraphrase as: "The Foundation for Young Australians predicts that today's young people will hold as many as 17 different jobs, in five different careers" (NISA) (DPMC, 2015a, p. 12) Limited or indirect cited paraphrasing noted to the OACS (2014) within the (NIICA) (DPMC, 2014)	Unreferenced (NISA) (DPMC, 2015) Referenced (NIICA) (DPMC, 2014)
OACS	"Digital technology was a particular source of anxiety, with many respondents unaware of the need to teach it, or how to teach it well … Technology encourages creativity, innovation and enterprise – skills integral to the future economy – and its importance is recognised in the form of the new Technologies curriculum. Yet it is only included in pre-service education in a small number of universities. To lift our game, we must collaborate to develop…" (Prinsley & Johnston, 2015, p. 4)	Referenced: E.g., Australian Science Teachers Association (ASTA), "Primary Science Teaching Survey final report", www.asta.edu.au/programs/assist/ primary_science_teaching_survey, pp 18-19, 30-31 (Prinsley & Johnston, 2015, p. 8)
DET	"[T]he current landscape of Computer Science resources, suitable for the Australian Curriculum: Technologies, to inform the consideration of the curation and/or creation of resources under the Coding across the Curriculum Program" (Falkner & Vivian, 2015, p. 6)	Referenced

National Executive Agencies

The Department of Prime Minister and Cabinet (DPMC)

Analysis of the NISA document noted the policy *Research* by the following paraphrase; a

form of *citation*:

> The Foundation for Young Australians predicts that today's young people will hold as
>
> many as 17 different jobs, in five different careers, over the course of their working lives.
>
> (DPMC, 2015, p. 12)

This NISA citation was unattributed, nor was a reference list included. This citation was also

ascribed to Policy 1 (as shown in the previous chapter). As stated, the research was limited by

the paraphrasing of a report and without a reference list.

On further analysis, the NIICA data featured two citations. The first was that the 'OACS' had

identified a critical need for learning resources that would engage students in Mathematics

and Coding; which was unattributed and not linked within the NIICA reference list. The

second noted paraphrase was:

> Coding across the curriculum will contribute to ICT industry feedback which consistently
>
> emphasises a looming acute shortage of computer programming skills. (DPMC, 2014, p.
>
> 51)

These paraphrases were unattributed and not located within the reference list. While there

was limited academic research identified, research was able to be gleaned as comprising

Government reports and industry feedback. Thus, the NISA citation alluded to 'coding across

the curriculum' based on a National Government agency report and ICT industry feedback,

rather than on academic research focused on Digital Technologies Education to inform this

policy.

The Office of the Australian Chief Scientist (OACS)

The OACS had a citation and a reference list as illustrated in the following data:

> Digital technology was a particular source of anxiety, with many respondents unaware of
> the need to teach it, or how to teach it well … Technology encourages creativity,
> innovation and enterprise – skills integral to the future economy – and its importance is
> recognised in the form of the new Technologies curriculum. Yet it is only included in pre-
> service education in a small number of universities. To lift our game, we must collaborate
> to develop an agreed national minimum curriculum and standards in science, technology
> and mathematics for primary school pre-service teachers. We must make collaboration
> between education and STEM faculties routine and address the incentive structures in
> universities which often prevent it. Discipline content should be taught well by discipline
> experts, and pedagogy by pedagogical experts. The Enhancing the Training of
> Mathematics and Science Teachers programme, involving 25 universities and funded by
> the Australian Government, provides innovative approaches and supplies the evidence
> base we need for action. (Prinsley & Johnston, 2015, p. 4)

This citation is a research-based report informing a Primary STEM Education policy to the
DPMC, which is the extent of the noted evidence. This OACS report is based on a literature
review that included the following reference as informing the citation:

> Australian Science Teachers Association (ASTA), "Primary Science
> Teaching Survey final report", www.asta.edu.au/programs/assist/
> primary_science_teaching_survey, pp 18-19, 30-31 (Prinsley & Johnson, 2015, p. 8)

The ASTA research comprised a survey of in-service primary teachers and informed the
OACS policy recommendation to the DPMC. The recommendation was for a coordinated
approach within universities Education and STEM faculties for the implementation of a core

STEM curriculum including Digital Technologies, and increasing the quality and amount of specialist STEM teachers in schools.

The National Department of Education and Training (DET)

The DET had cited research conducted by The University of Adelaide (UoA) as evident in the following data:

> [T]he current landscape of Computer Science resources, suitable for the Australian Curriculum: Technologies, to inform the consideration of the curation and/or creation of resources under the Coding across the Curriculum Program. (Falkner & Vivian, 2015, p. 6)

The DET had commissioned this academic research related to students learning to code. This research was a semi-systematic review of the current landscape of computer science resources informing ACARA in curating support for the school-based implementation of the new Technologies-Digital Technologies learning area.

The UoA systematic review offered thirteen recommendations. Two related recommendations were noted:

> Recommendation 1: That supplementary materials be developed to support the integration of existing high quality Computer Science resources into the classroom, to support the Australian Curriculum: Technologies
>
> Recommendation 2: That resources associated with the explicit development and assessment of the computational thinking process as a holistic process across F-10 be supported. (Falkner & Vivian, 2015, pp. 31-32)

The DET had cited and referenced this UoA research as part of a project entitled, *Coding Across the Curriculum* led by ACARA in concert with the State/Territory Governments.

Research: citation and reference summary.

The Policy 2 *research* was analysed with limited findings of National Government agency (OACS) research reports and ICT feedback. Notably, the DET had evidence of academic research to inform a specific project by ACARA with the State and Territory Governments on the school-based implementation of the new Technologies-Digital Technologies learning area across the Australian Curriculum (AC). The DET commissioned UoA research links with the OACS research report on the implementation of Digital Technologies within the AC, but focusses on the curation of available and complementary school-based learning and teaching resources. No further research was noted on other aspects to the OACS recommendations, for example on university collaboration between discipline and pedagogy experts. Further, no research was noted on the DPMC action of Year Five (and Seven) students learning to code by online challenges.

Dimension 4

Initiative and Budget-Projects and Funds

Definition.

The ***initiative and budget*** is the DPMC statement on the various projects and the allocation of funds to a priority policy within an agenda. For example, the Government of Australia had the initiative that Year 5 students learn to code by online computer challenges by projects defined and funded from a budget timeline (DPMC, 2015). Thus, Students learning to code was further framed by the National *initiative and budget* to the various funding of projects/programs as explained in the next section.

Data.

A sample of the data showing the coded Policy 2: initiative and budget is in Table 5.4.

Table 5.4

Coded Dataset: Initiative and budget

National Agency	Initiative Project (and Programs)	Budget (Allocation of funds)
DPMC	"Equipping young Australians to create and use digital technologies: Year 5 (and 7) students to learn coding through online computing challenges; Supporting and upskilling our teachers to implement the digital technologies curriculum through online learning activities and expert help" (DPMC, 2015, p.	$51m funded to 2019 (DPMC, 2015, p. 13) (bundled to three objectives)
DET	"By the government funding the Australian Digital Technologies Challenges for Year 5 and 7 students. The University of Sydney is developing an online series of 18 free, structured, progressive teaching and learning activities and challenges for all year 5 and 7 students, aligned to the Australian Curriculum. The initiative includes lesson plans, professional learning and online support for teachers and is funded to 2020. The first four challenges are now available on the Australian Computing Academy. To engage students across Years 4 to 12 in digital technologies activities, Cracking the Code week will be held for the first time in the second half of 2017. During this week a suite of fun and engaging coding activities and challenges will be available for all Year 4 – 12 students. (DET, 2017b, p. 1) The Coding across the curriculum programme will support the introduction of computer coding across different year levels in Australian schools. Importantly, this initiative will further support algorithmic thinking in	Total funding for Inspiring all Australians in digital literacy and STEM is $112.2 million. The DET initiatives total $64.6 million. These initiatives will be provided from 2016-17. (DET, 2017b, p. 1) (bundled) Funding of $3.5 million over four years (2014–15 to 2017–18) has been allocated to Coding across the

	the Australian Curriculum: Technologies and other key learning areas – including mathematics. The programme will lead to greater exposure to computational thinking, and, ultimately, expand the pool of ICT-skilled workers in Australia…the University of Adelaide was engaged to undertake a mapping exercise of existing teaching and learning resources with regard to the Australian Curriculum: Technologies and identify gaps and opportunities…In response to this report, the Department of Education and Training is working with states and territories to develop resources for teachers that will assist implementation of the Australian Curriculum: Digital Technologies. This includes the development of a web-portal by Education Services Australia. (DET, 2015c, p. 1) 40 Digital Literacy School Grants to be provided" (DET, 2016b, p. 33)	Curriculum (DET, 2015c, p. 1)
ACARA	"ACARA's Digital Technologies in Focus project, which provides support and expertise to primary and secondary school teachers to implement the Australian Curriculum: Digital Technologies is well underway. Eight Digital Technologies specialists have now been appointed to cover clusters across each state and territory around the country. As schools develop project proposals to drive implementation of Digital Technologies in their schools, the specialists will support professional learning. Trial introductory workshops for the Digital Technologies in Focus project have been held in Tasmania (Hobart and Burnie) and Queensland (Charleville, Toowoomba and Townsville). Workshops will also be held in SA and WA this month;	*Not evident/ bundled*

> and in Victoria, NSW and Northern Territory in
>
> September and October." (ACARA, 2017, p. 1)

National Executive Agencies

The Department of the Prime Minister and Cabinet (DPMC)

The Policy 2 *initiative* was noted as having three projects with allocated funding from a budget of $51,000,000 entitled "Equipping young Australians to create and use digital technologies" (DPMC, 2015, p. 13). Specifically, one of the three National projects was that Year 5 students learn to code by online computing challenges. An amount of funding for this project was not identified, however $51,000,000 was stated to fund these three projects including the Year 5 online computing challenges and:

> Supporting and upskilling our teachers to implement the digital technologies curriculum
>
> through online learning activities and expert help. (DPMPC, 2015, p. 13)

These two projects were noted in the NISA budget for National implementation from 2016-2017 to 2018-2019, which was irreconcilable to the stated budget as shown in Chapter 4.

Analysis of the National DET related documents to identify how (or whether) the DPMC had delegated this 'initiative and budget' to the two noted projects through an allocation of funds was conducted.

The National Department of Education and Training (DET)

The DET website communicated several projects including:

> The Government is funding the Australian Digital Technologies Challenges for Year 5 (and
>
> 7 students). The University of Sydney is developing an online series of 18 free, structured,
>
> progressive teaching and learning activities and challenges for all Year 5 and 7 students,
>
> aligned to the Australian Curriculum. The initiative includes lesson plans, professional
>
> learning and online support for teachers and is funded to 2020. The first four challenges
>
> are now available on the Australian Computing Academy. To engage students across
>
> Years 4 to 12 in digital technologies activities, *Cracking the Code,* week will be held for
>
> the first time in the second half of 2017. During this week a suite of fun and engaging
>
> coding activities and challenges will be available for all Year 4 – 12 students. (DET, 2017b,
>
> p. 1)

The DET focused attention on a project by the University of Sydney (UoS) to develop online

challenges for Year 5 (and 7) students in line with the ACARA AC. The Australian

Computing Academy (ACA) is the site that four of these UoS completed challenges were

made available to schools to use through funding until 2020. Further, a coding week for

students in Years 4 to 12 was a corresponding project to engage students with these online

challenges; but was not stated within the NISA.

The DET stated that their initiatives for projects totalled $64,600,000 until 2020, and was

purportedly allocated from the NISA irreconcilable budget of '$112, 200,000'. This DET

presented budget is irreconcilable with the NISA noted $51,000,000 funding for three

initiatives from a total and irreconcilable budget of $84,000,000 for "Inspiring all Australians

in digital literacy and STEM" (see DPMC, 2015, p. 13 and p. 16) up to 2019: So a DPMC

and DET discrepancy is evident on the total budget and funding amounts allocated to

initiatives (projects and programs) for the *Inspiring all Australians in digital literacy and*

STEM. As indicated, the DET's initiatives totalled $64.6 million, which stated that "these initiatives will be provided from 2016-17" (DET, 2017b, p. 1).

The DET (2017) alludes to projects worth $64, 600,000 with reference to the NISA digital literacy and STEM initiatives and budget, which commenced in 2016. The DET (2017b) noted projects such as:

> The National Innovation and Science Agenda – Inspiring all Australians in digital literacy and STEM … A variety of initiatives will be introduced to increase the participation of all school students and the wider community in STEM and improve their digital literacy under the Inspiring all Australians in digital literacy and STEM measure of the National Innovation and Science Agenda, announced on 7 December 2015. These initiatives include: online computing challenges for Years 5 and 7 students nationally; Funding for these initiatives will be provided over the next two to four years … As part of its Industry Innovation and Competitiveness Agenda, the Australian Government has committed an extra $12 million to restore the focus on, and increase student uptake of, science, technology, engineering and mathematics (STEM) subjects in primary and secondary schools across the country. Restoring the Focus on STEM aims to increase the number of students studying STEM subjects in school and, ultimately, their engagement in STEM higher education and careers through providing: $3.5 million towards Coding Across the Curriculum. (DET, 2017b, p. 1)…40 Digital Literacy School Grants to be provided. (DET, 2016b, p. 33)

In addition to Year 5 students learning to code project was the ACARA program of, *Coding Across the Curriculum,* which had $3.5 million allocated by the NISA and is additional to the NIICA *initiative(s) and budget*. This program was noted in the DET policy analysis to occur from the DPMC NIICA action, budget and initiative(s) and has not translated to the NISA action, budget, and initiative for improving the quality of Science and

Mathematics teaching in schools. This data shows how a DPMC led priority policy *initiative and budget* to defined actions, projects and allocation of funds in budgets appears as interspersed across policy agendas. Therefore, the NIICA initiative and budget has not been carried across to the NISA budget by the DET data. The additional Federal allocation of $12 million from the NIICA budget to the DET to increase students uptake of Science, Technology, Engineering, and Mathematics subjects has 'disappeared' from the NISA budget, and translated to $3.5 million to *Coding Across the Curriculum,* which ignores Science, Engineering, and Mathematics. Overall, the NISA budget has shown uncertainty about the 'extra allocation' of $12 million and the funding of 40 digital literacy school grants for increasing students uptake of STEM subjects at the time of this study.

With this regard, the DET analysis of the budget statements highlighted Program 1.3:

> Progressing initiatives under the Government's National Innovation and Science Agenda that impact directly on Australian education and research, including: - equipping students for the digital age in early childhood and schools. (DET, 2016b, p. 13)

However, analysis of the 2017-2018 DET (2017c) budget noted that Program 1.3 was changed to Program 1.7 and there was no data evident on the initiatives. A DET budget statement highlighted further evidence about the allocation of funds by the last line item in Figure 5.1, as follows.

Figure 5.1

DET 2017-2018 Budget Statement on Project 1.7 Digital Literacy and STEM

Program expenses 1.7 Early Learning and Schools Support

	2016–17 Estimated actual $'000	2017–18 Budget $'000	2018–19 Forward estimate $'000	2019–20 Forward estimate $'000	2020–21 Forward estimate $'000
Annual administered expenses:					
Ordinary annual services					
(Appropriation Act No. 1 and Bill No. 3)					
Australian Early Development Census	3,106	10,381	8,581	6,408	12,173
Australian Government Response to TEMAG	4,300	4,100	3,700	-	-
Boost the Learning for Life Program	5,700	10,100	13,800	18,400	-
Early Learning Languages Australia (ELLA)	4,312	1,622	-	-	-
Educating Against Domestic Violence	1,981	2,057	-	-	-
English Language Learning for Indigenous Children	-	803	3,305	1,204	571
Flexible Literacy Learning for Remote Primary Schools	6,200	1,600	-	-	-
Grants and Awards	1,353	1,353	1,353	1,373	1,394
Helping Children with Autism	5,737	5,818	5,899	5,988	6,078
Inspiring all Australians in Digital Literacy and STEM	14,607	16,496	16,343	15,350	-

Image retrieved from:

Https://Docs.Education.Gov.Au/Environment/Files/Doc/Other/Education_And_Training_Portfolio_Budget_Statements_2017-18_Full_Print.Pdfp.40)

The DET has evidence of *initiatives* and a *budge*t linked with the NISA *initiative and budget* on students learning to code, which is unclear on the projects and allocation of funds from a total of $62,796,000 in the 2017-2018 budget statement (which is a small variation to the $62, 600,000 or $196,000 stated in a DET online communication). The funding for this initiative commenced in 2016-2017 and ends in 2019-2020 as a forward estimate. However, the NISA budget ends in 2018-2019 indicating uncertainty on why this forward estimate of one year has been stated, and as to how the estimate is likely to be effected. Although, the 2018-2019 and 2019-2020 budget uncertainty may be explained by the Federal Government requirement to announce and hold an election by 2019, which was uncertain at the time of this study. The

DET evidence on the new NISA initiative as a framework of projects and allocation of funds on students learning to code by Year 5 computing challenges was not listed and unable to be reconciled. The DET budget of $64,796,000 from 2016 to 2020 cannot be reconciled with the DPMC NISA budget of $51, 000,000 from 2016 to 2019, which is the budget submitted to, and presented by, the National Treasury.

During the analysis, the DET website highlighted how they were progressing initiatives that included the ACARA project 'Coding Across the Curriculum' with $3,500,000 by a NIICA initiative and budget and is examined in the following section.

The Australian Curriculum and Assessment Authority (ACARA)

The DPMC, OACS, and DET data showed that students learning to code was aligned to the ACARA AC, which relates to an ACARA project, *Coding Across the Curriculum* with funding from the DPMC and DET. The Australian Curriculum (AC) is administered by ACARA in accordance with written directions by the EC (ACARA, 2017). On this basis, the ACARA policy documents and communications were analysed for their initiative and budget informing this policy. A resultant project was noted:

> ACARA's Digital Technologies in Focus project, which provides support and expertise to primary and secondary school teachers to implement the Australian Curriculum: Digital Technologies is well underway. Eight Digital Technologies specialists have now been appointed to cover clusters across each state and territory around the country. As schools develop project proposals to drive implementation of Digital Technologies in their schools, the specialists will support professional learning. Trial introductory workshops for the Digital Technologies in Focus project have been held in Tasmania (Hobart and Burnie) and Queensland (Charleville, Toowoomba and Townsville). Workshops will also be held in SA

> and WA this month; and in Victoria, NSW and Northern Territory in September and October. (ACARA, 2017, p. 1)

Along with the *Coding Across the Curriculum* project, which is a NIICA (DPMC, 2014) initiated project as shown through the DET DTiF project. This project has eight Digital Technologies specialists who were to provide school-based implementation support of the new ACARA Digital Technologies learning area Australia-wide. This project links with the NISA initiative and the second listed project on supporting teachers to implement the ACARA AC new Technologies-Digital Technologies learning area.

Although, the NISA allocation of funds to this project was not identified within the online ACARA sourced data ACARA stated that:

> Funding for ACARA is allocated by states and territories and the Australian Government under the Council's funding formula – with half of ACARA's funding provided by the Australian Government and the other half provided by states and territories. (ACARA, 2016, p. 12)

The funding of ACARA's projects is 50% from the National and 50% from across the State and Territory Governments based on the EC's formula, which was not evident in the EC data. How then, the NISA and DET budget allocations of $3,500,000 were considered by the EC funding formula in allocating funds to ACARA was indeterminable.

ACARA had limited evidence through Project 1.1 and the Australian Curriculum budget statement (2016) as highlighted in Figure 5.2.

Figure 5.2

ACARA Australian Curriculum Project 1.1 Funds Allocation

Outcome 1: Improved quality and consistency of school education in Australia through a national curriculum, national assessment, data collection and performance reporting system.

	2016–17 Estimated actual $'000	2017–18 Budget $'000	2018–19 Forward estimate $'000	2019–20 Forward estimate $'000	2020–21 Forward estimate $'000
Program 1.1: National Curriculum					
Revenue from Government					
Payment from related entities	2,670	4,565	4,619	4,798	-
Revenues from other independent sources	2,072	2,113	2,413	2,488	-
Total expenses for Program 1.1	**4,742**	**6,678**	**7,032**	**7,286**	-

Image retrieved from:

Https://Docs.Education.Gov.Au/Environment/Files/Doc/Other/Acara_Budget_Statements_2017-18.Pdf P. 86

This ACARA budget statement shows the Government revenue for the AC across the period 2017-2019 of $16,652,000, of which $8,326,000 is considered as the allocation from the National Government and $8,326,000 from the State and Territory Governments, which links with the DPMC timeline. However, the limited extent of data makes it difficult to link to the ACARA framed initiatives and budgets on the two projects of students learning to code. For example, the two projects of *Coding Across the Curriculum* and DTiF have limited evidence pertaining to their project specifics and budgets as framed by ACARA with relation to those by the DPMC NISA/NIICA, and the DET by the amounts and timeline differences of a year.

Initiative and Budget: project and funds summary.

Policy 2 has two projects of Year Five students learning to code by online computing challenges, and supporting teachers with the implementation of the ACARA AC Technologies-Digital Technologies learning area. From the NISA budget, $51 million had been allocated to fund these and another project from 2016-2017 to 2018-2019. In response,

the DET had data that the UoS and the ACA had completed and offered four Year 5 online computing challenges. In addition, a third DET project was noted as 'Cracking the Code week' for students in Years 4 to 12, which was unstated in the NISA. Overall, the NISA related projects and funding were limited in details and amounts, which was irreconcilable then against the DET amount of $62,796,000 and allocation to 2019-2020.

Further, two ACARA projects were linked with the DPMC *initiative and budget* with limited detail and funds allocation by the NIICA and NISA via the DET, which had evidence of $3,500,000. The DPMC, DET, and ACARA budget statements had limited evidence about the nature of each project, and the allocation of funds. Overall, the data showed that there were a limitations and disconnects with the National initiative and budget to the:

1. nature of the projects and the allocation of funds over time with Year 5 students learning to code through online coding challenges, and supporting school-based implementation of the ACARA AC Technologies-Digital Technologies learning;

2. amount of funds to support these two projects and other noted projects; and,

3. timeline of these projects that funds are allocated from and until as 2016 to either 2019 or 2020, along with their future focus, continuation, and/or scale following an evaluation over this timeline.

The DPMC had limited detail on the *initiative and budget* by the two projects and bundled allocations of fund, so again was irreconcilable. Further, the DET *initiative and budget* had limited evidence on the nature of a project and the allocation of funds on Year 5 students learning to code by online computing challenges by the UoS and ACA, along with supporting the school-based implementation of the ACARA AC Technologies-Digital Technologies learning area by eight experts. Concurrently a coding week for Year 4 to 12 students project was noted, with limited data to the DET, rather than the DPMC.

Concurrently, the ACARA projects of Coding Across the Curriculum, and Digital Technologies in Focus, were shown as limited with data on the *initiative and budget* linking with the DPMC NISA and NIICA, and DET initiatives and budgets.

Dimension 5

Evaluative Measure- Outcomes and Timeline

Definition.

The *evaluative measure* is the DPMC statement on the policy *outcome(s)* and the *timeline* within a Government agenda. For example, the Government of Australia had a stated outcome that Year 5 students would be learning to code by online computing challenges and a timeline based on the budget of 2016 to 2019 (DPMC, 2015). Thus, Students Learning to Code can be analysed in terms of a National evaluative measure.

Data.

A sample of the data showing the coded Policy 2: evaluative measure is in Table 5.5.

Table 5.5

Coded Dataset: Evaluative Measure

National Agency	Evaluative Measure Outcome(s)	Evaluative Measure Timeline
DPMC	*Not evident*, however noted to the action as: "Year 5s to learn coding by online computing challenges, and the implementation of the ACARA AC Technologies-Digital Technologies learning area by teachers in all schools" (DPMC, 2015, p. 13)	*Not evident*, however noted as: 2015-2019 based on funds allocation
EC	"Rollout of the Australian curriculum on technologies, including a deep engagement with coding" (EC, 2015, p.	*Not evident*, however noted as: 2016-2026 based on document title
ACARA	"Provide a world class curriculum from Foundation to Year 12 in specified learning areas agreed to by Council. Assemble the evidence base required to review, develop and refine curriculum Foundation to Year 10 … Technologies -Digital Technologies" (ACARA, 2016)	*Not evident*, however noted as: 2016 - 2021 (ACARA, 2016)

National Executive Agencies

The Department of the Prime Minister and Cabinet (DPMC)

The NISA or NIICA documents do not specify an evaluative measure on 'students learning to code'. The noted outcome and timeline is that all Year Five students learning to code by online computing challenges, and all schools have implemented the ACARA AC Technologies-Digital Technologies curriculum from 2016-2017 to 2018-2019. This

evaluative measure is derived from the two new projects and the timeline of the budget shown in the NISA.

The COAG Education Council (EC)

The analysis on the EC National STEM School Education Strategy 2016-2026 (ECNSESS) (EC, 2015) identified an evaluative outcome as:

> Rollout of the Australian curriculum on technologies, including a deep engagement with coding. (EC, 2015, p. 8)

The timeline for research on this outcome was noted as 2016-2026, which is the timeline of the NSSES document.

Therefore, the EC evaluative measure is that ACARA rollout Digital Technologies curriculum with coding from 2016 with school-based implementation achieved by 2026.

Subsequently, the ACARA evaluative measure was analysed and is presented next.

The Australian Curriculum and Assessment Authority (ACARA)

The ACARA noted outcome was to:

> Provide a world class curriculum from Foundation to Year 12 in specified learning areas agreed to by Council. Assemble the evidence base required to review, develop and refine curriculum Foundation to Year 10 … Technologies -Digital Technologies (ACARA, 2016, p. 2)

ACARA had evidence of an outcome in relation to Policy 2, which was providing a world-class curriculum by assembling the evidence base. As an outcome of evaluation, Policy 2 was to have an evidence-base available in the review, development and refinement of the learning area being viewed as a world-class curriculum.

The noted ACARA timeline for this outcome was:

> The accountability framework for ACARA includes: a Charter, a Board, a rolling Quadrennial work plan and budget, and monitoring by Ministerial Council through regular reporting. ACARA will - present its rolling quadrennial work plan and budget annually to Council for endorsement - report to Ministerial Council at least once per year regarding progress against the work plan - provide an annual report to Council in accordance with the Act-respond to requests from Council for supplementary information and/or additional reports. (ACARA, 2016, p. 5)

Further to these outcomes and timeline of accountability, ACARA documented the *Monitoring and Evaluation Framework of the Australian Curriculum* (2013) focused on monitoring and evaluating the effectiveness of the curriculum and not the implementation. ACARA documented outcomes and a timeline incorporating the Technologies subjects in order to review, develop and refine digital technologies across Foundation to Year 10. This data was then evident in the EC endorsed *2016 to 2021 ACARA Work Plan* (ACARA, 2015).

Evaluative Measure: outcome and timeline summary.

The *evaluative measure* of this policy was based on the NISA and the outcome is that Year Five students are learning to code through online challenges, and supporting the school-based implementation of the ACARA AC Technologies-Digital Technologies learning area from 2016 to 2019. Further, the EC and the ACARA outcome show the ACARA AC Technologies-Digital Technologies implementation was supported by eight experts.

For evaluation, the DPMC timeline from 2016-2017 to 2018-2019 was based on the funding of the current agenda at the time of this study. However, the COAG EC is noted as endorsing a timeline to support ACARA in the implementation of this learning area from 2016 to 2021, while the EC has a timeline endorsed at to 2026. Thus, the evaluative measure is limited to all Year Fives learning to code with online coding challenges, and the school-based

implementation of the ACARA AC 'new' Digital Technologies learning area from 2016 until 2019.

Overview of Policy 2

Using the five dimensions as an analytic frame, Policy 2 is summarized in Table 5.6, which is an overview of the second priority policy presented by this chapter.

Table 5.6

Policy 2: Students learning to code

Australian Government STEM Education Policy Context: Priority Policy Dimensions	
Priority Policy 2: Students learning to code	
1. *Priority*	*Action*: "Support all Australian students to embrace the digital age by promoting coding and computing in schools" (DPMC, 2015, p. 4) *Issue: "*Too few Australian students are studying science, maths and computing in schools – skills that are critical to prepare students for the jobs of the future" (DPMC, 2015, p. 4)
2. *Purpose*	*Rationale: "*Science, maths and computing in schools — skills that are critical to prepare our students for the jobs of the future" (DPMC, 2015, p. 4) *Objectives*: "Year 5 students learning to code by online computing challenges" (DPMC, 2015, p. 13)
3. *Research*	*Citation:* Uncited on this policy. However, a highlighted paraphrase as: "The Foundation for Young Australians predicts that today's young people will hold as many as 17 different jobs, in five different careers" (NISA) (DPMC, 2015a, p. 12) Limited or indirect cited paraphrasing noted to the OACS (2014) within the (NIICA) (DPMC, 2014) *Reference:* Unreferenced (NISA) (DPMC, 2015), and Referenced (NIICA) (DPMC, 2014)

4. *Initiative & Budget*	*Project*: "Year 5 (and 7) students to learn coding through online computing challenges, and supporting teachers to implement the ACARA AC Digital Technologies learning area" (DPMC, 2015, p. 13)) *Funds:* "$51m funded to 2019" (DPMC, 2015, p. 13) (bundled to three objectives)
5. *Evaluative Measure*	*Outcomes: Not evident*, however noted to the project as: "Year 5s to learn coding by online computing challenges, and school-based implementation of the ACARA AC Technologies-Digital Technologies learning area" (DPMC, 2015, p. 13) *Timelines: Not evident*, however noted as: "2015-2019" (DPMC,2015, p.12) based on funds allocation

The five dimensions are derived from the coded Primary STEM Education policy communications and documents by the mapped Context shown in Appendix 6. This policy is a priority within a National agenda(s) for the whole-of-government to administer, which includes the States and Territories. Policy 2 is the basis for the whole-of-government to develop and progress the policy for school-based implementation. Ideally, a priority policy is well explained through these dimensions by the Governments of Australia, which informs practice. This National data is limited in how it can inform school-based implementation because of the limited extent and quality of publically accessible data, which is further explored in following chapters, notably Chapters 7 and 8.

Chapter Close

This chapter has shown how to frame a priority Primary STEM Education policy, since it was not located in a single document. Based on the National agendas of the NIICA and NISA, Policy 2 was the second highest priority policy from the extent and relevance of the coded data. In applying the five dimensions, Policy 2 illustrated that it had:

1. *Priority action* that all student learn to code. The *priority issue* being addressed was noted as responding to all students not learning coding and computing in schools;

2. *Purpose* of learning coding was related to it being considered an essential skill to all jobs in the future. The objective that Year 5 students would learn to code by online computing challenges linked the ACARA AC Technologies-Digital Technologies learning area , and, primary teacher support to implement this learning area by curated online resources and Digital Technology experts to be accessed by all schools;

3. *Research* was uncited and unreferenced in the National agenda with the exception of a research-based report by The Foundation for Young Australians, the OACS, and ICT industry feedback. Research was therefore limited in terms of traditional academic peer-reviewed research;

4. *Initiative and budget* was *not evident*. The initiative and budget was limited although the four projects were noted: Year 5 learning to Code by online computing challenges by the UoS and for school-based use by the ACA; Cracking the Code week for Year Four to 12 students; the ACARA Coding Across the Curriculum; and the ACARA Digital Technologies in Focus; and,

5. An *evaluative measure* was not clearly stated but through implication could be described as being that all Year Five students learn to code by online coding

challenges. This evaluative measure was indirectly implied through the UoS and made available by the ACA, and school-based implementation of the ACARA AC Technologies-Digital Technologies learning area as noted in the budget timeline of 2016 to 2019. While limited, the EC and ACARA have an indirectly related outcome on supporting the implementation of the ACARA AC Technologies-Digital Technologies learning area by the timeline of 2016 to 2026 and 2021 respectively.

The next chapter continues with the data findings by reviewing the third and final major theme Policy 3: *School partnerships with STEM organisations*.

Chapter 6

School Partnerships with STEM Organisations

This chapter reports the data analysis of Policy 3*: School partnerships with STEM organisations*. As in the previous two chapters, analysis is organized by the five policy dimensions of *Priority, Purpose, Research, Initiative and budget,* and the *Evaluative measure*. Similar to the previous chapters, examples from the coded data sets are used to examine Policy 3 across these dimensions.

Policy 3: School partnerships with STEM organisations

Dimension 1

    Priority-Action and Issue.

    Definition.

School partnerships with STEM organisations is the third theme which came to the fore through analysis of policy priority. For example, the Government of Australia has a stated *priority action* of 'equipping students with the essential skills for high wage and productive jobs' (DPMC, 2015). The research-based *issue*, which this *priority action* addresses, was noted in Government policy documents as "some jobs will be lost to automation and new jobs will be created in both new and existing industries" (DPMC, 2015, p.12) and is explained through the following data.

    Data.

Table 6.1 offers a sample of the data coded to Policy 3

Table 6.1

Coded Dataset: Priority

National Agency	Priority Action	Priority Issue
DPMC	"Equipping Australians with the skills needed for high wage, high productivity jobs" (DPMC, 2015, p. 12)	"In the coming decades some jobs will be lost to automation but many other new jobs will be created in both new and existing industries" (DPMC, 2015, p. 12)
OACS	"To improve student participation in STEM-related disciplines by encouraging school and industry collaboration" (OACS, 2017, p. 1) "Seeing schools and industry working in partnership" (OACS, 2017, p. 2)	"Our primary and secondary schools are not equipping our students in STEM subjects as well as in years past. Students are increasingly opting out of STEM subjects and when they do take them, their performance shows an alarming trend towards mediocrity" (STEM Partnerships Forum, 2017, p. 5)
EC	"Facilitating effective partnerships with tertiary education providers, business and industry" (EC, 2015, p. 6)	"Inequities in STEM. Girls, students from low socio-economic status backgrounds, Aboriginal and Torres Strait Islander students, and students from non-metropolitan areas can be less likely to engage with STEM Education and therefore have a higher risk of not developing high capabilities in STEM-related skills and miss out on the opportunities STEM-related occupations can offer" (EC, 2015, p. 4)

National Executive Agencies

The Department of the Prime Minister and Cabinet (DPMC)

As derived from the DPMC (2015), Policy 3 emerges through the document, *The National Innovation and Science Agenda* (NISA). As stated in Chapters 4 and 5, the NISA has the list of new *priority* policies that are to support and build on those stated within, *The Industry Innovation and Competitiveness Agenda* (the NIICA) (DPMC, 2014). Policy 3 was noted in the NISA but not within the NIICA. Thus, the NISA has informed this *priority action* and *issue*.

The *action* is to 'equip' all students with the skills inherent in earning a high wage and functioning in productive jobs. This is a noted new *action* in the NISA, rather than building on an *action* from the NIICA by the DPMC. The *action* addresses the *issue* that some jobs are being automated with the manual-equivalent skills no longer as highly valued or as productive, while there are emerging jobs within and by new industries, which are more highly valued and productive. It is anticipated that students should develop those skills that are highly valued and productive in these emerging jobs within new and existing industries, which are STEM based.

The *priority* is that all students, which includes primary, are learning highly valued and productive STEM skills to address concerns about future jobs. This *priority* has been determined by the DPMC, and was noted as 'new' in the NISA, through an indirect *action* and *issue* leading to school- based partnerships with organisations of these industries. Through the data, other National executive agencies were similarly analysed about this *priority*, including the OACS.

The Office of the Australian Chief Scientist (OACS)

Analysis of the OACS data noted two related *actions* (see Table 6.1 above) to encourage and to see school and industry collaborative partnerships. These *actions* were formed at the first meeting of the STEM Partnerships Forum, an initiative of the COAG Education Council with representatives from business and education in May 2017. This Forum, which was chaired by the Chief Scientist of Australia, defined these two *actions* as a priority for school-based implementation, which are as follows:

> To improve student participation in STEM-related disciplines by encouraging school and industry collaboration (OACS, 2017, p. 1)

> Seeing schools and industry working in partnership (OACS, 2017, p. 2)

From the inaugural meeting, the *issue* was that school-based learning and teaching of STEM skills relies on current scientific methods and information from highly valued and productive STEM businesses. This *issue* has focused on Science methods and information from businesses to represent industries Therefore, school partnerships with STEM organisations are to occur with highly valued and economically productive Science-based businesses, with limited regard to STEM industries and research organisations.

Overall, the EC (2015) NSSES informed both the DPMC and OACS with this *priority* as is shown through the following data.

The Council of Australian Governments (COAG) with the Education Council (EC)

Analysis of the EC's STEM Education strategy policy document (NSSES) identified an *action* on STEM partnerships with universities, business, and industry, but did not include schools. However, the NSSES is a school-based STEM strategy so the *action* implies that schools 'effectively' partner with universities, business, and industry.

The EC *issue*, which this *action* addresses is that there are inequalities within the schooling

system in terms of learning highly valued and productive STEM skills. Specifically, female, low-socio economic status, non-metropolitan, and Aboriginal and Torres Strait Islander students have a higher risk of not developing highly valued and productive STEM skills through the current system of schooling.

As stated, the EC reframes all *priorities* so as to have the greatest impact on school-based STEM Education. Thus, the EC priority focuses on effective STEM partnerships with universities, businesses, and industries by all schools to resolve these student-based inequalities.

Dimension 2

Purpose-Rationale and Objective.

Definition.

Purpose is the DPMC stated *rationale and objective* of a *priority* policy listed within an agenda. For example, the Government of Australia has a *rationale* of school partnerships with STEM organisations for students to be successful entrepreneurs, hold diverse jobs or work across different industries (DPMC, 2015). Linked with this *rationale*, the *objective* is to prepare the workforce for future jobs by implementing new initiatives in STEM partnerships that are school-based. Thus, a *priority* policy has a *purpose*.

Data.

Table 6.2 illustrates a sample of the data coded as National *purpose* for Policy 3.

Table 6.2

Coded Dataset: Purpose

National Agency	Purpose Rationale Statement	Purpose Objective
DPMC	Unstated and designed as: "[S]tudents to be successful entrepreneurs, hold a diverse number of jobs or work across a number of industries" (DPMC, 2015, p. 12)	Unstated and designed as: "Preparing our workforce for the jobs of the future (DPMC, 2015, p. 13) and; New initiatives…in…STEM partnerships" (DPMC, 2015, p. 13)
EC	"To encourage students to develop higher level STEM capabilities to build aspiration for STEM participation at tertiary levels and for STEM-related careers" (EC, 2015, p. 5)	"Ensure that students are inspired to take on more challenging STEM subjects" (EC, 2015, p. 5); "Establish a STEM Partnerships Forum" (EC, 2015, p. 10)
DET	"Students and teachers understand how STEM is applied in the real world…be introduced to emerging STEM innovations and potential career path…" (DET, 2017b, p. 1), and; "to help students understand how STEM is applied in the real world. This initiative builds on the existing Scientists and Mathematicians in Schools program delivered by the CSIRO" (DET, 2017b, p. 1)	*Not evident* and designed as: "flexible partnerships between STEM professionals and schools, helping students and teachers understand how STEM is applied in the real world. They will be introduced to emerging STEM innovations and

	potential career paths, student mentoring opportunities, and a better understanding of industry expectations. There will be a focus on brokering partnerships with women currently working in STEM" (DET, 2017b, p. 1)

National Executive Agencies

The Department of the Prime Minister and Cabinet (DPMC)

A direct DPMC policy *purpose* was unspecified within the NISA, but a *rationale* statement was noted that school partnerships with STEM organisations develops students as successful entrepreneurs, to hold diverse jobs, and work in different industries in the future. This *rationale* links with the *priority action and issue* of equipping Australians with the skills for high quality and productive jobs to address the loss of jobs to technological automation and the emergence of new jobs and industries.

The policy *purpose* has an *objective* but has limited data. The two-fold objective was noted as a workforce prepared for the jobs of the future. A second and more direct *objective* was to implement new *initiatives* (see Dimension 4 below) on school-based STEM partnerships.

Led by the DMPC, the policy *purpose* is that school partnerships with STEM organisations develops a workforce prepared for future jobs as successful entrepreneurs, holding different jobs, and in diverse industries, which is to occur through the implementation of new school-based initiatives in STEM partnerships.

The Council of Australian Governments (COAG) Education Council (EC)

The COAG EC, *National STEM School Education Strategy* (NSSES) (2015) *rationale* was noted that STEM partnerships support teachers and develops all students' aspirations and capabilities in STEM skills. As stated, the EC *purpose* is to frame, develop, and coordinate all Government STEM Education policies to support those that evidently can improve on school-based STEM Education practices. Thus, the DPMC *purpose* has been reframed to partnerships to support teachers and develop students to aspire to, and be capable of, highly valued and economically productive STEM skills.

The EC NSSES has two *objectives* attributed to this *rationale*:

> Ensure that students are inspired to take on more challenging STEM subjects (EC, 2015, p. 5);
>
> Establish a STEM Partnerships Forum (EC, 2015, p. 10)

There was limited EC data on how school-partnerships with STEM organisations might ensure students take on more challenging STEM subjects. STEM skills and regard to an ethical and moral framework for learning and teaching was not evident as a *purpose*.

As stated, the NSSES *priority* and the *purpose* were agreed to by the National and State/Territory Government education ministries with regard to the *Melbourne Declaration on Educations Goals for Young Australians* (MDEGYA) (EC, 2008). The MDEGYA had limited data linked to the EC NSSES on a *purpose* of future workforce preparation by governments collaborating with schools.

The National Department of Education and Training (DET)

The DET webpage has a *rationale* that school partnerships with STEM organisations had helped students and teacher to understand contemporary professional practices in STEM. The *purpose* is that school-partnerships develop teaching and learning practices that are authentic to and introduces the emerging innovations and careers in STEM. This *rationale* links with the DPMC and EC. School partnerships with STEM organisations for learning and teaching 'real-world' STEM innovations and careers is the DET noted *purpose*.

The limited data by the DET noted the objective as flexible school-partnerships with STEM professionals that include females working in STEM helping students and teachers to understand STEM careers and innovations for work in the future. Noted from an online DET communication, this objective differs from the DPMC and EC to focus on female professionals working in STEM.

Overall, the DET had limited further data on a *purpose* notably on school-based partnerships with females working in STEM in policy documents.

Dimension 3

    Research-Citation and Reference.

    Definition.

Research is the evidence or academic research base used to inform a Primary STEM Education policy formulated by the Government of Australia, which is identified by the research *citations* and *references* to a policy within an agenda and policy documents. For example, the Government of Australia has paraphrased research by The Foundation for Young Australians in the National NISA agenda (DPMC, 2015), which was considered limited in the extent, relevance and quality of *research* informing the policy dimensions. While, a *reference* to this *citation* was not listed, *references* had been listed in prior agendas (i.e., the NIICA).

Data.

Table 6.3 illustrates a sample of the data coded to National *research* for Policy 3.

Table 6.3

Coded Dataset: Research

National Agency	Research Citation	Research References
DPMC	Uncited on this policy. However, a highlighted paraphrase as: "The Foundation for Young Australians predicts that today's young people will hold as many as 17 different jobs, in five different careers" (NISA) (DPMC, 2015, p. 12)	Unreferenced (NISA) (DPMC, 2015)
OACS	"This approach is consistent with the Australian Government's Guiding Principles for School- Business Relationships (2012)" (The AiGroup, 2017, p. 9)	Referenced industry report
DET	Guiding Principles for School – Business Relationships (DET, 2013)	Unreferenced

National Executive Agencies

The Department of Prime Minister and Cabinet (DPMC)

Analysis on the NISA document noted the policy *research* by the following paraphrase; which is a form of *citation*:

> The Foundation for Young Australians predicts that today's young people will hold as many as 17 different jobs, in five different careers, over the course of their working lives (DPMC, 2015, p. 12)

This NISA marked *citation* was unattributed and a *reference* list was not included. (This citation was also ascribed to Policies 1and 2, shown in the prior chapters.) As stated, the academic *research* was limited by the paraphrasing of a report and without a *referenc*e list.

The Office of the Australian Chief Scientist (OACS)

The OACS had funded and presented a research-based report through the STEM Partnerships Forum on school partnerships with STEM organisations, which was *cited* and *referenced*. The Australian Industry Group (AiGroup) - *Strengthening School – Industry STEM Skills Partnerships* (SSISSP), completed the commissioned OACS research using the following methodology:

> This approach is consistent with the Australian Government's Guiding Principles for School-Business Relationships (2012) (The AiGroup, 2017, p. 9)

A case-study method was used with the data sourced from approximately 30 secondary schools across Australia, and overseen by a reference group that included one academic education researcher from Monash University.

On analysis, the *actions* are noted:

> Teacher Professional Development
>
> 1. Education systems to provide:
>
>   a) professional development for teachers of mathematics on how to integrate mathematics into a STEM-based curriculum
>
>   b) professional development activities for teachers of digital technology on how to integrate digital technologies into a STEM-based curriculum
>
>   c) professional development for teachers on integrating other subjects into a STEM-based curriculum
>
> Resources for Schools
>
> 2. Education systems to develop advice and resources for schools on how to engage with industry partners to develop STEM skills in schools.
>
> 3. Education systems to promote the three models of school-industry engagement identified in this project:

a) Single school – single company

b) Multiple schools and multiple companies and university

c) Multiple organisations – schools, government, peak industry bodies

Resources for Industry

4. Develop resources for use by employers that highlight approaches to forming

partnerships with schools to implement STEM strategies.

5. Establish a national forum that will facilitate dialogue between industry and schools in

STEM education, thus enabling best practice to be shared. (AiGroup, 2017, p. 4)

The OACS presented a research-based report on school-based initiatives in STEM

partnerships, which was completed by an industry-based organisation. The findings were

focused on teacher professional development in STEM disciplines, school resources, and

industry resources from a case-study of 30 secondary schools, which are linked to this

policy by the OACS. Analysis for a Government response to these recommendations and

research on primary schools was not evident in the datasets at the time of this study.

The AiGroup (2017) *reference* list included:

ACARA STEM Quality Project Report, ACARA, June 2016.

Australian Council of Learned Academies STEM: Country Comparisons, Final Report,

May 2013.

Australian Council of Learned Academies, The role of science, research and technology

in lifting Australia's productivity, June 2014.

Australian Industry Group, Lifting our Science, Technology, Engineering and Maths

(STEM) Skills, 2013.

Australian Mathematical Science Institute, Dealing with Australia's Mathematical

Deficit, May 2014.

Australian Workforce and Productivity Agency, Australia's skills and workforce development needs, Discussion Paper, July 2012.

Becker, K. & Park, K. Effects of integrative approaches among STEM subjects on students' learning, Journal of STEM Education 12, July – September 2011.

Bybee, R. The Case for STEM Education: Challenges and Opportunities, NSTA Press, 2013.

Craig, E. et al. No Shortage of Talent: How the global market is producing the STEM Skills needed for growth, September 2011, Accenture Institute for High Performance.

Font, R. R. et al. CRECIM, Universitat Autonoma de Barcelona, Bellaterra: Establishing and Maintaining STEM-Related School-Industry Partnerships: Opportunities and Obstacles in : In C. P. Constantinou, N. Papadouris & A. Hadjigeorgiou (Eds.). E-Book Proceedings of the ESERA 2013 Conference

https://www.esera.org/media/esera2013/Raquel_Rios_13Feb2014.pdf

Hoyles, C., Noss, R., Kent, P., and Bakker, A. (2010) Techno-mathematical Literacies in the Workplace RESEARCH REPORT.

Hoyles, Celia. (2007). Understanding the Environment: Techno-Mathematical Literacies in the Workplace: Full Research Report ESRC End of Award Report, RES-139-25-0119. Swindon: ESRC: REFERENCE No. RES-139-25-0119).

Korbel P. Measuring STEM in vocational education and training: NATIONAL CENTRE FOR VOCATIONAL EDUCATION RESEARCH, 18 October 2016.

National Foundation for Educational Research (UK), Research Report DFE-RR147: The STEM cohesion programme: final report, Department of Education ISBN: 978-1-84775-984-9 © NFER July 2011.

National STEM School Education Strategy, Education Council, December 2015.

Norton, A.: Mapping Australian higher education 2016- Grattan Institute, August 2016.

Office of the Australian Chief Scientist, Science, Technology, Engineering and Mathematics: Australia's Future, September 2014.

Research Councils UK, Evaluation: Practical Guidelines, Department for Business Innovation and Skills, April 2011.

Rickards, F., Dean of Education, University of Melbourne, August 31 2016 in The Conversation Scientific American: STEM Education is vital-but Not at the Expense of the Humanities-The Editors October 1, 2016 (https://www.scientificamerican.com).

Siekmann, G.: What is STEM? The need for unpacking its definitions and applications: (NCVER: 18 October 2016. ISBN: 978-1-925173-66-6).

STEM Programme Index 2016 at http://www.chiefscientist.gov.au/2016/01/spi-2016-stem-programme-index-2016-2/

Thomson S. Director, Educational Monitoring and Research Division; Research Director, Australian Surveys Research Program, Australian Council for Educational Research in The Conversation April 13, 2016.

Tytler R. et al: Partnering with scientists boosts school students' and teachers' confidence in science–-Deakin University: in The Conversation, April 27, 2016.

Universities Australia, STEM and non-STEM First Year Students, January 2012.

Williams, J., University of Waikato, New Zealand, STEM Education: Proceed with Caution, Design and Technology Education: An International Journal 16.1 (2011).

(AiGroup, 2017, p. 78-80)

This list of *references* reflects the limited extent of academic *research* (only two recognised academic references) and the reliance on commissioned and industry based research with their associated limited review processes to form an evidence base in this report. The *reference* list has limited academic *research* on primary school-based STEM Education partnerships, indicating that there has been scant research on Primary STEM Education partnerships or that the policy research has focussed on secondary and tertiary STEM Education research data, or both.

The National Department of Education and Training (DET)

The DET (2013) documented the *Guiding Principles for School – Business Relationships,* which was *cited* in the OACS *research*. On analysis, this document did not *cite* nor *reference research,* which is interesting as three *research projects* were linked to this documented framework. On further analysis of the datasets, three *uncited* and *reference* listed *research projects* were linked to this DET document, and were included as follows:

1. Department of Education*, Employment and Workplace Relations. Unfolding opportunities: a baseline study of school-business relationships in Australia - Final Report* (PhillipsKPA, 2010).

2. *The Benefits of School-Business Relationships* (Australian Council for Educational Research (ACER, 2011).

3. *Realising Potential: Businesses Helping Schools to Develop Australia's Future* (Business-School Quality Roundtable, 2013).

These three reports had completed *research* on business and industry partnerships across the schooling years to include vocational education using case-study, survey and international country comparisons to inform this DET framework. Each report was limited in the extent of the data on primary school-based STEM partnerships, other than that the findings identified 90% of the studied partnerships being with secondary schools (in order to transition students into future work).

Dimension 4

Initiative and Budget-Projects and Funds.

Definition.

The *initiative and budget* is the DPMC statement on the various projects and the allocation of funds to a policy within an agenda. For example, the Government of Australia has the *initiative* of equipping students to create and use digital technologies by bringing scientists and ICT professional into classrooms with *funds* allocated from a *budget* of $51,000,000 from 2016 until 2019 (DPMC, 2015).

Data.

Table 6.4 offers a sample of the data coded to *initiative and budget* for Policy 3.

Table 6.4

Coded Dataset: Initiative and budget

National Agency	Initiative Project (and Programs)	Budget (Allocation of funds)
DPMC	"Equipping young Australians to create and use digital technologies…Scientists and ICT professionals in classrooms" (DPMC, 2015, p. 13)	"$51m funded from 2016 to 2019" (DPMC, 2015, p. 13) (bundled to three initiatives)
OACS	STEM Partnerships Forum (OACS, 2017)	*Not evident*
DET CSIRO	"The STEM Professionals in Schools program partners teachers with STEM professionals to enhance STEM teaching practices and deliver engaging STEM Education in Australian schools. STEM Professionals in Schools is funded by the Australian Government Department of Education and Training" (CSIRO, 2017, p. 1)	"Total funding for Inspiring all Australians in digital literacy and STEM is $112.2[M]. The DET initiatives total $64.6[M]. These initiatives will be provided from 2016-17. (DET, 2017b, p. 1) (bundled) Turnbull Government will provide $10 million for CSIRO to extend the Scientist and Mathematicians in Schools programme. The $10 million in funding, which is through the Science, Technology, Engineering and Maths (STEM) partnerships with Schools initiative under the Government's National Innovation and Science Agenda, will be allocated to the programme over the next four years" (CSIRO, 2016, p. 1)

National Executive Agencies

The Department of the Prime Minister and Cabinet (DPMC)

The Policy *3 initiative* entitled "Equipping young Australians to create and use digital technologies" (DPMC, 2015, p. 13) has three *projects* with *funds* allocated from the NISA budget of $51,000,000. Specifically, one of the three National *projects* was stated as "Targeted ICT and STEM programmes like…STEM partnerships to bring Scientists and ICT professionals in classrooms" (DPMC, 2015, p. 13). The amount of funding for this *project* was not identified. Although, $51,000,000 was stated to *fund* three *projects*, which links with the projects shown in the prior chapter on Policy 2. This *project* had an allocation of *funds* from this *budget* from 2016 until 2019.

The National agencies communications and documents were analysed to identify how (or whether) the DPMC had delegated this *initiative and budget*.

The Office of the Australian Chief Scientist (OACS)

The OACS (2017) presented a communique on the first meeting of the *STEM Partnerships Forum*. The *STEM Partnerships Forum* (Forum) was an *initiative* of the EC (2015) and a *project* by the OACS. The newly appointed Chief Scientist of Australian (ACS), Dr Alan Finkel, was the first Chair of this Forum. This *project* had two relevant activities:

1. More consistent monitoring and evaluation of the outcomes of STEM initiatives to build a reliable evidence based to inform partnerships

2. Partnerships on discipline-specific professional development for teachers (OACS, 2017, p. 2)

An OACS *project* on school partnerships with STEM organisations through a STEM Partnerships Forum is evident. The project has two activities of more consistent *research* on the *outcomes* from STEM initiatives, and forming partnerships for discipline specific teacher

professional development. The *project* did not elaborate on which area of schooling, and was considered to include primary and secondary. The *project* did not offer details about 'bringing Scientists and ICT professionals into schools', which is in contrast with the DPMC. No budget or allocation of *funds* for this *project* was evident in the data, which included the *budget* statements of the DPMC, Treasury, EC, and OACS.

This *project* is based on the EC NSSES, which reframed Government STEM policies in order to improve school-based STEM Education.

The communique listed the members of the forum, which included the Associate Secretary of the DET, and is presented next.

The National Department of Education and Training (DET)

In contrast, the DET detailed an *initiative and budget* on 'bringing Scientists and ICT professionals into schools':

> The STEM Professionals in Schools program partners teachers with STEM professionals to enhance STEM teaching practices and deliver engaging STEM Education in Australian schools. STEM Professionals in Schools is funded by the Australian Government Department of Education and Training … STEM Professionals in Schools (formerly Scientists and Mathematicians (and ICT Professionals) in Schools connects primary and secondary school teachers and STEM professionals with a broad range of expertise and experience to enhance STEM learning in Australian classrooms. The program is Australia's leading STEM Education volunteering program and provides an opportunity for business and individuals to contribute to the community through STEM Education. It provides individual matching of partnerships for you, your school or business, supported by a national team (CSIRO, 2017, p. 1)

The CSIRO had a *program* entitled STEM Professionals in Schools, a DET directed *initiative and budget*, but with limited evidence from the DET data. The *initiative and budget* was unspecified from the DET (2017), which had been allocated $64,600,000 from the NISA *budget*.

The CSIRO website stated on this *project and funds*:

> As part of National Science Week, the Turnbull Government will provide $10 million for CSIRO to extend the Scientist and Mathematicians in Schools programme. The programme links practising scientists, mathematicians, engineers and IT professionals with classroom teachers and their students. The $10 million in funding, which is through the Science, Technology, Engineering and Maths (STEM) partnerships with Schools initiative under the Government's National Innovation and Science Agenda, will be allocated to the programme over the next four years. CSIRO will continue to manage the program over the next four years, working with Australian educators from Foundation to Year 12 (CSIRO, 2016, p. 1)

A CSIRO developed *program* entitled Scientists and Mathematicians in Schools programme was extended to form partnerships with Engineers and IT professionals to support primary students and teachers within classrooms. The *program* was extended by a new NISA initiative in STEM partnerships to bring Scientists and ICT professionals into classrooms with $10,000,000 or 19.6% allocated from the $51,000,000 budget for four years. However, the *program* details and funds were indeterminable from the DET and DPMC, neither of which stated the nature of the *projects/programs* and allocation amounts from their *budgets* of $64, 600,000, and $51,000,000 respectively.

Dimension 5

Evaluative Measure - Outcomes and Timeline.

Definition.

The *evaluative measure* is the DPMC statement on the policy *outcome(s)* and the *timeline* within an agenda. For example, the Government of Australia has an *outcome* to bring Scientists and ICT professionals into classrooms and a *timeline* based on the budget of 2016 to 2019 (DPMC, 2015) or four years.

Data.

Table 6.5 offers a sample of the data coded as *evaluative measure* to Policy 3.

Table 6.5

Coded Dataset: Evaluative Measure

National Agency	Evaluative Measure Outcome(s)	Evaluative Measure Timeline
DPMC	"Scientists and ICT professionals in classrooms" (DPMC, 2015, p. 13)	*Not evident*, however noted as: "2016-2019" based on the allocated funds shown in the NISA to this initiative and budget (DPMC,
EC	"A STEM Partnerships Forum supporting teachers and developing students' STEM aspiration and capabilities, which may include; -Developing guidance and support materials for best practice models of partnerships -Increasing industry involvement in effective school-based partnerships" (EC, 2015)	*Not evident*, however noted as: 2016-2026 based on document title (EC, 2015)
DET DET/ CSIRO	*Not evident* by the data (DET), however noted as: " 1. What are the outcomes for students, teachers, and STEM professionals as a result of the Scientists and Mathematicians in Schools program (SMiS)? 2. How is the SMiS changing students' and teachers' engagement with, and knowledge and understanding of STEM practices?	*Not evident* within the data (DET) "Since 2007 the program has been evaluated three times"

3. What are the similarities and differences among the partnerships developed by teachers and scientists, teachers and mathematicians, and teachers and ICT professionals? 4. What are the strengths of the SMiS model? 5. What significant attributes of the SMiS model are highlighted when considering an overview of a range of initiatives involving STEM professionals, including university and industry working with schools? 6. In what ways could the SMiS model be implemented which would result in it being ahead of leading practice and which would enhance program outcomes and impact?" (Tytler, Symington, Williams, White, Campbell, Chittleborough, Upstill, Roper, Dziadkiewicz, 2015, p. 2)	(Tytler, Symington, Williams, White, Campbell, Chittleborough, Upstill, Roper, Dziadkiewicz, 2015, p. 1)

National Executive Agencies

The Department of the Prime Minister and Cabinet (DPMC)

The NISA did not specify an *evaluative measure* for bringing Scientists and ICT professionals into classrooms. A noted *outcome and timeline* is that all Scientists and ICT professionals were to be brought into primary classrooms for learning and teaching in highly valued and productive STEM skills and careers from 2016-2017 to 2018-2019, or four years. This *evaluative measure* was drawn from the NISA as a new *initiative* by a *project* on STEM partnerships to bring Scientists and ICT professionals into classrooms, which was *funded* from a $51,000,000 *budget* over four years.

The COAG Education Council (EC)

The analysis on the NSESS identified an *evaluative outcome*:

> A STEM Partnerships Forum supporting teachers and developing students STEM
>
> aspiration and capabilities, which may include;
>
> > -Developing guidance and support materials for best practice models of
> >
> > partnerships
> >
> > -Increasing industry involvement in effective school-based partnerships (EC, 2015)

The *outcome* was for a STEM Partnerships Forum to support teachers and develop students' aspirations and capabilities in STEM. Two further *outcomes* were listed and 'may include' best practice partnerships models as guidance and support materials, and increasing effective industry involvement.

The measurable *timeline* was unstated but considered between 2016-2026, which is the *timeline* of the NSSES document.

The National Department of Education and Training (DET)

The National DET data showed no policy *evaluative measure*. However, the CSIRO included an evaluation report. The report was defined as an *evaluation* of a DET and CSIRO *initiative*. This evaluation report, *Building Productive Partnerships for STEM Education: Evaluating the model & outcomes of the Scientists and Mathematicians in Schools program 2015,* noted a number of evaluative questions to indirectly suggest an *evaluative measure* to this policy with understanding on the *outcome(s)* as:

> 1. What are the outcomes for students, teachers, and STEM professionals as a result of the Scientists and Mathematicians in Schools program (SMiS)?
>
> 2. How is the SMiS changing students' and teachers' engagement with, and knowledge and understanding of STEM practices?

3.   What are the similarities and differences among the partnerships developed by teachers and scientists, teachers and mathematicians, and teachers and ICT professionals?

4.   What are the strengths of the SMiS model?

5.   What significant attributes of the SMiS model are highlighted when considering an overview of a range of initiatives involving STEM professionals, including university and industry working with schools?

6.   In what ways could the SMiS model be implemented which would result in it being ahead of leading practice and which would enhance program outcomes and impact? (Tytler, Symington, Williams, White, Campbell, Chittleborough, Upstill, Roper, Dziadkiewicz, 2015, p. 2)

The *timeline* for *evaluation* was unclear, yet the date of the document (report) was 2015, which is prior to the presentation of the NISA, and evaluated participants who had been involved in this project for three and seven years. While, the outcomes from this CSIRO report influencing the subsequent National priority *initiatives and budget* impacting this program (i.e., the NISA) were not evident in the data.

An *evaluation-measured timeline* was evident:

Since 2007 the program has been evaluated three times, leading to affirmation of the success of the model in terms of outcomes for students, teachers and the STEM Professionals, and recommendations for expansion (Tytler, et al., 2015, p. 1)

This *evaluation* report had details on *outcomes*:

First[ly], SMiS leverages considerable volunteer STEM professional resources to address the important national problem of student engagement. For the partnerships reported on in the survey, each partnership represents an estimated annual commitment of $1250 from the Australian Government Department of Education and Training and CSIRO. This funding input leverages however the equivalent of almost three times this amount

through the commitment of STEM professionals dedicated to improving STEM teaching and learning in schools…Second, to deliver the outcomes of the program by alternative means would be expensive…Third,…Teachers involved in the partnerships engage in significant professional learning through planning with the STEM professional and working with and observing their interactions with students. These professional learning opportunities and activities are consistent with current thinking about effective teacher development as being action oriented, collaborative, and grounded in local practice. The types of experiences and learning for students brought by STEM professionals, focusing as they do on authentic practice and offering role models of thinking and working in the disciplines, are consistent with current thinking concerning best practice in supporting engagement with learning in science and mathematics and student choice of STEM futures. Outcomes for STEM professionals include increased commitment to educating future generations, and skills in interpreting their practice for a wider audience. Fourth, there are valuable longer-term impacts attributable to the SMiS program because of its distinctive and central role as a STEM outreach activity. The impact of the SMiS program relates to its status within Australia as emblematic of the incorporation of contemporary STEM practice into school curricula, its focus on ways of thinking and working in the STEM disciplines, and its alignment with contemporary directions in science, mathematics and ICT curricula. Discontinuation of the program would represent a significant loss to innovation in contemporary thinking in STEM teaching and learning. Continuing and scaling up the program would open the possibility of establishing in Australia a significant new direction in teaching and learning in STEM subjects (Tytler, et al., 2015, pp. 4-5)

Even though the DET data was not noted as an *evaluative measure*, DET had evidence of a CSIRO commissioned *evaluation* occurring every three years linked with the NISA *initiative and budget* 'STEM professionals in classrooms' program since 2007.

The CSIRO program evaluation provided an evidence-base from which to inform this policy in the longer term of the Government. Government regard to the CSIRO evaluation outcomes to inform subsequent National priority policy initiatives and budgets was not evident. For

example, an *outcome* was that continuing and scaling the CSIRO program in Australia offers

a significant new direction in learning and teaching STEM subjects (Tytler, et al., 2015),

which was not evident in the NISA. This *outcome* is based on the contemporary professional

practices that STEM professionals have directly contributed to classroom practices by

evaluating this CSIRO program every three years since 2007.

Table 6.6 offers an overview of the data by dimension for Policy 3.

Table 6.6.

Policy 3 School Partnerships with STEM Organisations

Australian Government STEM Education Policy Context: Priority Policy Dimensions	
Priority Policy 3: School partnerships with STEM organisations	
1. *Priority*	*Action*: "Equipping Australians with the skills needed for high wage, high productivity jobs" (DPMC, 2015,p. 12) *Issue*: "In the coming decades some jobs will be lost to automation but many other new jobs will be created in both new and existing industries" (DPMC, 2015, p. 12)
2. *Purpose*	*Rationale*: *Not evident* and designed as: "[S]tudents to be successful entrepreneurs hold a diverse number of jobs or work across a number of industries" (DPMC, 2015, p. 12) *Objectives: Not evident* and designed as: "Preparing our workforce for the jobs of the future" (DPMC, 2015, p.13) and; "new initiatives…in…STEM partnerships. to bring Scientists and ICT professionals into schools" (DPMC, 2015, p. 13)
3. *Research*	*Citation:* Uncited on this policy. However, a highlighted paraphrase as: "The Foundation for Young Australians predicts that today's young people will hold as many as 17 different jobs, in five different careers" (NISA) (DPMC, 2015, p.12) *Reference:* Unreferenced (NISA) (DPMC, 2015)
4. *Initiative & Budget*	*Project: "*Targeted STEM partnerships to bring Scientists and ICT professionals in classrooms" (DPMC, 2015, p. 13) *Funds: "*$51[M] funded from 2016 to 2019" (DPMC, 2015, p. 13) (bundled to three projects)
5. *Evaluative Measure*	*Outcomes*: "Scientists and ICT professionals in classrooms" (DPMC, 2015, p. 13) *Timeline: Not evident*, however noted as: "2016-2019" based on the allocated funds shown in the NISA to this initiative and budget (DPMC, 2015, p. 12)

Chapter Close

Policy 3 was the third and final *priority* policy based on the data coded for this study. Policy

3 illustrates that:

1. *Priority action* that all students are equipped with the skills for high wage and productive jobs to build the national economy. The *priority issue* to be addressed is noted that jobs are being lost to technological innovation and new jobs in STEM emerging and existing industries require these skills, which are higher in wages and are economically more productive;

2. *Purpose* of school partnerships with STEM organisations is for students to be successful entrepreneurs, work in many diverse jobs and industries. The *objective* is to prepare a workforce for the higher wages and economically productive jobs and industries in the future;

3. *Research,* which was *uncited and unreferenced*, in the current National agenda was a research-based report by The Foundation for Young Australians on the nature of work as STEM skill based in the future. Primary school-based partnerships with STEM organisations evidence of academic research was limited in the data;

4. *Initiative and budget*, which was limited with *projec*t details and reconcilable budgets to the allocation of *funds* from the data. The CSIRO has noted on extending a program bringing Scientists, Mathematics, Engineering and IT professionals into classrooms with $10,000,000 over four years from the DET via the NISA *initiative and budget*; and,

5. *Evaluative measure* that was unspecified and indirectly implied as Scientists and ICT professionals in all primary classrooms from the budget *timeline* of 2016 to 2019. The DET has evidence that a CSIRO volunteer-based program bringing STEM professionals into classrooms has been evaluated every three years since

2007. Several *outcomes* were provided such as continuing the development of and to scale this program up to assist in contemporary learning and teaching of STEM skills Australia wide.

This chapter has presented analysis of the *priority* policy of *School Partnerships with STEM Organisations*. The next chapter continues with the data outcomes through analysis of the State and Territory Education Government agencies in relation to these three National policies.

Chapter 7

Policy Fidelity

This chapter is the analysis of policy fidelity or continuity by the Government of Australia. Informed by the literature review and the data analysis explained in Chapter 3, five policy attributes of *Alignment, Coherence, Continuity, Focus, and Scale* were evident and have been used as an analytic frame to further examine the quality of the STEM Education policy environment. In this chapter, Policy 1: Specialist STEM teachers, has been examined as an indicative case using the five attributes in order to assess the fidelity of policy development and application or interaction between the Federal and State/Territory Governments. This policy is indicative because of the extent of data that was available to comprehensively inform a Primary STEM Education policy for school-based implementation as formulated by the Government of Australia, when compared to the data collected and analysed at the time of this study.

Background

The Government of Australia STEM Education policy is disconnected, fragmented, incoherent, and inefficient according to research (see, Freeman, 2013; OACS, 2013, 2014; OECD, 2015a, Shomos, 2010). As noted at the outset of this thesis, a conceptual framework has been conceptualised to visually represent this study and is represented again in Figure 7.1 for ease of access for the reader in situating this chapter in relation to the three previous chapters.

Figure 7.1

Conceptual Framework
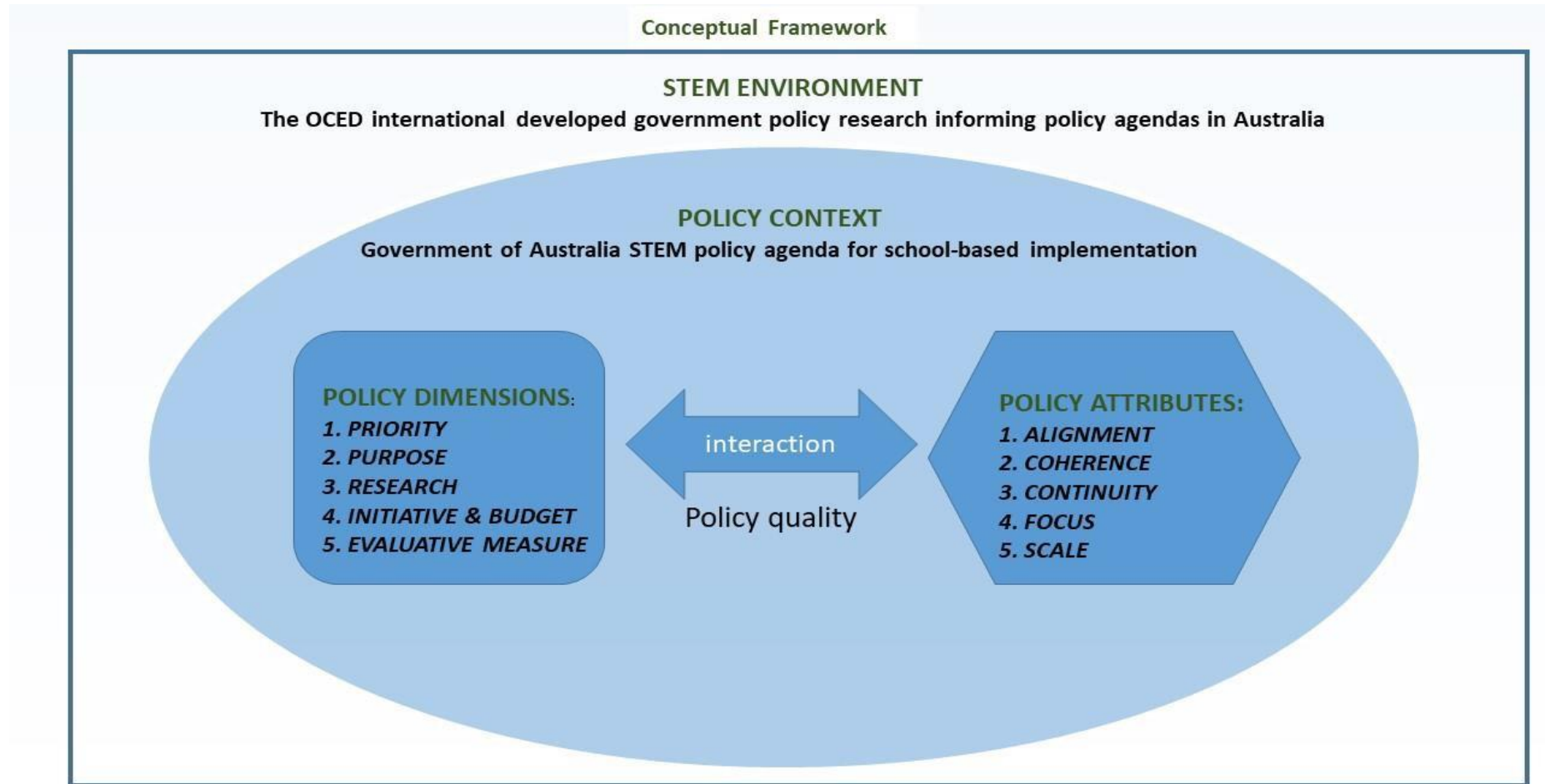
Following analysis of the three priority policies using the five *dimensions* in Chapters 4 to 6, the policy attributes from the conceptual framework were then used to examine policy fidelity between the Federal and State/Territory Governments. As explained in Chapter 3, the five *attributes* used for analysis of Policy 1 (as an indicative case) are:

1. *Alignment*—The matching of a policy specified by the current National agenda through to the State/Territory education ministerial portfolios and agencies (Earley, 2005; Pieters, Dimkov, & Pavlovic, 2013);

2. *Coherence*—The systematic presentation of mutually reinforcing policies (which impact school-based Primary STEM Education) across Government departments to create synergies in order to achieve agreed objectives and to limit contradictions. The importance of coherence is to minimise inconsistencies between the policies by the Federal, State, and Territory Governments by creating collaboration between their education ministries, and agencies, with the intention of increasing the effectiveness of school-based implementation (European Commission, 2018);

3. *Continuity*—The evolution of a priority policy from production to implementation informed by academic research to effectively build and develop policy over the longer term of a Government (Dunn, 2015). Continuity is required in order to produce incremental shifts that improve and change the nature of a policy rather than to have competing, conflicting, or ineffective policies (Cerna, 2013);

4. *Focus*— The extent that a policy is framed to a shared vision and strategy by the Federal and State/Territory Governments (Curtin, 2000). For example, to have a policy framed by the Federal to which each State and Territory is concurrently interacting with regard to school-based implementation (i.e., framing the nature of the workforce, curriculum, assessment, pedagogy, resources, infrastructure, and administration) ; and,

5. ***Scale―*** The ability of a framed policy to be efficacious on a small scale under controlled conditions, and through academic evaluative measure(s) to then be reliably expanded nation-wide (Milat, King, Bauman, & Redman, 2013).

Together and in this order, it can be well argued that these *attributes* exemplify fidelity in terms of policy formation, and in this specific case, Primary STEM Education policy. The *attributes* can be viewed as a proxy for the comprehensive nature of a policy and offer a window into the notion of quality in policy formulation.

Policy 1: Specialist STEM teachers

Using Policy 1 as an indicative case, fidelity is able to be determined when analysed using the five attributes noted in Figure 7.1. The State and Territory Governments' STEM Education policy communications and documents, as located online, were analysed across the three National policies presented in the three previous chapters. While Policy 1: Specialist STEM teachers is offered in this chapter as an indicative case (see Table 7.1 below), similar summary overviews of Policies 2 and 3 are included in Appendices 15 and 16 respectively. Policy 1 is used as a representative case of analysis of fidelity because it had the greatest amount of coded data; although similar outcomes were noted on Policies 2 and 3.

Table 7.1

Policy 1: Specialist STEM teachers

Australian Governments STEM Education Policy Context: Priority Policy Dimensions	
Priority Policy 1: Specialist primary STEM teachers	
1. Priority	Action: "Requiring that new primary school teachers graduate with a subject specialisation, with priority for science, technology, engineering and maths (STEM)" (DPMC, 2015, p. 5) "Teacher quality…Work with state governments on the area of teacher quality" (DPMC, 2014, p. 47) Issue: "There are obstacles we need to overcome… School students' maths skills are falling" (DPMC, 2015, p. 1) "Election commitment to restore the focus on science and mathematics in primary schools" (DPMC, 2014, p. 47)
2. Purpose	Rationale: "A more innovative Australia will improve the quality of life of Australians across the country, from our cities and our regions, to our rural and remote communities. Every Australian will benefit from an agenda that puts innovation and science at the heart of government" (DMPC, 2015, p. 5) Objectives: Unspecified and designed to: "Our education system, therefore, must equip students to be successful entrepreneurs, hold a diverse number of jobs or work across a number of industries" (NISA) (DMPC, 2015, p. 12).
3. Research	Cited: Uncited on this policy. However, a highlighted paraphrase as: "The Foundation for Young Australians predicts that today's young people will hold as many as 17 different jobs, in five different careers" (NISA) (DPMC, 2015, p. 12) Limited or indirect cited paraphrasing noted to the OACS (2014) within the (NIICA) (DPMC, 2014) Referenced: *Not evident* (NISA) (DPMC, 2015), referenced (NIICA) (DPMC, 2014)
4. Initiative & Budget	Project: *Not evident*, however noted and attributed to the NIICA policy as a "built on and supported policy" (NISA) (DMPC, 2015, p. 5); and, "working

	the States and Territories on a national STEM School Education Strategy" (NISA) (DMPC, 2015, p. 12) Funds: *Not evident* from the imbalanced and bundled "$1.1B budget" (NISA) (DPMC, 2015, p. 16)
5. Evaluative Measure	Outcomes: *Not evident* on the action to: "Requiring primary pre-service teacher STEM specialisation" (DPMC, 2015, p. 5) Timelines: *Not evident* from the imbalanced budget timeline of: "2015-2019" (DPMC, 2015, p. 12)

Attribute 1

Policy Alignment.

Definition.

Policy *alignment* is the matching of a policy specified by the PM, the DPMC, and the DPMCP with the Federal and State/Territory Education and Training ministries, agencies, and portfolios on Primary STEM Education (Earley, 2005; Pieters, Dimkov, & Pavlovic, 2013). Analysis of *alignment* is based on examples from the six States and two Territory Governments' STEM education policy agendas. Two Government education ministries' agency data (the NT, and QLD) are used in detail to show the variation with *alignment* to Policy 1.

Data.

The NISA begins with how the State and Territory Governments, "require[ed] pre-service primary teachers to choose to graduate with a specialisation in STEM" (DPMC, 2015, p. 5). Graduating with a specialisation in STEM is the priority action intended to align with a whole-of-government approach for Policy 1. However, the *issue* being addressed (see Chapter 4) was unable to be determined, limiting *alignment* by the State and Territory Governments, despite, a Federal election commitment to address 'students' falling math skills'. This commitment led

to a whole of government expectation that STEM specialisations would be offered in primary initial teacher education programs to boost primary STEM Education across schools in each State and Territory. In addition, the expectation was that the Federal Government would work with the State and Territory Governments to administer policy. Therefore, it might be expected that such 'offerings' would clearly be evident in the action plans, strategies and budgets of each of the six State and two Territory education agencies. Analysis of these State and Territory Government education agencies showed no such action, and, hence their 'policies' differed and were 'unaligned' with the NISA as explained below.

State and Territory Government Ministers and Agencies

The Government of the Northern Territory (NT)

The NT Department of Education (NTDOE) did not have evidence of an *action* in place to require pre-service primary teachers to "choose to graduate with a specialisation in STEM". Instead, a NTDOE annual reported *action* was:

> To improve the way science, technology, engineering and mathematics (STEM) is taught in our schools (NTDOE, 2017, p. 62)

This *action* was to be realised by several 'activities' that specifically included:

> The department visited 40 Northern Territory government schools, including 13 remote schools, and three libraries demonstrating technology, providing professional development for teachers and facilitating lessons for students in STEM (NTDOE, 2017, p. 62)

Initiatives and budgets to improve how STEM would be taught in schools and would align with the NISA Policy 1 were not forthcoming.

Policy 1 *alignment* was unable to be identified in NTDOE documents. The NTDOE had framed policy linked to the Government of the NT policy agenda, which was entitled *Framing the Future* (NTDCM, 2016), as opposed to links to the NISA:

> Our Strategic Plan reflects Government's Framing the Future priorities and sets out the goals and strategies to achieve our vision to educate young Territorians to become confident and capable global citizens. Our goals and strategies are translated into actions through division and directorate plans; into business unit and school plans; and then into individual staff plans (NTDOE, 2016, p. 8)

This NTDOE Strategic Plan (NTDOESP) offers a *Literacy and Numeracy Improvement Policy* (LNIP) (NTDOE, 2015), rather than a STEM Education policy. The NTDOESP was the most recent and related STEM policy document published by the NTDOE at the time of this study.

The NTDOESP featured an introduction by the NTDOE, CEO, Ken Davies, who stated that:

> The plan provides the strategic direction for education and children's services in the Northern Territory for the next three years. It supports the Government's Framing the Future agenda of improving the social and economic circumstances of people in the Northern Territory, particularly in remote communities and building a strong society with a robust economy and prosperous outlook (NTDOE, 2016, p. 2)

As shown, the NTDOE *actions* align with the NT Department of the Chief Minister's (n.d.) *Framing the Future policy agenda (*NTFFPA), rather than with the NISA. While, the stated *issues* of improving social and economic 'circumstances' aligns with the NISA, these issues were to be addressed by a literacy and numeracy policy with the Territory agenda. The analysis outcomes from the NTDOESP and NTFFPA documents showed no *priority action, purpose rationale, research, initiative and budget, or an evaluative measure* (i.e., policy dimensions, see chapter 4), which *aligned* with the NISA.

As the data makes clear, the NT Government had limited *alignment* with Policy 1 when considered in terms of an all-encompassing and whole-of-government approach. Improving teaching in STEM was made an *action* in a NTDOE plan that appears in-concert with the NISA, but is unaligned in terms of the requirement for specialist STEM teachers. *Alignment* was noted by the NTDOE to a Territory policy agenda entitled 'Framing the Future' rather than the NIICA or NISA in following a Literacy and Numeracy Policy. Limited *alignment* by the Government of the NT was evident because a Territory policy on specialist STEM teachers in schools was not noted in the data (the full dataset is in Appendix 17). The NT is one example that shows how policy fidelity (according to analysis by this first attribute of *alignment*) is not evident.

The Government of Queensland (QLD)

The QLD Department of Education and Training (QLDDET (2016a) *A Strategy for STEM in Queensland State Schools* (QLDSSQSS) was their concurrent policy document, which noted three *actions* linked to the NISA. One *action* was noted in relation to Policy 1:

> Building teacher capability to transform STEM learning (QLDDET, 2016a, p. 1)

The QLDDET had a *priority action* to build teacher capability to transform STEM learning in schools. However, this *action* was unaligned with the NISA as it did not require pre-service primary teachers to choose to graduate with a specialisation in STEM.

The QLDSSQSS noted that:

> Our challenge is to ensure we prepare every young Queenslander to take advantage of the many opportunities a knowledge-based economy offers and become the entrepreneurs of tomorrow (2016a, p. 1)

The QLDDET *issue* is therefore to have a STEM prepared workforce. The QLDDET *priority* is then to prepare students for the knowledge-based economy of the future as entrepreneurs by

building teacher capability to transform STEM learning. This *issue aligns* with the NISA, however the *action* does not.

The QLDDET *purpose* was:

> Science, technology, engineering and mathematics (STEM) touch every aspect of today's world, and the innovations that emerge from these fields underpin the global economy … Our teachers are critical to the success of our plan for STEM. Supporting teachers to innovate and engage with cutting edge science and teaching practice will transform the teaching of STEM in every state school (QLDDET, 2016a, p. 1)

The policy *rationale* is that STEM skills are the basis of global economic development and innovation, which aligns with the NISA. Further, teachers and support them are critical to a successful STEM policy. Interestingly, the QLDDET has rationalized that supporting teachers to innovate and engage with 'cutting edge Science' rather than STEM will transform the teaching of STEM in school-based Primary STEM Education. The QLDDET has presented STEM teaching practice as Science based rather than STEM as a transdiscipline.

The noted QLDDET *objective* is:

> Giving every state school access to specialist STEM teacher (QLDDET, 2016a, p. 2)

This *objective* was also noted in a STEM Education strategy by the QLD Office of the Chief Scientist (QLDOCS) (2013), which showed *alignment* with the *actions* by the EC and OACS, rather than the DPMC (NISA).

The research:

> In primary schools - where our students are below the national average in science–most Australian teachers do not have a tertiary background in the major traditional sciences (QLD Office of the Chief Scientist (QLDOCS), 2013, para. 9)

A QLDOCS STEM Education strategy *cited and referenced research* on the location of primary students below the national average in Science, based on the NAPLAN-SL data, with the extent of tertiary qualifications in traditional Science held by primary teachers. However, this *research* indicated that those primary schools with student achievement below the national average in NAPLAN-SL was where teachers 'do not have a tertiary qualification in Science' (AITSL, 2017a), which is likely for the overwhelming majority of schools since the initial primary teacher tertiary qualification is based on a generalist teacher workforce and is therefore neither Science nor STEM based. This research draws on the NAPLAN assessment data on Science Literacy, rather than also regarding academic research and data on STEM learning and teaching by a generalist educated and trained primary teaching workforce. This *research* showed *alignment* to that of the Federal OACS and QLDOCS, rather than the NISA, which had limited or no *research*. The limited extent of academic research *cited and referenced* by the NISA therefore limits the *alignment* by the State Governments. As indicated in Chapter 4, this policy has limited relevant academic *research* with which *alignment* might be evident.

As the data shows, the QLDDET was not fully *aligned* with the NISA policy. The QLDDET had an *action* to build teacher capability in STEM by giving every state school access to a STEM specialist teacher, rather than to require graduate STEM specialists. The *purpose* was that contemporary STEM skills are the basis for economic development and innovation, and that support for teachers in learning contemporary STEM practices is critical to policy success, which aligns. The *cited and referenced research*, while limited with academic research on Primary STEM Education, was not *aligned* with the NISA, which has *uncited and unreferenced research*. As this section illustrates, the QLDDET has limited *alignment* in relation to *action, purpose, research, initiatives and budgets, and evaluative measure* (the full dataset is in Appendix 18), and therefore Policy 1 cannot be considered an *aligned* policy.

Overview of Attribute 1: Alignment

Policy *alignment* between the Federal and State/Territory education agencies was limited at best. This limited *alignment* is because the Federal (i.e., DPMC, DET, and EC) and State/Territory education ministries and agencies formed differing State Government policy agendas to the NIICA, NISA and NSSES. The NTDOE was shown to have a limited STEM Education policy that was linked to a NT policy agenda entitled *Framing the Future*, rather than from the NISA or NSSES. In contrast, the QLDDET had a STEM Education policy 'to improve teaching capacity in STEM' by an *objective* to 'support all schools with access to a specialist STEM teacher', with regard to *research cited and referenced* by the OACS and QLDOCS. Overall, no State or Territory education agency had evidence of an aligned *action* to require that pre-service primary teachers would 'choose to graduate with a specialisation in STEM', even though the National agencies hold universities accountable for teacher education. National, State and Territory agency alignment is critical for a whole-of-government approach to formulating quality policy (which is discussed in Chapter 9). A detailed action plan, vision, and strategy on how all pre-service primary teachers would be required to choose to graduate with a specialisation in STEM was not evident, therefore there was no 'whole of government' policy *alignment*.

Attribute 2

Coherence.

Definition.

Policy **coherence** refers to the systematic presentation of mutually reinforcing policies across Government departments to create synergies towards achieving agreed objectives and to limit contradictions. Policy *coherence* is a process that takes into account the development of objectives and outcomes in all policies, which on evaluation, impact school-based Primary STEM Education. The purpose of *coherence* is to minimise inconsistencies between the policies by the Federal, State, and Territory Governments through collaboration between their education ministries, and agencies (European Commission, 2018). *Coherence of* a STEM

Education policy would be evident if the policy framework of the State and Territory education agencies interlinked with the NISA, i.e., were coherent in terms of the over-arching National policy dimensions.

Data.

For State and Territory Government policy *coherence*, evidence was sought that linked with the NISA policy, which includes the *purpose* (see Table 7.1 and Chapter 4):

> A more innovative [and entrepreneurial] Australia will improve the quality of life of Australians across the country. (NISA) (DPMC, 2015, p. 5)

> The Education system … must equip students to be successful entrepreneurs, hold a number of diverse jobs or work across a number of industries. (NISA) (DMPC, 2015, p. 12)

Table 7.1 draws on the NISA to link with *purpose* as a basis for determining *coherence*. Two Government education ministry data (NSW and VIC) are used in detail to show the variation with *coherence* to Policy 1.

The Government of New South Wales (NSW)

The NSW Department of Education and Training (NSWDOE) had evidence of *coherence* with the NISA policy. However, the NSWDOE STEM policy was not formally documented and was designed based on several NSW STEM and STEM Education policy texts, which included a communication made by the NSW premier (2017) via a NSWDOE (2017) website entitled, STEM. The following quote is representative of this Government's initiative:

> In a NSW first, future primary school teachers are being trained as science and maths specialists to engage younger students in STEM (science, technology, engineering and mathematics) subjects … Primary teachers are currently trained as generalists in a range of subjects. From this year, teaching students from at least three NSW universities can become STEM specialists by electing to study additional maths and science courses.

> These specialists will help give young students more confidence in maths and science, so
>
> they're well prepared for high school and future careers (NSWDPC, 2016, p. 1)

The NSW Premier had an *action, purpose, and initiative* that pre-service primary teachers could "become STEM specialists by electing to study additional maths and science courses" (NSWDPC, 2016, para. 2) from at least three universities in NSW. A NSW STEM Education policy document was not identified at the time of this study, which was noted as such in a briefing paper (NSW Parliamentary Research Service, 2017).

The primary 'STEM' or Science and Mathematics specialist teacher education course requirements were developed by the NSW Board of Teaching and Educational Standards (BOSTES) in consultation with teachers, teacher educators and the education sector. Limited data was noted in terms of consultation with AITSL on these standards. AITSL (2017b) had no definition for primary STEM specialists, but instead maintained a generalist primary teacher definition. As this data suggests, limited *coherence* on STEM specialists with Science and Mathematics specialists was evident between the NISA and NSW. Furthermore, limited *coherence* existed between the two as a disciplinary versus a transdisciplinary understanding of specialist STEM teachers was not clear within the NSWBOSTES and AITSL datasets.

In contrast with the NSW Premier, a NSWDOE *rationale* links with the NISA:

> Rationale: A vibrant capacity in science, technology, engineering and mathematics (STEM)
>
> is pivotal to increasing our nation's productivity.
>
> Objective: Fostering quality teaching and leadership in STEM (STEM) (NSWDOE, 2017, p.
>
> 1)

This NSWDOE *rationale and objective* illustrates some connection or *coherence* with the National NISA, yet there is limited evidence because there is no formal NSWDOE STEM Education policy or strategy plan. So, again, as an *attribute*, the notion of policy *coherence* is limited. Interestingly, this lack of *coherence* is exacerbated by the difference between the

Premier's statements and those documents of the NSWDOE. (The NSW dataset is shown in Appendix 19).

The Government of Victoria (VIC)

The Victorian Department of Education and Training (VICDET), *VICSTEM STEM in the Education State* (VICSES) (VICDET, 2016), was the noted policy agenda linked with this State Government and the NISA. VICSES recorded an *action and outcome*:

> Ensuring an adequate supply of teachers with contemporary content knowledge in STEM subjects, and the pedagogical skills to stimulate their students' interest and learning (VICDET, 2016, p. 5)

This VICDET *action and outcome* has limited policy *coherence*. The VICDET defines STEM teaching as subject based by all primary teachers rather than as specialists. Hence the notion of ensuring an adequate supply of primary teachers with both the contemporary content knowledge in STEM subjects and the pedagogical skills to 'inspire' students' interest and learning in STEM has (through this document) shifted emphasis from specialist STEM teachers to teaching requirements for all primary school teachers.

The VICDET *issues* to be addressed:

1. Falling behind the world's top performing countries in STEM participation and achievement

2. Lacking skills required by the technology and knowledge industries (VICDET, 2016, p. 1)

This Government has a policy addressing Victoria's future economic development, so there is a level of *coherence* with the National issues.

Further, the VICDET (2017) *initiative*:

> Primary Maths and Science Specialists initiative will train 200 primary school teachers as maths and science specialists in 100 of Victoria's most disadvantaged government primary schools (VICDET, 2017, p. 1)

Rather than an *initiative* on pre-service primary teaching students to specialise in STEM, this initiative illustrates a shift toward the training of 200 in-service teachers as specialists in either Science or Mathematics. Therefore, the notion of specialist STEM teachers across the VICDET illustrates a loss of *coherence* with the NISA through both *action* and *initiative*.

It seems fair to assert that, this VICSES is dissimilar to that of the NISA and therefore lacks *coherence* in terms of the nature of primary STEM teaching in schools (i.e., as STEM, Science, or Mathematics specialists, or as generalists trained in contemporary STEM practices and pedagogy). Thus, the VICDET can be regarded as an agency showing clear variation with, and limited *coherence* to, a whole-of-government approach on Policy 1 (the VIC dataset is shown in Appendix 20).

Overview of Attribute 2: Coherence

Policy *coherence* is limited. The Government of NSW had an undocumented *initiative* of pre-service primary teachers to train as STEM specialists by electing to take courses in Science and Mathematics through at least three universities, rather than in STEM, and as a 'requirement'. This 'NSW first and new initiative' featured a pre-service primary teaching education course framework with STEM specialists, which had been designed for implementation by the NSWBOSTES rather than the framework by AITSL. AITSL defined a generalist primary teacher education and training framework with subject specialisation, rather than a STEM specialist teacher, which further limited *coherence*. The VICDET had a *project* to train 200 in-service primary teachers as specialists in Mathematics or Science in order to ensure an adequate

supply of teachers with contemporary STEM knowledge and pedagogy, further highlighting a lack of overall *coherence*. Overall, Policy 1 showed limited *coherence* because the Federal (i.e., DPMC, DET via AITSL, and EC) and State/Territory education ministries and agencies had differing initiatives from that of the NIICA and NISA in terms of the definition and a strategic framework on specialist STEM teachers.

Attribute 3

Continuity.

Definition.

Policy ***continuity*** is defined as the evolution of a priority policy from production to implementation through academic research to robustly build and develop or change policy over the longer terms of a government (Dunn, 2015). *Continuity* is required in order to produce incremental shifts that improve and change the nature of a policy rather than to have competing, conflicting, or ineffective policies (Cerna, 2013). For *continuity* to be evident, the State and Territory education agency policy communications and documents need to improve or shift the policy dimensions based on and across each National agenda in order for the Federal and State/Territory Governments to appropriately reflect and link to that of the National Policy over various terms.

Data.

For State and Territory Government *continuity*, the evidence was linked with the NISA to build on the prior NIICA *action and initiative* of establishing TEMAG to "improve schooling outcomes" (DPMC, 2014 p. XIII) for "advice on how to improve STEM subject knowledge in teacher training" (DPMC, 2014 p. 47). As an *initiative*, TEMAG (2014) was formed and a research-based report with 38 recommendations provided this advice. However, the NIICA and

NISA were limited by the extent of academic *research*, and regard to the recommendations made by TEMAG (as documented in Chapter 4).

The NISA framed policy, see Table 7.1 (above), is the evidence base for *continuity* across the mapped context, which has limited academic *research cited and referenced.* The preceding National agenda (NIICA), however, did drawn on *research* that was *cited and referenced* to feature the ABS, IEA, OACS, OECD, and PC to support arguments about the quality of teaching in STEM Education. This notable difference in how *research* was used (or not) highlights the variations as to the *continuity* by the State and Territory education agencies.

With regard to Policy 1 and drawing from within the NISA document, *research* is exemplified that was largely of the non-cited form and did not have an accompanying list of *reference*s to illustrate the sources and evidence used to inform the *priority, purpose, initiative and budget, and the evaluative measure*. The NISA, and to a lesser extent the NIICA, had a common form of *citation* as paraphrasing without citing the *research* source, and was drawn from Government supported sources (rather than academic sources). This example provides a snapshot, the overall analysis (see Chapter 4 for detail) highlighted that *research cited (or uncited) and references listed (or unlisted)* was limited on which to build and strategically frame a STEM Education policy within and across National and State/Territory Government agendas for *continuity*. Two State datasets, QLD and WA are examined below.

The Government of Queensland (QLD)

The State and Territory education agencies had limited evidence of a linked policy around specialist STEM teachers in primary schools. The QLDDET did not have any evidence of an *action* to require pre-service primary teachers to 'choose to graduate with a specialisation in STEM', yet had *actions* to support quality teaching in school-based STEM Education by state

schools to have access to a specialist STEM teacher. A logical interconnection or policy *continuity* is made further evident, which was noted as limited or discontinuous.

The QLDDET SSQSS research differed with the NISA, which listed reference as follows:

> 1 Craig, E. et al., (2011). No Shortage of Talent: how the global market is producing the STEM skills needed for growth, Accenture Institute for High Performance.
>
> 2 OECD (2011). Over-Qualified or Over-Skilled: A review of existing literature, OECD Social, Employment and Migration Working Papers, No 121.
>
> 3 Marginson, et al., (2013). STEM Country Comparisons: International comparisons of science, technology, engineering and mathematics (STEM) education, Australian Council of Learned Academies, Melbourne.
>
> 4 Office of the Chief Scientist 2014, Science, technology, engineering and mathematics: Australia's future, Australian Government, Canberra. (QLDDET, 2016a, p. 2)

The QLDDET had limited *continuity* with the nationally framed policy in terms of academic research and/or the type of research paraphrased within the NISA.

The QLDDET Annual Report (2016b) noted the following 2015-2016 *projects*:

> 1. Expanding scholarship programs to attract high-quality pre-service teachers in STEM subjects
>
> 2. Partnering with Queensland universities to provide a suite of professional development opportunities (including online coaching modules) to increase the expertise of STEM teachers in state schools (QLDDET, 2016b, p. 31)
>
> 3. Providing a suite of professional development and upskilling opportunities to increase STEM teacher availability in state schools (QLDDET, 2016b, p. 46)
>
> 4. Refreshed Advancing Education Action Plan (QLDDET, 2016b, p. 51)

The fourth *project* (above) details the QLDSSQSS *action* on specialist STEM teacher access by all state schools. However, subsequent analysis of the QLDSSQSS for the *initiative and budget* showed no evidence of carry through by the QLDDET.

The *initiative and budget* is also important in consideration of *continuity*. The QLD Treasury Budget (2017) reported that:

> In line with Advancing Education, the department will position schools to support students by improving the teaching of science, technology, engineering and mathematics (STEM) in state schools (QLD Treasury, 2017, p.4)

This *budget* along with the concurrent QLDDET annual report did not include details of the amount of *funds* allocated to these four QLDDET *projects*. The QLDDET and QLD Treasury had limited data on *projects* and the allocation of *funds* to: 'requiring pre-service primary teachers to graduate with a STEM specialisation'. Therefore, there is limited *continuity* by this Government in relation to the federal Government (which had commissioned TEMAG to advise on improving STEM teacher training nation-wide). As stated, the QLD dataset is shown in Appendix 18.

The Government of Western Australia (WA)

The WA Department of Education (WADOE), *2016-2019 Strategic Plan* (WADOE, 2015) had limited evidence of a linked policy that included academic *research*. However, the WA Technology and Industry Advisory Council (WATIAC) commissioned, framed and funded two research-based *projects* into STEM Education in WA schools. The first *project* was reported in 2011 and the second in 2014 to the WA Government Science Education Committee (Committee), rather than to a Federal and State/Territory STEM Education committee or the WADOE.

The first study, *Productive partnerships: Advancing STEM Education in Western Australian schools* (Murdoch University, 2011) aimed to strengthen the "formal and external components of STEM Education in WA" (p. 3). On this basis, the WATIAC (2011) proposed that the then Government complete a WA STEM strategy (which was not recorded as conducted at the time of this study).

The submitted report included the following recommendations for *action*:

Strengthen the expertise of teachers in STEM through a combination of short and long term initiatives that will:

1. Provide support through professional learning opportunities and high quality resources;

2. Enables supportive partnerships with external STEM Education providers;

3. Further develops STEM teacher undergraduate programs; and,

4. Attracts high level STEM graduates to the profession and retain them. (Murdoch University, 2011, p. 8)

These recommendations (above) were based on a review of external STEM Education programs and the views of STEM teachers about these programs for primary and secondary learning and teaching in schools.

The second commissioned study, *Optimising STEM Education in WA Schools* (WASTEMEd) (Edith Cowan Institute for Education Research, 2014), was submitted to this same Committee with three *issues* raised for further research to inform *actions*:

1. Concern about the availability of teachers with requisite STEM expertise;

2. Substantial challenges resulting from out of field teaching and the requirements of the new Australian curriculum; and,

3. Absence of integrated strategies to build and strengthen the capacity of the STEM teaching workforce. (Edith Cowan Institute for Education Research, 2014, p. 4)

These research-based *issues* were informed by secondary schooling data, with limited primary schooling data. For example, the second listed *issue* (above) had limited *continuity* with primary teachers since all teachers are educated and trained as generalists with a specialisation, as framed by AITSL, to teach across the ACARA AC.

The final noted *issue* (above) relates to the absence of integrated strategies to build and strengthen the capacity of the STEM teaching workforce. This *issue* links with a TEMAG (2014) outcome that the National and State/Territory "available workforce data are inconsistent. Some employers report a significant oversupply of teachers, and others report ongoing recruitment difficulty" (p. 45). For *action*, TEMAG made four recommendations:

> Higher education providers pre-register all entrants to initial teacher education programs, on a nationally consistent basis.
>
> Teacher regulatory authorities collect robust workforce data on a nationally consistent basis, including areas of specialisation, to inform workforce planning.
>
> Teacher regulatory authorities share data to contribute to a national workforce dataset and national workforce planning.
>
> Higher education providers take into account national workforce needs, in consultation with employers. (TEMAG, 2014, p. 47)

The WA Government, and the federal Government had separately commissioned and presented *research* on the nature of the primary (STEM) teaching workforce supply and demand data, which had limited *continuity* in terms of a 'nationally consistent basis' on specialist STEM teachers.

The WASTEMEd report had nine recommendations for *action*, with four relating to this policy:

> Enhance the capability of the existing STEM Education workforce through developing mechanisms for more coordinated, systematic and sustained provision of discipline-specific teacher professional learning, mentoring and resource development.
>
> Provide incentives to attract additional high quality applicants into pre-service education in areas of STEM teaching shortages, currently mathematics, physics and technology education.
>
> Enhance the capacity of STEM Education service providers to deliver discipline-specific teacher professional learning and curriculum resources needed by science, mathematics and technology teachers.
>
> Projects initiated as outcomes of this report should be formally evaluated and include a dissemination strategy. (Edith Cowan Institute for Education Research, 2014, p. 4)

These recommendations were not linked with the National policy and therefore illustrates that, for State policy, there is limited policy *continuity*. In essence, *continuity* was limited to this state-based commissioned *research*, which included the quality of workforce demand and supply data.

The analysis of a STEM-WA (2015) STEM Education proposal for national application, highlighted research by the: Commonwealth Government (2015); Department of Industry, Innovation, Science, Research and Tertiary Education; Higher Education Statistics Data Cube (n.d.); OACS (2014), PISA (2012), TIMSS (2012); and, TEMAG (2014). The TEMAG (2014) noted recommendation:

> Higher education providers equip all primary pre-service teachers with at least one subject specialisation, prioritising science, mathematics or a language (WA Steering Committee, 2015, pp. 8-9)

This proposal was supported by the WA Minister for Education and The WA Office of Science; however, no further data was noted.

As stated, two WATIAC commissioned and funded *research* reports were presented to the STEM-WA Steering-Committee with several findings and recommendations, which were not evident as policy by this Government. Thus, this *research* had limited *continuity* with the nationally framed policy. (The WA dataset is shown in Appendix 21)

Overview of Attribute 3: Continuity

Policy *continuity* is limited. The Government of QLD had different and limited academic *research cited and listed* with the NISA to address *issues*. Further, QLD Treasury *initiatives and budgets* had limited evidence related to the funding allocations to the QLDDET STEM projects, hence limited *continuity* by this State Government. The Government of WA had limited policy with regard to the research recommendations raised from two WATIAC projects presented to a WA Science Education Committee. Overall, Policy 1 showed limited *continuity* because the federal (i.e., DPMC, DET via TEMAG, and EC) and State/Territory education ministries and agencies' documents had differing and/or limited academic research related to building and developing a policy agenda.

Attribute 4

Focus.

Definition.

Policy *focus* is the extent to which *dimensions* requiring pre-service primary teachers to choose to graduate with a specialisation in STEM direct school-based implementation. *Focus* of a Primary STEM Education policy would be evident if policies of the State and Territory education agencies interlinked with the NISA, i.e., were *focused* in terms of the o v e r -arching

National *dimensions* about a primary specialist STEM teaching workforce that is implemented by all schools.

Data.

In the NISA, limited evidence of *focus* on the school-based implementation of specialist STEM teachers was identified by, for example, *the research, initiative and budget, and evaluative measure*. The NISA *initiative and budget* were articulated, but in general terms:

> *Not evident*, however noted and attributed to the NIICA policy as a built on and supported policy (NISA) (DMPC, 2015a, p.5), and; Working with the States and Territories on a national STEM School Education Strategy. (NISA) (DMPC, 2015, p. 12) … *Not evident* from the imbalanced NISA $84 M budget total for "Inspiring all Australians in digital literacy STEM" (DPMC, 2015, p. 16)

The result of these statements was the whole-of-government expectation of primary-school based implementation of Policy 1 to occur across the various States and territories via the education ministry and agencies through similarly framed agendas and policies, for example, with defined and interlinked *programs* and an allocation of *funds*.

Analysis (see Chapter 4 for detail) showed variations and limitations in the *focus* on the *projects* and allocation of *funds* across the agencies of the Federal Government. For example, the Treasury had limited evidence in the corresponding *budget* of allocations designated to support this policy. The Treasury evidence actually suggested a reduction or reappropriation of the *funds* allocated from the NISA policy *initiative*s on Primary STEM Education.

The DET had an extensive range of *projects and programs* with various education agencies (including ACARA and AITSL) to support pre-service primary teachers to 'choose to graduate with a specialisation in STEM', the policy translation of these collaborations became:

1 Activities to improve initial teacher education courses in Australia as recommended by the Teacher Education Ministerial Advisory Group (TEMAG) in its 2014 report, Action Now: Classroom Ready Teachers (DET, 2015d, p. 13); and,

2 The department and AITSL continue to support implementation of the Government's reforms to improve the capability of the teacher workforce based on the recommendations of the Teacher Education Ministerial Advisory Group (TEMAG) report. In December 2016 all education ministers, through the COAG Education Council, committed to developing the national Initial Teacher Education and Teacher Workforce Data Strategy to assist with workforce planning and assess the outcomes of initial teacher education. (DET, 2017a, p. 34)

The DET budget to fund these initiatives was:

Not evident from the $16.9 M. (DETd, 2015)

In terms of the *initiative and budget*, this DET statement has limited detail on funding *projects* that required pre-service primary specialist STEM teacher graduates with schools, hence further limiting the *focus*.

Across the data sets, the *focus* of the various Federal and State/Territory education ministries and agencies to administer, for example, *projects* and allocate *funds*, and to define an *evaluative measure* with the NISA were varied and limited. Policy 1 *focus* was noted through the concurrent State and Territory Government Primary STEM Education policies with analysis drawn from two State and Territory Governments, the ACT and SA, as examined below.

The Government of the Australian Capital Territory (ACT)

The ACT Education Directorate (ACTED) data was analysed with regard to *focus*. The communication and documents analysed were the ACTED *2014-2017 Strategic Plan* (2014) and the 2016-2017 *Annual Report* (2017). However, the results of this analysis showed no text-based data coded which linked with Policy 1. For example, the Draft 2017 Action Plan

(ACTED, 2017) stated several related, and yet unfocused *actions* with regard to specialist STEM teachers:

Quality Teacher

Recruit, develop, retain and reward quality teachers, and maintain sustainable teacher workloads (ACTED, 2017, p.2)

This action has limited *focus* on primary-school based specialist STEM teachers. Overall, the ACTED was unfocussed in relation to the National policy because the strategy and *action* plans related to Generalist Primary Education teachers rather than Primary STEM Education teachers. (The ACT dataset is shown in Appendix 22)

The Government of South Australia (SA)

The SA Department of Education and Childhood Development (SADECD), *STEM Learning Strategy 2017-2020* (SLS) (SADECD, 2016) was analysed and highlighted a *purpose* with regard to this *rationale*:

The economic case for STEM is clear. Between 2006 and 2011 in Australia, the number of people in positions requiring STEM qualifications grew 1.5 times faster than all other occupation groups. Over the past 10 years, the number of people employed in STEM occupations in South Australia has increased on average by 2.3% per year compared with the state average annual rate of growth of 0.9%. It is a world-wide trend that the fastest growing industry sectors require STEM skills. (SADECD, 2016, p. 2)

The SADECD showed evidence of *focus* with the Federal Government.

The SADECD SLS (2016) had these *objectives*:

1. By 2020 the state government will develop and build systematic capacity to provide cutting edge STEM teaching and learning. (STEMLS) (SADECD, 2016, p. 5)

2. By 2020 there will be 500 primary teachers with a STEM specialisation. (SADECD, 2016, p. 7)

3. Every primary school in South Australia will have a minimum of one teacher with a Science, Technology, Engineering and Mathematics (STEM) specialisation by 2019. (SA Department of the Premier and Cabinet (SADPC), 2017, para. 2)

The SADECD *purpose* was the:

1 Rationale for a future supply of graduates with the STEM skills for the national need to develop industries to trade world-wide and State trends for STEM positions; and,

2 Objective to provide quality STEM teaching and learning, primary teachers with a STEM specialisation and every primary (state) school with a minimum of one teacher with a specialisation in STEM (by 2019).

Noted in this analysis was how the SA Premier and SADPC provided data, which linked with the SADECD data, which was an uncommon finding when reviewing the State premiers and education departments (agencies). Therefore, in terms of this State Government, policy *focus* was evident for school-based Primary STEM Education, and is linked to the National policy on specialist STEM teachers.

The SADECD showed evidence of an anticipated *outcome and timeline* supporting pre-service primary teachers to "choose to graduate with a specialisation in STEM". The translation into an *evaluative measure* by the SADECD for the outcome and the timeline became:

500 primary teachers with a STEM Specialisation … All primary schools will be represented in the professional learning program … Progressively over four years from 2017 to 2020. By 2020 (SADECD, 2016, p. 7)

This Government data is an exemplar of *focus* in terms of pre-service STEM teachers leading to school-based implementation specifically linked to the NISA *action* and *issue*. (The SA dataset is shown in Appendix 23)

Overview of Attribute 4: Focus

Despite the SA analysis, it still seems reasonable to assert that the Policy *focus* is limited. The Government of the ACT did not have *dimensions focused* on requiring pre-service primary teachers choose to graduate with a specialisation in STEM. In contrast, the Government of SA had exemplary *focus* with an *objective, and evaluative measure* on supporting pre-service primary teachers to teach STEM within all state schools by 2020; thus a notable difference in focus between the two. Overall, Policy 1 showed limited *fidelity* because the Federal (i.e., DPMC, DET via TEMAG, ACARA, and AITSL, and EC) and State/Territory education ministries and agencies had differing and limited data in relation to requiring a specialist primary STEM teaching workforce.

Attribute 5

  Scale.

  Definition.

Policy *scale* is the ability of a framed policy to be efficient and efficacious on a small scale under controlled conditions, and through academic evaluative measure(s) to then be reliably expanded for implementation nation-wide (Milat, King, Bauman, & Redman, 2013). The purpose is to maximise an efficient and efficacious policy that is framed by the federal, State, and Territory Governments by collaboration between their education ministry, and agencies. (European Commission, 2018). *Scale* of a Primary STEM Education policy would be evident if policies of the State and Territory education agencies interlinked with the NISA, i.e., were scaled in terms of the over-arching National policy *dimensions* on Policy 1.

Data.

For State and Territory Government *scale*, the evidence was linked with a statement within the NISA, which was the Policy 1 *action and budget* timeline (see Table 7.1, and Chapter 4):

Primary pre-service teacher STEM specialisation by 2019 (DPMC, 2015)

The result of this statement was the whole-of-government expectation of primary-school based implementation of Policy 1 to occur across the various States and territories via the education ministries and agencies through similarly framed agendas. For example, with defined and interlinked *actions and timelines* for pre-service primary teachers to choose to graduate with a specialisation in STEM being implemented by all schools. This NISA noted statement (above) is also the transcribed Policy 1 *evaluative measure*.

Analysis (see Chapter 4 for detail) uncovered varying *evaluative measures* noted as *outcomes and timelines* supported by each of the federal education ministries and departments for the *scaling up* of this policy. In further National analysis, for example, AITSL completed an evaluation report on projects, which was presented to the DET about the TEMAG recommended *action* for primary specialist STEM teachers with a priority in Science, Mathematics and a Language:

> The Australian Institute for Teaching and School Leadership (AITSL) has a key role in implementing the Australian Government's response to the Teacher Education Ministerial Advisory Group (TEMAG) Action Now: Classroom Ready Teachers report. Six reform themes guide the redesign of Initial Teacher Education (ITE) in the period 2015 to 2021 with the full impact apparent in 2022 (PTR Consulting Pty Ltd, 2017, p. 3)

> The requirement in the accreditation standards that all primary teaching graduates have a subject specialization is being addressed by providers and is mostly unproblematic –

although some jurisdictions have concerns to be worked through (PTR Consulting Pty Ltd,

2017, p. 4)

The accreditation standards require that all primary teaching graduates have a

specialisation in a learning area of the Australian Curriculum. Most authorities and

employers see that this has been relatively easily agreed in principle and preparation is

underway. Providers generally see that it is their responsibility to structure their course

offerings accordingly and for many it is an opportunity and unproblematic. A few

jurisdictions regard implementation as an unresolved challenge. There are concerns that

the requirement will essentially be interpreted as leading to a greater focus on science,

technology, engineering and mathematics (STEM) to the detriment of a broader spread

of capabilities; that local needs for skilled generalists in rural and remote areas could be

ignored and that state based priorities also need to be taken into account. The overall

view however is that any concerns will be settled through further dialogue at the local

level and with reference to how other jurisdictions are adapting the accreditation

standards. AITSL – TEMAG Evaluation: Stakeholder perspectives on progress (PTR

Consulting Pty Ltd, 2017, p. 12)

These comments from AITSL suggest that *scale* was taken into account and seemingly

occurring although acknowledging the problematic nature of this in some States/Territories. A

timeline, was unclear and indicates by 2022. Hence, yet again, the evidence that some

States/territories were still an unresolved challenge for implementation on specialist STEM

teachers suggests that *scale* is yet to be realised. Also noted is that this data is limited to a

primary generalist teacher defined and framed by AITSL with a specialisation in any learning

area of the ACARA AC.

The evidence for *scale* was noted through the *evaluative measures* of *outcomes and timelines*

across the mapped context, which were current at the time of this study. However, the National

data (i.e., the NIICA, the NISA, and the NSSES) with a stated *evaluative measure* on the framed Policy 1 was noted as unstated on the *action* to: "require[e] primary pre-service teacher STEM specialisation" (DPMC, 2015, p. 5). A tangible *timeline* for that *outcome* was unable to be determined, rather it simply stated that there was a requirement for all pre-service primary teachers in Australia to graduate with a specialisation in STEM and ready for school-based practice by 2019. This *timeline* was noted within the imbalanced *budget* of 2015- 2019 in the NISA appendix. Thus, *Scale* was limited by the extent of detail by the Federal Government in defining and framing dimensions such as the *evaluative measure*.

These examples provide a snapshot, the overall analysis (see Chapter 4 for detail) highlighted that *initiative and budget* was limited on which to build and strategically frame a Primary STEM Education policy within and across federal and State/Territory Government agendas for *scale*. Two State datasets, TAS and WA are examined below.

The Government of Tasmania (TAS)

The Tasmanian Department of Education and Training (TASDET) did not have any evidence of a *funded project* to support pre-service primary teachers to "choose to graduate with a specialisation in STEM". The translation of the TAS Government Primary STEM Education policy *priority* became an in-service professional development program, as detailed below:

1. Introduction to STEM - Primary

2. Next steps STEM –Primary

   Programs for; primary teachers (including Early Years – Year 6) who wish to develop STEM approaches in alignment with the STEM Framework. (TASDETPLI, 2014, p. 1)

This TASDET statement has evidence of *programs* of in-service teacher professional development rather than pre-service primary specialist STEM teacher education, which limits

the *scale* by all schools in Tasmania. The TASDE linked *program* was sourced data from webpages entitled, *Programs* (see Figure 7.2 below).

Figure 7.2

TASDE Specialist STEM Teachers Professional Development Program

Image retrieved from: https://pli.e.ducation.tas.gov.au/programs/For-School-Teachers/Pages/Next%20Steps%20STEM%20-%20Primary.aspx
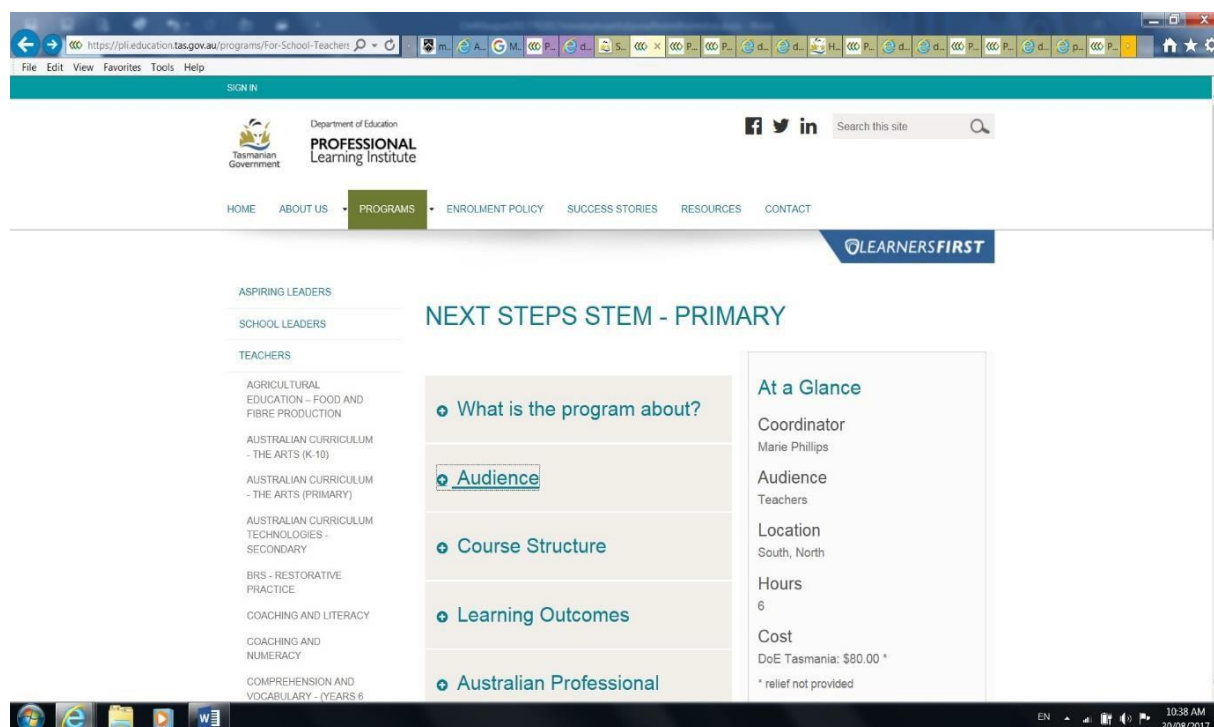
The TASDET data, which included budget papers, statements, and communications, did not provide specific *project* details with *funding* allocations to determine the *scale* needed to carry through on the National *action*. The extent of evidence by the TASDET was that:
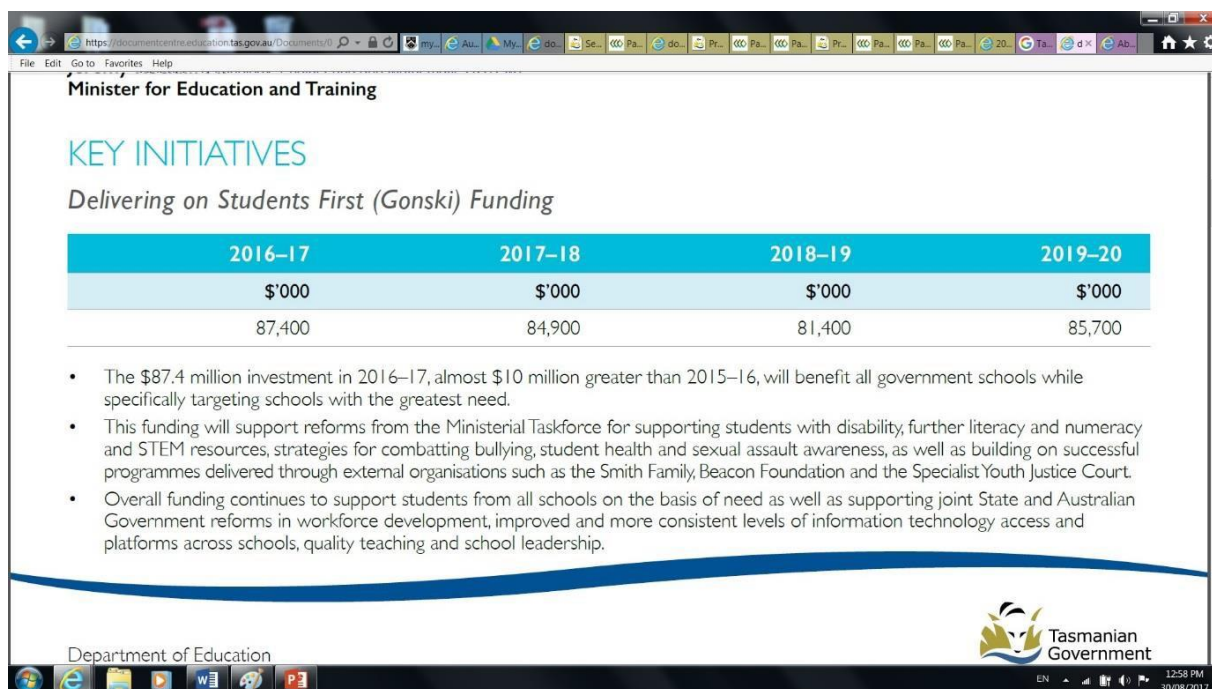
> We are also funding targeted research to improve educational provision and developing new curriculum resources to support an integrated approach to teaching and learning in Science, Technology, Engineering and Mathematics (STEM). (TASDET, 2016, p. 1)

This statement on funding *research* was limited by *scale* with the nationally framed *action*, and rather was *scaled* as a State framed policy on in-service primary teacher education programs and targeted research.

As stated, the NISA *initiative and budget* that linked with the TASDET *programs* and allocation of *funds*, was limited in *scale* and is shown further in Figure 7.3.

Figure 7.3

TASDET (2016) STEM Education Fund Allocation

Image retrieved from: https://documentcentre.education.tas.gov.au/Documents/047_16_Factsheet_Overview_FA_Web.pdf)

Figure 7.3 shows the concurrent TASDET *budget* that is unstated in terms of the allocation of *funds* for a range of *projects*, which includes STEM resources in the budget of $345,700,000 from 2016 to 2020 or four years. This data could not be explicitly linked to funds allocated to specialist STEM teachers to show *scale* by this Government (the TAS dataset is shown in Appendix 24.

The Government of Western Australian (WA)

Analysis on the WA's Department of Education (WADE) *2016-2019 Strategic Plan* (WADE, 2015) showed no *initiative* or *budget* for specialist STEM teachers, a similar outcome arose in analysing the Treasury 2016-2017 budget papers (WA Government, 2016). However, a STEM-

WA Steering Committee (STEM-WA) documented a proposed STEM Education *pilot project* and *funding* allocation, which was endorsed by the WA Education Minister and Office for Science (as shown in Attribute 3 above). The framed WA-pilot *project*:

> Coordination of existing educational resources to strengthen the teaching of primary and lower secondary school maths, science and technology. In-kind commitments from the three school sectors will focus on strengthening the teaching of primary and lower secondary school maths, science and digital technologies by coordinating, enhancing and optimising the PL, resources, mentoring and networks required to meet the needs outlined in Priority 2 (WA STEM Steering Committee, 2015, p. 12)

A WA Committee was presented with a proposal to frame a state-based policy for national scale, which was endorsed and yet un-noted in the policy data. This State proposal indicated how the Government of Australia approached *scaling* policy. A policy can be framed by a State/Territory and then *scaled* nationally. However, this proposal was not noted in the data as a policy. *Scale* was evidently limited to being State/Territory-based. (Figure 7.4 highlights the proposed *budget* to frame this state-based policy prior to national scaling.)

Figure 7.4

Initial estimates of in-kind funding for STEM programs

Table I: Initial estimates for distribution of in-kind funding across coordinated STEM programs ($000'S)

SECTOR	Primary maths	Primary science	L. sec. maths	L.sec science	Technology	Engineering	School Principals	Annual total	2016/17-2021/22
Govt.Ed	593.2	871.0	276.0	1165.4	687.7	147.6	180.0	3,920.9	19,604.5
Catholic	615.7	240.3	383.6	317.8	217.7			1,775.1	8,875.5
AISWA	309.3	60.1	68.9	154.6	240.3	34.4	116.2	985.8	4.929.0
SCSA[1]								196.6	983.0
TOTAL	1,518.2	1,171.4	728.5	1,637.8	1,145.7	182.0	296.2	6,878.5	34,392.0

Note: 1. The SCSA in-kind will be allocated in accord with the time commitments of the STEM-WA Unit, i.e.across the coordinated programs and also engaging with Employers and other external stakeholders.

Image retrieved from: (STEM-WA, 2015, p. 20)

Follow-up analysis was unable to uncover any further policy documents or communications referencing this STEM-WA *initiative or budget*. No further evidence referencing a similar *initiative and budget* linked with the NISA, and with this proposed *scale* of this national STEM-WA pilot project was found across the mapped context at the time of this study. Thus, this Government illustrates again, limited *scale* with regard to the implementation of specialist STEM teachers by all schools in WA.

Overview of Attribute 5: Scale

As analysis demonstrates, policy *scale* is limited based on response to the NISA Policy (Specialist STEM teachers) by the State and Territory education departments and agencies. As indicated, no State or Territory Government showed evidence that the NISA identified *action* to require pre-service primary teachers to choose to graduate with a specialisation in STEM had occurred or was the *focus* in order for *scale* to be achieved as a whole-of-government response for implementation by all schools.

Chapter Close

This chapter presented analysis to determine the fidelity of a priority-listed policy by the Government of Australia. Three priority-listed policies were identified and framed by the methodology and Policy 1 (Specialist STEM teachers) was used as an exemplar case for in-depth analysis to determine the extent to which policy development and implementation was linked and efficacious across the whole of government (Federal, States and Territories).

The next chapter is the final data chapter and is a case-study of a leading Primary STEM Education policy administrator. The purpose of the case-study is to illustrate and juxtapose the situation of National policy setting from the personal perspective of a major stakeholder in the

overall process and to contextualize the real world associated with the outcomes highlighted by this study.

Chapter 8

Henri's Case on Specialist STEM Teachers

This chapter reports an in-depth interview with a National Executive administer with responsibility for STEM policy who made prime ministerial recommendations in particular around Policy 1: Specialist STEM teachers, which is based on a single case-study method of an in-depth interview. This chapter offers insights into the differences in the development of policy as it exists and the reality of working within this Context. Issues on the quality of policy associated with alignment, coherence, continuity, focus, and scale (the five Attributes explained in the prior chapter) to develop and implement, which links to practice are also detailed with regard to the policy dimensions (explained in Chapters 4, 5, and 6) from this interview.

Background

The case-study outcomes of an in-depth interview have been based on the analysis (explained in Chapter 3), which was recorded with a senior Government National Executive administrator and prime ministerial advisor on STEM policy, Henri (pseudonym). Henri has held prime ministerial delegated responsibility to research and recommend on the priorities listed within the nationally framed STEM policy agendas. His view has been that Policy 1: Specialist STEM teachers be the only listed policy priority for implementation within this context. With reference to international practices, Henri had been researching and recommending on how this or any policy required a social compact to a scientific STEM Enterprise policy framework on the vision for Australia and the strategy to get there by National leadership.

To occur under prime ministerial leadership, Henri's requirement for a national framework was to align, cohere or connect the various Federal and State/Territory Government ministers and agencies to the priority policies of the Government of Australia's one vison and destiny (i.e., Parkes, 1891). This framework was to be developed based on a social licence, and to the national interests of Australia in the future and over longer terms of a party's leadership within the Government, to frame and progress STEM policy. Henri's vision for the STEM Enterprise with regard to STEM Education has been through Policy 1, and has been to realise a social compact to develop a scientific literate community and be internationally STEM collaborative, competitive, and developed economically. Henri stated alignment in particular with The U.K Prime Minister on the formation of a social compact (see Blair, 2002), and to the OACS recommendations (see OACS, 2013). Through this case-study, Henri's experiences while working within the Federal Executive Government on the STEM Enterprise policy priorities to the National policy agenda(s) have been examined specifically with respect to Primary STEM Education for school-based implementation, and is based on the thematically coded transcribed interview text. Henri's words predominate across this chapter to show the depth of his experience and point of view, which was noted by this study.

Framing and Leading the Government of Australia on STEM and STEM Education Policy

According to Henri, Policy 1 in comparison with others, which had included Policies 2 and 3, was the only policy based on research and to a vision and collaborative approach rather than an economic focus and political response. Hence, Henri had spoken essentially about Policy 1 as the priority policy in realising his vision and approach while working within this context to develop and implement such policies. In this regard, Henri clarified that for this research-based policy to be implemented necessitated Federal ministerial leadership via a social compact adopted by the Government of Australia STEM policy Enterprise Framework that clearly stated a vision and strategy.

During Henri's experience, such a STEM framework was recommended, but was not evident even though the context had responded that it was a work-in-progress. In conveying Henri's experiences, his transcribed data has been structured around the five policy dimensions that has shaped the policy structure of Chapters 4 to 6 (and shown by the Conceptual Framework in Chapter 7 Figure 7.1). An overview of the analysed dataset representing Henri's STEM policy recommendation and also his future perspective on the policy direction by the Government has been included in Table 8.1 next.

Table 8.1

Case-study Coded Dataset

Australian Government STEM Education Policy Context: Priority Policy Dimensions	
Priority Policy: Specialist primary STEM teachers (Policy 1)	
Coded Dataset: (Data type, description, AG agency, date, online link/sourced): Case-study data, voluntary face-to-face semi-structured interview, Henri (pseudonym), Canberra Australia August 2017)	
Policy Dimensions:	
1. Priority	**Action**: Specialist primary STEM teachers to teach Primary STEM Education in schools. **Issue**: The number of primary teachers with contemporary Science and mathematics teacher education and training, and students' to experience inspiring teaching in learning Science.
Future: Priority	COAG Education Council NSSES administration communicated and documented by the State Governments in a similar policy, however unlikely to occur in the near term.
2. Purpose	**Rationale:** A teacher confident to teach STEM has a significant effect on improving concerns on declining students' achievements, interests, and motivations in STEM and STEM Education. **Objectives**: 1. A scientific literate nation, and 2. Improvements in students' achievements, interests and motivations in STEM and STEM Education by schools.
Future: Purpose	Viewed as subject to what are the delegated Commonwealth Science Council (CSC) and Innovation and Science Australia Committee (ISA) STEM policy recommendations are presented to the DPMC and the DPMC's response by the subsequent National priority policy agenda (i.e., following on from the NISA)
3. Research	**Cited:** OACS (2013; 2014; 2015). International government policy actions by: Finland, Germany, the U.S.A and The U.K... (see Chapter 2).

	Referenced: Included in the list of references of this study from Chapter 2.
Future: Research	Pessimistic for a research-based STEM prioritised policy to occur within implementation at this point.
4. Initiative & Budget	**Project:** The Government of Germany that has had a long-term initiative of the Frobel project, which can be regarded for specialist STEM teachers in schools. **Funds:** Increase funding amount, commitment, and term based on economic value rather than cost to address a budget surplus.
Future: Initiative & Budget	Project: Education Ministers and departments to focus on this initiative by projects and programs within schools. Funds: Reliant on a Treasury policy by a whole-of-government approach to the focused allocation of funds to programs forming this initiative.
5. Evaluative Measure	**Outcomes**: 1. All schools with access to a specialist primary STEM teacher, and 2. All primary students inspired in learning STEM with a specialist primary STEM teacher in formalised schooling that is practiced based on research informing a quality STEM Education to have evidently well improved students' achievement, interest and motivation in STEM and STEM Education. **Timelines**: 1. 2020, and 2. 2020 onwards.
Future: Evaluative Measure	Reliant on Federal minister leadership that is genuinely, interested, passionate, and motivation on Policy 1 with quality to this Area by a social compact by the STEM policy context framed vision and strategy (Framework) to form a research-based policy.

A STEM Framed Vision and Strategy

Henri had completed a review of comparative national and international OECD developed country research to recommend that of all the STEM policies there was one, which mattered most to develop and implement. By comparison between the various policies, specialist STEM teachers, was stated and valued as the prime policy to prioritise on the longer terms agendas of governments for primary school-based implementation. The vision of this policy was that students would be supported across the schooling system (from pre-school onwards) to learn STEM, which is taught:

> In an interesting way that is so compelling and interesting that everybody wants to do it. People are living in a highly scientific and technological time and the way to make best use of that means they understand something about it and so use it to advantage. And they don't get frightened by scaremongers.

Henri elaborated on his vision for Australia:

> My vision is that Australia would have a highly Science-literate community so that we can exercise good judgments about what Science outcomes and technologies are good and which are not. What to adopt and what not. We have that latent capacity, but we need the education environment to step up. Australia should be technologically very capable. We should continue to make things. I would [then and also] say that scientific achievement is critical and so is scientific knowledge. And I would illustrate how Science would achieve it. I would say this is how industry will achieve it and so on [about how Education and Training will achieve it by primary school-based implementation], so to build the economy that we need [to realise that vision for Australia ...].

Henri conveyed this vision as the point to this policy for STEM Education across the schooling system is to develop a scientific literate society that can understand STEM professionals whom seek to develop an Australia worthy of future generations.

A comprehensive policy was articulated by Henri, who explained:

> So I took the view that there was a very specific role for Government and, in particular a very specific role for National Government in providing leadership - in the nation's interest. And most of what I did from that time onwards was to argue that point and I was pleased that just before I retired the State, Territory and Federal ministers released a single document, or agreed on a document, the National STEM strategy for schools. And I think there is a lot in that that is good. There are probably some places where I would have been a bit stronger but I doubt that any person in a position like mine has ever been completely happy with the response to their advocacy. It is always compromised or strategized in some way and I understand that. I mean that's the way the world works. I am not being critical or anything when I say that I might have done a few things differently if I'd been doing it myself; had I been able to implement it myself. The politics of the moment will change things and that's the world we live in. I live in that world but I don't have to agree with the position politicians adopt. So I can say, it is fine, it is an important step. But when you look at what other countries have done, or are doing, you see, that they start in primary school, that some even start before primary school and it is not simply aimed at producing a whole bunch of extra scientists, necessary as that might be in some places. But it's not specifically designed just to increase the number of scientists, it's to increase the scientific literacy in the community - something critical for our development. It's the opposite of the notion that you can do without expertise. But in order to get maximum benefit from that expertise you have to understand a little bit of what they are talking about or how they go about deciding what they talk about - whether it is climate change or vaccination or robotics...For example, if you're [a citizen] who has no idea, no sense whatsoever of statistics or what a very high probability means, you have less chance of drawing sensible conclusions about what to do… that's how people [can] run scare campaigns. [For example] 'high

probability' means lack of certainty therefore [some people without an understanding

of Science or Scientific Literacy] ignore it. But a person with even a basic understanding

of statistics will know what that means and respond accordingly. We should encourage

enrolments in mathematics and teach it interestingly: show its relevance while

developing the basic principles. I would always argue that the more literate the

community is in terms of some basic understanding of how Science works, some basic

statistics, basic Mathematics, that community will be better off.

To Henri, this was an urgent National priority policy with a STEM framed vision and strategy

reflected in National policy. With Henri's review of comparative research there were

seventeen OECD governments with national and cohering policies. Henri saw that the

Government of Australia was behind; it had no comprehensive and aligned or coherent

whole-of-government approach to a scientific and STEM framed national vision and strategy,

which he then elaborated on (see Table 8.1 above).

The Government of Australia Priority STEM Education Policy: Specialist STEM Teachers

Henri stated that the Government has many short-termed policies, limited National

leadership, a limited research-based framework, and have used the international policy

environment research to impede policy quality, which is administered for implementation. To

improve policy quality, Henri, worked on one Primary STEM Education policy for

implementation and that was Policy 1: Specialist STEM teachers. Policy 1: Specialist STEM

teachers was explained by Henri and is presented based on the five dimensions and attributes

from the conceptual frame on policy content and quality (see Figure 7.1). Henri's interview

was were coded from the transcribed interview data by the methodological approach

explained in Chapter 3. These codes are similar with the online sourced data. However,

Policy 1 was the only policy that Henri focused on and recommended. Also, Henry defined

STEM as a transdiscipline, with Science and scientific literacy based first and foremost.

Priority.

On analysis, Henri has raised several issues as a matter for framing priority action(s), which had begun when he was asked by the Prime Minister:

> To provide some advice on the specific matter. This was the first time that I had looked into it and I discovered a lot of things that surprised me.

As indicated, Henri has undertaken an extensive review of comparative studies examining STEM Education across the schooling systems, which had included a comparison of international government STEM policies, similar to the approach by this study as shown in Chapter 2. Those comparative findings were where those 'surprises' appeared.

Specific to Primary STEM Education, there are these two:

> The number of primary teachers teaching Science and Mathematics who had little scientific background. Also, the lack of a systematic approach to professional development of teachers. This was a bad deficiency because the Science of today in many fields is substantially different from when the teacher graduated, even if that was just ten years ago. Teachers, even those with a scientific background, need serious, systematic support to teach Science and Mathematics as they are today.

Henri considered that these were two *issues* that are to be addressed in the national interest, even though individual States and Territories were responsible. He argued that it was clearly too important to leave to them alone: there was a role for the Federal Government. He then had to look for actions across the international STEM policy environment with regard to this context.

Through a whole-of-government approach, Henri suggested a *priority action* was to support that all students learn STEM Education by a specialist STEM teacher beginning in pre-school through to university, clarified as:

> I think the policy action is that primary schools should have specialist STEM teachers.

Henri has stated that this was a policy action, which had been well framed by the Government of the U.S.A (see, Chapter 2) and recommended that this framework be referenced by this context. Henri then explained that to develop enough specialist primary STEM teachers for schools would require policy *alignment* across teacher education and training, mentoring, professional development, curriculum, assessment, resources, etcetera as an all-encompassing policy and coordinated approach leading to practice. From his perspective, the specialist STEM teachers policy is to be implemented as a matter of priority across the schooling system, and would enable appropriate change in practice over time, which would be similar with the framed policies undertaken and already underway by well-regarded international governments.

The quality of teaching in STEM across the schooling system, and Henri's recommended action to address this issue through a priority on and across National and State/Territory agendas was limited because the Government lacked a framework with a vision and the strategy by which to align, cohere, continue, focus, and scale policy in Australia. In fact, disconnection was evident and that gave cause for a concern for the future, as Henri said:

> When you look at what the rest of the world has done in recent years, mostly there has been a coherent strategy to do something about their need. And that's at the National level. So when you look at what and how Australia is different by not taking responsibility for what ought to have been a serious issue in the nation's interest, you see a lot missing. And that's where I began. I was happy when the education ministers put out a single document or an 'agreed on' document to a National STEM strategy for STEM Education by schools.

Henri considered that this document was a "good" outcome. The EC's NSSES (described in prior chapters) represented the first whole-of-government approach toward a strategy on

STEM Education in schools, even without an overarching framework of the STEM vision and strategy for the nation.

Looking to the current Federal Executives demonstrating 'passionate' leadership with this policy for it to be sustained and progressed through to school-based implementation, Henri was concerned because:

> It requires leadership. I think it takes political leadership. Once a policy is developed you just don't hand it on and forget about it and leave it to your officials to do something about. If the Prime Minister or a minister thinks it's important to implement that policy, it will get implemented. But it takes leadership to do it and that means prioritising. For me it's a high priority but for somebody else it mightn't be as high. But that is the discussion we have to have, as a nation really. Is it a high priority to provide a first class education for Australian people in Australia's schools that prepare them for the uncertainty of the future? Yes, I argue. Sadly the rhetorical commitment is rarely matched by leadership to implement.

The quality point to be made here is that there needs to be alignment and coherence in the actions that address the most critical issues as priority with the associated social-compact included within a framed and formalised STEM and STEM Education vision and strategy, led by Government, in order for this EC NSSES to be progressed by the whole-of-government. A Federal ministerial leader was essential to drive policy action in the long term. Henri's purpose on Policy 1: Specialist STEM teachers with a rationale and objective(s) was then further elaborated upon.

Purpose.

Relying on a research-based approach, Henri's *rationale* was that it is important to think about:

> How it's taught. I think it is about just how confident the teacher is in their knowledge. If they know the content that they have to teach well, then they will more likely teach that much more inspiringly. They will encourage their students to ask questions and, if they ask questions to which the teacher doesn't know the answer, they will have a discussion about it to try and figure it out. It is different if you are unfamiliar with a topic. For example, I taught a topic I was unfamiliar with and I simply taught like I was a text book on legs. But, when I was familiar with it I could send students off to read the latest papers in physiology and we could have a discussion. And I would learn from them and they would learn from me and we would all be happy. I do not believe that we have high quality teaching in every pre-service teacher education program, certainly not in terms of STEM content, and that's an area where universities and governments need to step up.

Consistent with this rationale, Henri's *objective* was embedded and reflected in his vision for an:

> Increase in the level of scientific literacy in the community as a whole.

Henri argued that there was a national imperative to increase scientific literacy to understand STEM professionals in order to make sensible decisions when called to do so.

Firstly, the objective had been to increase scientific literacy. In addition, Henri also spoke about having Science taught in an interesting way rather than to have Science education mandated, which was discussed later:

> My argument [was] that we should have Science taught in an interesting way. So that ideally everybody develops a basic understanding of how Science works, what it means, how scientists work, a basic understanding of probability, all that sort of thing. And

> then, we get to have a debate about which of the Science that we can do is good or bad.
>
> And make judgements about what to accept, what to use, what to ignore.

From this objective of having Science taught in an interesting way, Henri considered another objective, which was the role of STEM in society.

Again, the objective(s) requires a social compact through education between scientists and the community. Henri reflected on how the various rationales and objectives on specialist STEM teachers had lacked alignment, coherence, and focus to support these teachers to practice within schools:

> Fundamentally, support for teachers has not been done as well as it could be. It's best if it is coherent, [so] that we do have students loving Science, and improving their understanding in part by observing the world.

Overall, Henri recommended that the best way to have this policy connect from policy to successful implementation, was to have a National priority with a framed vision and strategy.

Specifically, the rationale for action on specialist STEM teachers in schools was to build and support teacher confidence in understanding contemporary issues (and content knowledge) in STEM. Primary teacher lack of confidence affects the quality of Science learning and scientific literacy in their classes. Building such confidence means that teaching STEM:

> ...is more likely done in an interesting way that inspires and motivates learning. It would have to be supported by governments and universities. In turn, students' achievement, interest and motivation in STEM has the developmental impact on community scientific literacy and on sustained economic development in the future.

Henri has indicated that the purpose of Primary STEM Education is to have the developmental impact on future scientific literacy, supported by governments and universities, which could ultimately result in economic development. The objective of this

Government is for university support on primary specialist STEM teachers teaching in an interesting way to inspire and motivate students' interest in STEM and STEM Education. Henri explored STEM policy research and examples from the interview data is now discussed.

Research.

The quality of a STEM policy, Henri explained, had been focused on economic issues, political perspectives, and party-based election timeframes more than to the contemporary knowledge or scientific research and use of STEM. According to Henri, the extent of sector and area engagement or *coherence, continuity, focus, and the scale* of a priority policy with academic research was limited in place of: political perspectives, differing election timeframes, and shorter terms in Government as reasons that evidence was often uncited or limited across policy communications and documents. While Henri was working within the Government there were four Prime Ministers, two elected Federal Governments, and multiple ministers (about seven Science ministers and several education ministers), all of whom had separate National STEM policy priority agendas. Given the changes in personnel, each agenda was replaced or significantly changed within a short time.

Henri elaborated on how each policy was focused on growing the economy with no vision for the country and how policies, including economic policies would help achieve the vision. 'Jobs and growth' was the political mantra of the day, stated Henri. One minister had an economic and political focus rather than the best way to get STEM widely adopted by:

> A [National Education] minister … talked about making Science compulsory and I responded by saying it shouldn't be compulsory it should be so compellingly interesting that everybody wants to do it. It's not to quadruple the number of scientists we have it's so that people who are living in a highly scientific technological time, have available to them the best way to make use of it.

Henri said that he did not believe that there is good evidence that mandated or compulsory STEM learning and teaching has had more than very limited effect on future outcomes in STEM Education and career choices. By contrast, Henri noted more sophisticated actions in the USA. Their more comprehensive STEM policy to educate and train 100,000 new specialist STEM teachers nation-wide, rather than mandate Science education in schools.

Henri was concerned that rather than continuity in policies leading to an evidence-based STEM framework, ministers were prioritising policies based on their political timeframe. He was of the view that policy was framed more around an economic and political agenda fragmented amongst a suite of policies at varying stages of implementation whereby:

> … What this [Context] supports is an economy first and jobs so that's the so-called vision. And I don't think that's a vision. I think we should have a vision for the type of Australia we want to build, and be transparent about how the policies cohere to take us towards that vision. Underpinning that is STEM. The vision should come first by contrast with what we now see: the economy limits the vision rather than showing us the wherewithal to achieve what we want. And it takes leadership: we are one country. [A former Minister] had the line that giving (most of) the responsibility to States and Territories leads to competition and was therefore better. And I asked how many people he knew who had moved across a State boundary because the State education environment was apparently better. I don't know one, nor did he. If all the States each have different subjects and curriculums to compete amongst each other in education, what is the value to the nation? Why is it valuable to have as much as a two year gap in educational attainment between States and Territories for a given age cohort. Or the value of a 'national curriculum' when each is able to pick which bits it will offer and how. What is the value added by each State administering their own STEM policies on Primary STEM Education with regard to teacher registration, curriculum, and teacher

> education and training? And limiting teacher mobility between them? Tell me what is the value to NSW and VIC? Or in the NT? There are disgraceful discrepancies within the [education] environment. And you think back to Henry Parkes who argued for 'one nation one destiny'. How do you have one nation and one destiny if your education environment is disadvantaging some young people because of where they live or the circumstances into which they were born?

Henri explained that policy formed without much relationship to contemporary (pedagogical and Scientific) or academic research limits the value of STEM practices supporting Australia's future, and its economic, cultural and social development.

Henri was pessimistic about the comprehensive implementation of an evidence-based policy:

> If you listened to evidence would you even talk about another coal powered fire station? Especially when it is obvious that it is all about squeezing political advantage. You might have a conversation, but given the evidence, would you push for one? In my world, the community would know enough to be engaged rather than be swept along by some politician whose primary aim is to get re-elected. The problem is too many heads in the sand and too much political short-termism. It is not rational. So am I an optimist or a pessimist? Neither. I think I am a realist. I think you have got to own up to a problem and then solve it if you can, or try to avoid it if you can't.

Despite this view, Henri, also pointed out that ministers were different in their interests and approaches:

> Things could happen, so too much pessimism is not helpful. Well, the one big thing that they did growing from what I had advised was to create Innovation and Science Australia (ISA). It is a committee of Cabinet. And then you have the Commonwealth Science Council (CSC). I support the ISA and I think it's a good idea and the Cabinet link

> was beyond what I ever thought they would do. The ISA is helping them to deliver this
>
> vision.

Henri has explained that Innovation and Science Australia (ISA) was responsible for the *2030 Strategic Plan for the Australian Innovation, Science and Research Environment,* and that this 'Strategic Plan' (which was not yet released at the time of this case-study interview and analysis) has the aim of contributing to the wellbeing and prosperity of Australians by ensuring innovation potential was reached. He drew a link between this ISA strategic plan and a National STEM and STEM Education strategy as the policy continuity to the research-base on Policy 1, yet was not certain on the potential actions from the ISA that would be realised, since:

> … I don't know what's in it. But if all it is saying is that we need more of something
>
> without saying how and how many, it will miss an opportunity. So we will see.

By this statement, Henri is making evident the extent that this policy is framed, which has fidelity for school-based implementation. For example, the extent (or lack thereof) that the academic research is relied on to inform and frame initiatives and budgets, which are *aligned, coherent, continue, focus, and scale* with the various National and State/Territory projects and allocation of funds leading to implementation.

Initiative and Budget.

From Henri's experience, the policy initiatives and budgets were littered with a number of too many and small in scale projects by funding allocated for time-limited periods or had unplanned 're-appropriation' to fund new projects. Further, projects were limited because there was no strategic framework and there were constant changes in National leadership presenting new priority policy agendas with limited regard to prior agendas or research. He has illustrated the nature of these initiative and budgets, by using a project for the

introduction of 'Coding' in schools - because a Prime Minister saw students doing it in another country:

> ... it's distracting ... It happened because [a Prime Minister] went to a school in New York and saw young people coding and said we will have some of that, and all of a sudden it ends up [happening]. It might be important (it probably is) but when you do it that way, it has a consequence. There is no coherence. There is nobody sitting back and saying so what is the impact of each of these [whims and actions and issues] ... since it will take resources away from other projects. Yes it can be done, but surely there is a need for a serious consideration of priorities. We can't do everything which means we have to choose wisely, not be swept along by the whim of the moment. But, is it a good idea? Well, if it's the future we should fund it. But...do we have the infrastructure across the portfolios to do this? Do we know the implications for other portfolios; resourcing, facilities - some would say no. Do the universities produce the teachers capable of teaching the whim of the moment? Unlikely, certainly at the start. And if they shift resources to accommodate the whim, what suffers?

For Policy 1: Specialist STEM teachers, Henri's experience with regard to the various initiatives and budgets highlighted how projects and funds were in competition with too many other policies. An all-encompassing and coordinated policy is how quality is ideally implemented.

Although, by experience this was not the case as:

> You may not be able to implement a policy because the budget in the portfolio is supporting all existing initiatives and or projects. In most circumstances, the only way to implement something new is to 'stop' an [existing project]. Such a mechanism certainly reduces capacity to move in strategically determined new directions.

Henri considered that funding this policy or Policy 2 (as presented in Chapter Five) was limited in scope or focus by the reallocation and the re-appropriation of budgets and funds from other STEM policies. Students learning to code, was implemented through the introduction of a New York inspired project without due reference to the current budget and policy agenda on STEM. Yet, this program was administered with funds that were reallocated largely from other STEM policies:

> Off-sets within the present budget … combined with the efficiency dividend, does not necessarily deliver a good strategic outcome. Each affected budget area (say a university) will make decisions in its own rather than the national interest. The strategic approach and vision are pushed aside by short-term exigencies.

Implemented and effective programs were experienced as short-term and limited in scale because funds were re-allocated to other portfolio areas with greater priority, or to implement new policy initiatives or programs based on changes in Government leadership administering a different priority policy agenda.

In effect, the present mechanism was limited with alignment, coherence, continuity, focus and scale – the antithesis of what Henri would regard as crucial to policy success or quality. The nature of the policy is defined by Government leadership, which is responsible for the quality, for example:

> There are different curricula supported in the National and State Governments by schools whereby students will be learning different things, but still consistent with the National Curriculum. That is why I kept going on about Science in the national interest, and the leadership role required of the Federal Government. The National Government must be held responsible for the overall leadership of the country, and for defining the sort of country we are trying to build. They have a Commonwealth education bureaucracy to help. We need the vision and the strength to deliver it. We need an

> economy to deliver it, not to limit it. We are a people, not economic robots drifting in a
>
> sea of uncertainty.

The lack of leadership is as palpable, as is the lack of vision because:

> What we have been led to believe is that the economy is the end game. So Australia is
>
> just an economy on legs. As long as we get the economy right everything else will be
>
> good. So they try to balance the budget at all costs: and cut our collective investment in
>
> our future - education. And all for political advantage. The age of entitlement might be
>
> over for disadvantaged people, but surely not for politicians. Spending money in
>
> marginal seats held by the party with the purse strings is all about them, not about us.

With this substantial statement, Henri restated the urgency for a STEM framework to
prioritise investment in STEM Education as a coordinated Government from National
leadership, rather than by National and State/Territory political competition based policy
administration.

Henri further explained this imperative for National leadership and a research-based
framework was to connect the various policies by the Government, or ideally to form an all-
encompassing and coordinated Policy 1: Specialist STEM teachers rather than as disparate
National and State/Territory agencies with competing policies, by quoting Henry Parkes:

> One people one destiny. If all you are is a State where a Federal Government is on top
>
> and saying that this is not our responsibility (for example, it's a State matter and so we
>
> don't have to do anything), then the notion of one destiny is lost. So then it comes back
>
> to what is the role of the National Government in a federation. So I took the line that if
>
> you are ever going to have a specific role for Government, and there was a very specific
>
> role for National Government, it is in providing leadership, and vision and character.

Leadership and a framework was needed to focus support for specialist STEM teachers.

Henri then provided an example to illustrate Policy 1: Specialist STEM teachers using a
policy supported by the governments in Germany.

According to Henri, The Government of Germany has supported specialist STEM teaching that begins in pre-school and continues across the schooling system, and all students are learning STEM Education with specialist STEM teachers. He noted again the importance of policy quality through alignment, coherence, continuity, focus and scale in his statement:

> I think that pre-schools should have STEM teachers and the funding of pre-service STEM teachers could be copied from the Germans. In fact, the Germans funded the first one here [initiative with a project Froebel]. Ian MacFarlane, when he was Minister started here on a small scale. The Germans were then funding more than 100 … So you could scale it up. What you would have, in a coherent [education] environment, is kids coming out of pre-school who would have some understanding of STEM and they would go to primary school where they would have STEM specialist teachers or access to them. You would have students entering secondary school better prepared for higher STEM. All of them would be equipped to learn about Science and some would be extended to learn deeper Science. You would have people coming out of secondary school with a better understanding [of STEM] and some of them would go on to do Science at university … We are not prepared to enable that to happen. A big problem in our system is out of field teaching. I was often told about the need to smooth the transition from primary to secondary school: I was told too often how students could finish primary school [Year Six students] with their lights turned on and then go into Year Seven and too often (not always!) be taught Science by a 'P.E. teacher with a bung knee'. And the kids would be turned off very quickly. There is little point in 'fixing' [primary school Science] if you switch them off in secondary - it is important to keep them enthused in Years 7 & 8.

Henri has remarked on how Policy 1: Specialist STEM teachers could be improved in the administration with reference to Germany. This program has been purchased for pre-schools to implement in Australia and, unlike the Government of Germany, it has not been scaled across the schooling system. Henri is suggesting that there is an evidence-based program here

in Australia from a prior National policy initiative, which could be aligned with, focused to, and scaled for primary-school based implementation by the Government of Australia.

Evaluative Measure Outcome and Timeline.

Henri was clear on the policy evaluative measures to a STEM policy:

> They do evaluate some of them. I mean I can't totally have a complete picture, but they do do evaluations of the programs. But, I am critical of the National [Government] of terminating program grants. It means they fund someone for so many years and it's gone unless they win a renewal. Well, the reason that they do it is because they need an easy way out. If they do not want to continue, or if they want to save money they say, Oh well it's a terminating grant we don't have to re-fund it. And sometimes it does not matter how well it has gone … if industry and Science wants to do a new initiative next year then they have got to find off-sets within the present budget … [it] is not necessarily a good strategic outcome.

Henri indicated that policy is evaluated based on the programs implemented. The variances in policy with the evaluative measure on outcomes and timeline revolves around the budget and not on the real measure of outcomes, which is seen as a limitation. On analysis, the policy initiative and budget alongside the evaluative measure requires alignment, coherence, continuity, focus, and scale by National leadership and a research-based framework over the various party leadership changes and terms of the Government.

He then suggested drawing on the Government of the U.S.A. approach to policy research and evaluation, which have relied on a formalised and shared framework for a STEM vision and strategy (see, Chapter 2). Henri stated that the Government of the U.S.A. and other international STEM policy environments can provide an approach to evaluative measures.

Henri then acknowledged that a National defined evaluative measure defined by an outcome and timeline (for example within the NISA (DPMC, 2015) was not in his experience completed based on an all-encompassing STEM Enterprise framework, which had for example a coherent definition and rationale on STEM and STEM Education. Henri has indicated that a priority policy is limited by the quality of evaluation based on a formalized and share framework by the Government of Australia. Instead, policies are evaluated based on the programs implemented, which may have limited alignment, coherence, continuity, focus, and scale with the framed policy dimensions. Therefore, to improve policy quality is to consider the Government of the U.S.A. STEM Education strategy and approach, as an exemplar.

Although a specific timeline was not stated by the National Government, Henri regarded that his outcome for specialist STEM teachers be phased in over a short, medium, and longer termed defined timeline, across the various terms of governments in Australia. Henri made the point that to scale the evaluation of Policy 1, all the education ministers were important. The education ministers were the influential determinants of this policy. Henri's experience was that Policy 1 was limited in each of the policy dimensions, which includes the evaluative research by the National and State/Territory education ministers and agencies.

Looking to the future, the CSC and ISA have the research capacity to develop a quality policy with regard to this outcome and a longer-term timeline across governments, Henri suggested. However, his concern was whether the National leadership regards this CSC and ISA research, or instead, to a surplus budget to frame a Primary STEM Education policy. Henri, was pessimistic about the Government regarding his framed policy, which includes this evaluative measure across the various party leadership changes and competing policies from a short term agenda.

At this point, Henri concluded our interview, and a summary of this analysis is next.

Summary

The presented case-study showed how the Context within the [education] Environment framed and connected a priority Primary STEM Education policy, which is summarised as:

1. Policy 1: Primary STEM teachers to be the all-encompassing policy produced, processed, and presented over the longer terms of goverments

2. Policy 1 (and all STEM Education policies) be administered (i.e., formulated and development) with sustained alignment and continuity across National, State, and Territory budgets, be collaborative between the various political party processes to support fidelity and quality; and,

3. Policy 1 (and all STEM Education policies) administer or reference a social compact on a national STEM Enterprise framework with the vision and strategy (within the national interests for Australia over longer terms of governments).

Further, the specific details of a framed STEM policy that is a priority within and across a National agenda requires a framework, and a research-based approach prior to implementation. In particular, the Context could improve on the quality of policy by academic research and evaluation with regard to the International STEM Policy Environment informing a national STEM Enterprise Framework by National and State/Territory ministerial leadership.

Chapter Close

In this Chapter, Henri has recommended a priority policy, specialist STEM teachers, with urgency on National and State/Territory agendas to address evidence-based concerns of future social and economic development. Policy quality has been exemplified in terms of the supportive actions on primary teacher confidence, and student achievement, interest, and motivation in STEM. The recommended action has been stated that specialist primary STEM teachers be supported with contemporary teacher education and training over the long term.

The rationale for this action has also stated that specialist STEM teachers have comparatively higher confidence in teaching STEM, which in turn has had a significant positive influence on student learning. The objective has been found that primary students learn STEM through compelling and interesting teaching on practical Science in the world around us. Underpinning this, academic research, has been used by the Government of the U.S.A in their approach as a basis for a priority policy leading to implementation. While the initiative and budget for a project and allocated funds has been suggested as that similar to the Government of Germany in supporting the Frobel project with specialist STEM teachers in pre-schools and across the school system. Finally, an evaluative measure with outcomes and timelines has been recommended as all students inspired to learn Primary STEM Education using inspiring primary specialist STEM teacher by 2020. Through this case-study, Henri has demonstrated that Primary STEM Education policy could continue through a formalised and shared framework, Federal ministerial leadership, and coordination to ensure the quality which would lead to improvements in school-based STEM Education nationally. A discussion on policy quality, based on this case-study, the online findings presented in the prior four chapters, and the reviewed international policy environment is laid out in Chapter 9 next.

Chapter 9

Policy Quality

Introduction

As this study has illustrated, a priority listed STEM Education policy (i.e., Specialist STEM Teachers) does not exist as a single delineated policy (document). A priority Primary STEM Education policy was not formulated and developed using a formalized framework by Governments of Australia, despite the fact that an evidence-based, all-encompassing, and coordinated by the National Government 'framework' to formulate and develop policy quality in harmony had been recommended (i.e., the OACS, 2013). The value of a framework is that it offers a 'roadmap' for Governments to administer (i.e., produce, process, and present) a 'quality policy' in which harmony (i.e., connection, coherence, and transparency) rather than tension (i.e., disconnection, fragmentation, and opacity) might prevail and therefore appropriately support school-based implementation.

Thus, the Conceptual Framework of this thesis is a tangible outcome of the study, and is offered here as an ideal for Governments in developing and administering policy in harmony.

This chapter is organized into four parts based on the four aspects of the Conceptual Framework. The purpose of this chapter is to critique policy quality, based on the data analysis presented in Chapters 4, 5, 6, 7, and 8, through the lens of this Conceptual Framework as a foundation to understanding policy quality. Harmony and tension arise as descriptors of policy whereby harmony (i.e., National, State, and Territory Government priority policy congruence) across all aspects from development to implementation is viewed as productive, meaningful and a measure of quality, as opposed to tension (OACS, 2014) evidenced by fragmentation (Freeman, 2013), competition (see the case-study in Chapter 8), or incongruity.

International STEM Policy Environment

The international STEM policy environment (Environment) is the first aspect of the

Conceptual Framework. The international context serves as a benchmark for Governments,

and policy researchers to reference quality. Interestingly, as the literature review in Chapter 2

suggested, non-federated governments (e.g., Finland) and/or federated governments that had

a research-based framework (e.g., Canada, Finland, Singapore, Hong, Kong, and South

Korea) were illustrative of a more harmonious STEM policy landscape. The literature review

concluded that harmony was evident by non-federated governments (e.g., Finland, Singapore,

and Hong Kong) using a framework through which priority policies were presented by

National leadership, a clear definition and vision, and collaborative long term non-

government STEM partnerships. Federated governments (e.g., Canada and South Korea)

illustrated harmony through National, State, and Territory/provincial congruence to an

evidence-based framework. These frameworks defined and envisioned STEM through a

STEM Education (or STEAM Education in the case of South Korea) State and

Territory/provincial connection to National leadership, and long-term partnerships with non-

government organisations to progress policy on Primary STEM Education. In contrast,

tension, and hence limited policy quality, was noted by those federated governments (e.g.,

Japan, and the United Kingdom), which lacked policy based on an aligned definition and

nationally led vision for STEM and STEM Education.

    International policy quality.

Using Finland as an example, harmony was evident as Finnish policy is based on a

framework overseen by National leadership and supportive of non-government STEM

partnerships in response to its unique social and economic context. Specifically, Education

policy in Finland is based on a professional teacher education and training workforce

(Sahlberg, 2010) including a minimum registration requirement for a primary teaching

masters qualification, completion of practice-based research and the development of communities of practice based on Science learning and teaching. Teachers use a National curriculum, and Government relies on an evidence-based evaluation of policy linked to school-based practices. This has been achieved by a system of government that is a 'single nation state', which is less complex than a federated nation of States/Provinces/Territories that often administer short-termed, concurrent or competing 'STEM' policies. Thus, policy harmony has prevailed across and over the various terms of the government in Finland, which the OECD has indicated is a model for other member nations.

From the Canadian perspective, Governments have framed 'STEM' as all-encompassing (i.e., for cultural, social and economic development) and coordinated (i.e., by the National, Provinces, and Territories) policy through the formation a research-based framework. As a consequence, Canada has a National STEM Education framework for pre-school through to Year 12 established through non-government partnerships. A framework and partnerships with specificity across the schooling years helps the various National, provincial, and territorial entities to interconnect with policy dimensions and attributes. This, therefore, reduces the tensions inherent in short-term competing policies and policy agendas over different terms of government. Through a STEM and STEM Education framework, Government has been able to form a clear and congruent vision.

In contrast, policy tension in the U.K. was evident through a lack of a formalized and accepted working definition of 'STEM' as a transdiscipline (i.e., UKDFE, 2010). The Government has uncoordinated policies and agendas on STEM and STEM Education that struggle to address issues raised from various sectors including the Royal Academy of Engineering. Further to this, the UK system of government is administratively focused on

Science and Mathematics, and is disconnected from the STEM and STEM Education policies framed in Scotland, Wales, and Northern Ireland.

In a similar vein, policy tension exists in Japan as STEM is also typically viewed as either Science or Mathematics and also lacks an all-encompassing and cohering framework. The Government has been unable to coordinate policies on STEM and STEM Education to address social and economic issues, notably with regard to female interest and participation. In Japan there was no framework or persistent National leadership across the Japanese Ministry of Education, Culture, Sports, Science and Technology (JMEXT) to address concerns regarding female career interest and education in STEM. Therefore, the Prime Ministerial action prioritising female STEM Education to address future social and economic development has not been harmonised by the JMEXT and rather is in tension.

Overview of International policy environment.

As a foundational aspect of the Conceptual Framework, the Environment comprises those international governments seeking to encompass and coordinate STEM and STEM Education to address unique cultural, social and economic development. In terms of quality, a harmonious government policy approach to STEM education comprises:

1. An evidence-based framework that defines, envisions and strategizes;

2. Sustained National leadership that interlinks across the National ministries and agencies/departments with State/provincial/Territory education ministries and agencies/departments; and,

3. Diverse partnerships with non-government organisations (i.e., schools, universities, STEM organisations, companies, and foundations).

If these factors are not present, the STEM policy landscape of any given country is under tension and characterized by disunity or fragmentation and incoherence.

Australian Government STEM Policy Context

The Australian Government STEM policy context (Context) is the second aspect of the

Conceptual Framework. As stated in Chapter 1, Government is responsible for producing,

processing, and presenting (Althaus, et al., 2014) Primary STEM Education policy, which

leads to school-based implementation and ultimately effects the desired outcomes for social

and economic development in the future. The reviewed literature indicated that there was no

Government of Australia research-based STEM and STEM Education policy framework

(OACS, 2014) and that policy was disconnected, incoherent and fragmented by the numerous

programs both nationally and across the State/Territories (Freeman, 2013). Thus, as the data

makes clear, tensions prevailed as much of the National policy agenda did not rely on a

framework to conceptually frame a quality policy approach. As a consequence, narrow

policies were noted extensively across this Context.

   Evidence-based framework.

A National policy agenda arose in response to social and economic issues of concern from

political party election commitments (NISSA, 2014) and industry-based research reports (i.e.,

AiGroup, 2014; PricewaterhouseCoopers, 2015) as opposed to an evidence-base including

academic research. For example, the NISA nor NIICA did not cite or reference academic

research on any of the three policies (i.e., Chapters 4, 5, and 6), nor rely on a framework.

Policy based on evidence can inform and progress definitions of key policy terms, such as

STEM, STEM Education, and Primary STEM Education. It can also establish the clear

definitions and vision intended to impact school-based learning and teaching practices, and

ultimately the social and economic outcomes intended for the future. Through an evidence-

based framework, STEM, STEM Education, and Primary STEM Education could be defined

and the vision explicated and facilitated across the Federal DPMC, DET, EC, AITSL and

ACARA, the State and Territory ministries and education departments and agencies in a harmonious manner.

Academic-research has defined 'STEM' and STEM Education (the learning and teaching of contemporary practices in STEM for social and economic development) as a transdiscipline (Sanders, 2009) for school-based practice. However, data analysis in this study indicated that Government policy had focused on the disciplines of either Science or Mathematics, rather than STEM as a transdisciplinary practice. Specifically, the definition of key terms within the STEM Education Strategy (NSSES) by the EC (2015) lacked clarity on key definitions that link to those of the of Federal DPMC, DET, ACARA, AITSL and the State/Territory premier departments and education agencies

National Government leadership.

Sustained Federal Government leadership, which develops and progresses policy across longer terms and agendas is illustrative of policy harmony. Without Federal Government leadership tension prevails because the States and Territories tend to form and progress separate policies and agendas to those of the Federal Government. The data in Chapters 7 and 8 showed how separate State/Territory policies and agendas existed and differed with that of the Federal Government due to a lack of sustained National leadership. Separate or 'competing' policies (see Chapter 8) rendered National efforts redundant, inefficient (PC, 2016), or ineffective, because State and Territory jurisdictions leading policy for school-based implementation were in tension.

As the case-study in Chapter 8 demonstrated, The Government of Australia was unable to sustain National leadership of the extensive National, State, and Territory policies designed for school-based implementation.

Non-government STEM partnerships.

Policy quality is also supported through diverse partnerships with non-government STEM and STEM Education agencies that have links to school-based practices. Diverse partnerships with non-government organisations (i.e., schools, universities, STEM organisations, companies, and foundations) that are sustained and developed over the various terms of a government foster harmony. Through partnerships, quality is enhanced by the additional research, administrative, and financial resources available beyond Government and can help link to a global STEM Education ecosystem (Kramer, et al., 2015). The Governments of Australia data lacked evidence of such diverse STEM partnerships.

Overview of Australian Governments STEM Policy Context.

Overall, across the Governments of Australia STEM policy context, tension was continually evident due to a lack of:

1. a formalized and evidence-based framework with a definition, vision and strategy for STEM and STEM Education;

2. sustained National leadership to frame and coordinate Federal, State, and Territory ministries and agency priorities across Government agendas; and,

3. a diversity of non-government STEM partnerships to support school-based Primary STEM Education across Government agendas.

As the data in Chapters 4, 5, 6, 7, and 8 made clear, tension rather than harmony tended to pervade policy formulation in Australia.

Policy Dimensions

Five policy dimensions comprise the third aspect of the Conceptual Framework. It seems fair to suggest that if a policy is interlinked across each of the five *dimensions* harmony prevails. In contrast, tension, and hence inadequate policy, is evident when *dimensions* are not interlinked across each Federal ministry and agency responsible for administering policy and school-based implementation.

The five policy dimensions comprise:

1.   *Priority action and issue;*

2.   *Purpose, rationale and objective;*

3.   *Research citation and reference;*

4.   *Initiative and budget*; and,

5.   *Evaluative measure, outcome and timeline*.

Priority.

The National policy agenda sets the policies for the Government of Australia led by the DPMC and interlinked by Federal ministries and agencies on a *priority action to* address a stated *issue*. A *Priority action and issue* is defined as the initial and cumulative *dimension.* In the NISA, the Policy 1 *Priority action* was noted as requiring all pre-service primary teachers to graduate with a specialization, preferable as a priority in STEM (DPMC, 2015). This *action* was indirectly noted to address several *issues* of concern raised including students' declining skills in Science and Mathematics, meeting an election commitment, and primary teacher levels of confidence to teach contemporary Science and Mathematics.

Harmony could be considered to exist when the *priority action and issue* interlink in-and-across National agendas of the various ministers and agencies of the Federal Government (i.e., ACARA, AITSL, the DET, EC, DPMC, OACS, PC, and Treasury). As the data

suggested, this *action* was not stated in the prior agenda (i.e., the NIICA focused on Science and Mathematics teaching quality), or by the above listed ministerial-led agencies. Since, the various National agencies had different *actions and issues*, in particular the OACS elaborated an *action* on in-service teacher support for Science and Mathematics specialists, and the EC re-prioritized National agenda policies in order to support effective learning and teaching outcomes. The Government of Australia *priority action and issue* was disconnected from the DPMC.

Purpose.

The *Purpose rationale and objective* comprises the second policy *dimension*. The *Purpose* is defined as the stated evidence-based *rationale and objective* for the stated *Priority action and issue.* The *rationale* for Policy 1 was based on "more innovation and Science benefits and improves the quality of life of all Australians by schools better equipping students to be successful entrepreneurs in order to hold a number of diverse jobs, or work across a number of industries" (DPMC, 2015), which was similarly linked to Policy 2 and 3. While, *outcomes* were unclear for Policies 1 and 3, Policy 2 indicated that all Year 5 students would learn to code through online coding challenges. In the NISA, the *rationale and objectives* varied across the Federal ministries and agencies (see Chapters 4, 5, and 6), which included the DET (2016a) *rationale* of reflecting the educational priorities of the Government without stating what those education priorities were, nor the outcomes.

The *rationale and objective* was mostly unstated in the National agenda for interaction by the Federal ministries and agencies, to build as policies across Government agendas. The NIICA and NISA, did not provide a coherent *rationale and objective* across Federal ministries and agencies. Therefore, the Policy 1, 2, and 3 *Purpose* as explicated by the *rationale and objectives* existed in tension across the National agencies, indicating inadequate priority policies on Primary STEM Education through this second *dimension*.

Research.

Research is the third *dimension* and, as defined in Chapter 3, is defined as the evidence-base of a priority policy, which is identified by the *citations and reference list* of a National agenda. The evidence-base comprises Government commissioned, industry-based research, and academic research that links across Federal ministries and agencies in leading and administering school-based implementation. However, the data showed that there was no academic-research (*cited and/or referenced*) informing policy *dimensions*. The extent of *research* was limited to Government commissioned and industry-based research reports. In particular, the NISA paraphrased industry-research reports, which included an unreferenced report by the Foundation for Young Australians, and lacked evidence of academic-research on Policies 1, 2, and 3. Also, the NISA *research* varied across the National ministries and agencies, and agendas (i.e., the NIICA) (see Chapters 4, 5, and 6). Notably, the NIICA *research* cited and referenced Government commissioned research of the OACS (2014), TEMAG (2014), and National (i.e., NAPLAN) and international assessment data (i.e., PISA and TIMMS) and lacked clarity.

Primary STEM Education policy quality relies and builds on an evidence-base, which is *cited and referenced,* to include and link academic-research with Government commissioned and industry-based research reports. However, the quality of Policies 1, 2, and 3 across-and-by the National agendas of the DPMC demonstrated a lack of academic research.

Initiative and Budget.

Initiative and Budget is the fourth *dimension* and is defined as the *projects and/or programs* with allocated *funds* to address a priority issue and realise action through implementation. However, the data showed no coherent *initiative and budget* on any of the three policies. While no cogent initiative was evident, a 'bundled' budget was established but was not reconciled in the NISA. Further, the concurrent Federal Treasury budget reallocated funds from the NISA STEM Education initiatives to support a competing and higher valued Government priority to realise a balanced budget by 2020 (see, Chapters 4, 5, 6 and 8).

The *Initiative and Budget* was mostly unstated in the National agenda in terms of connecting the *dimensions* across the respective Federal ministries and agencies. Therefore, the quality of the three policies as evident in the *initiative and budget* were clearly in tension.

Evaluative Measure.

Evaluative Measure is the final dimension and is defined as the policy-based *outcome(s) and a timeline* to research the impact of a policy following implementation. However, the National data showed no specific *outcomes nor timeline* to evaluate the impact on implementation. The NISA indicated an *outcome* when derived through the noted *actions* and a *timeline* through the *budget*, yet it was unclear that these policies were to be evaluated by the Government. In relation to the NISA, the *Evaluative Measure* varied across the National agencies (see Chapters 4, 5, and 6) and notably featured AITSL reporting on progress to implement National priority actions directly to the DET, which had not defined an *outcome nor timeline* on the implementation to support the Policy 1 *action.*

Overall, an evaluative measure was unstated in the National agenda in relation to either linking agencies or to build and progress these policies across Government agendas. The three policy *outcomes and timelines* were problematic because there was no consistency or frame of reference. The three policies were therefore in tension based on the undefined *outcomes and a timeline* to evaluate the policy impacts on school-based implementation.

Overview of Policy dimensions.

Harmony could be seen to exist when all *dimensions* of a priority policy are evident across the Federal Executive Government. The data showed continued tension as all *dimensions* were not present across the three framed policies comprising the National agendas (i.e., the NIICA and NISA).

Policy Attributes

Emergent from the literature review and data analysis explained in Chapter 3 and defined in Chapter 7, the following five policy *attributes* comprise the fourth and final aspect of the Conceptual Framework. The attributes include:

1. *Alignment;*

2. *Coherence;*

3. *Continuity;*

4. *Focus; and,*

5. *Scale.*

Alignment.

Alignment is defined as each State and Territory *dimension* being linked with those of the Federal Government in leading and administering a priority policy for school-based implementation. Chapters 7 highlighted a lack of *alignment* with no State or Territory having an action to require pre-service primary teachers to graduate with a specialization in the priority area of STEM, and had differing *actions*. Chapter 8 indicated that the States and Territories had competing policies in place in relation to the National agenda. Federal and State/Territory policy misalignment is a form of tension, and research has shown that different or competing policies have led to educational inequality in Australia (PC, 2016). For harmony to exist, State and Territory agendas clearly need to *align* with the National agenda as 'competing' policies would inevitably foster tension.

Cohesion.

Cohesion is defined as the systematic presentation of mutually reinforcing policies across Government departments. Analysis in chapters 7 and 8 showed a clear lack of *coherence.* Further to this, chapters 4, 5, 6, and 7 actually indicated that the National agenda had neither cited nor referenced academic-research; neither did the States or Territories. At best, it can be noted that OACS (2014; 2015) and TEMAG (2014) research reports were noted in National,

State, and Territory datasets, but there was a difference between Government ministries and agencies. Through this *attribute,* tension was consistently evident as not all States and Territories *cohered* with the National agenda.

Continuity.

Continuity is defined as the evolution of a priority policy from production to implementation informed by an evidence-base to effectively develop policy over the longer term across Government agendas. With regard to Policy 1, Specialist STEM teachers, *continuity* was not evident across the National, State and Territory agendas (i.e., the NIICA and NISA). The States and Territories require *continuity* with the National agenda for harmony. Chapters 7 and 8 showed a lack of c*ontinuity.* As a result, a priority policy was not progressed across National agendas. Further to this, tension was evident through policies rendered obsolete by the frequency of changes and interests in Federal Government leadership forming differing and superseding priorities, which resulted in discontinuity across States and Territories. Harmony would be evident through continuity and fidelity across *Evaluative Measures* at State and Territory levels, yet discontinuity was observed when linking each *dimension*.

Thus, it would be reasonable to suggest that Policies 1, 2, and 3 would be unlikely to persist, or be progressed, across future agendas.

Focus.

Focus is defined as the extent that the States and Territories specifically interact according to the National agenda *dimensions*. Conceptually, *focus* occurs when each of the State and Territory Governments have corresponding *dimensions* that interact with a *dimension* directly related to school-based implementation, which indicates harmony. As Chapters 7 and 8 showed, there was a distinct lack of policy *focus*. Different State and Territory *actions* led to fragmentation (Freeman, 2015), which inevitably impacted implementation. For example, implementation including the DET allocation of funds to ACARA and AITSL to address TEMAG (2014) recommendations to improve pre-service teacher education courses in

Australia, and to develop a 'Teacher Workforce Data Strategy' (Strategy) to assist with workforce planning and assess pre-service teacher education outcomes became a discernible focus. Through this Strategy, the systematic impact of the *priority action* for a Primary STEM teacher specialization with a priority in STEM on the teaching workforce was meant to occur. Yet, AITSL (see PTR Consulting Pty Ltd (2017)) reported that not all States/Territories had implemented this NISA *action* for pre-service primary specialist STEM teachers. In addition, Federal Treasury reduced and reallocated funds away from NISA STEM Education initiatives, which included the funding allocated to the DET for supporting this Strategy and other projects by ACARA and AITSL (see Chapter 7). Since the Federal Government is the predominate source funding compulsory education or Primary STEM Education in Australia, budget variations, imbalances, and indeterminable allocations (as noted in the NISA with the concurrent Federal Treasury, DET, and State/Territory education agency reported budgets) inevitably lead to policy fragmentation across States and Territories. Policy tension is an obvious outcome as Federal Government financial support for the States and Territories becomes uncertain and lacks transparency, impacting initiatives and budgets by the States and Territories (see, Chapter 8, OECD, 2015); focus is lost. Chapter 8 highlighted a shift in the Federal Government focus for surplus National budget by 2020 and would do so through reducing the budget spend on education - as evident in the Treasury (2015) budget. Since the National NISA, Treasury and DET had priority policies with *initiatives and budgets* that were not balanced, funds reduced or reallocated, and limited transparency, the State and Territory focus with National agenda pertaining to Policies 1, 2, and 3 lacked harmony.

Scale.

Scale is defined as the ability of a framed policy to be effective from a small and controlled size, such that, on evaluation, it could inform and build an evidence-base in order to be expanded across-and-through agendas nationally. With regard to Policies 1, 2, and 3, *scale* was not evident. No State nor Territory had an *initiative or budget* to require pre-service

primary teachers graduate with a specialization with a priority in STEM, thus indicating no expansion of this National *action*. Chapter 8 indicated that the National Government had 'too many short, underfunded, and small in scale projects', which were often implemented without research or regard to existing evaluated and effective projects that could be *scaled*. Further to this, Chapter 7 showed that primary teachers and STEM organisations were struggling with the implementation of the Policy 3 *action* on forming school-based partnerships. Teachers were not implementing this policy because they did not see how it linked to the ACARA AC, nor viewed it as a formal requirement for student learning outcomes. Across the three framed priority policies, *scale* was not evident and the likelihood that the policies could be implemented as intended nation-wide was unlikely; a clear policy tension.

Overview of policy attributes.

Five policy attributes (*Attributes*) comprise the fourth and final aspect of the Conceptual Framework by which policy quality might be measured. Ideally harmony rather than tension should prevail. As the literature review suggested, when the State and Territory education ministers and agencies interact with National agenda *dimensions* (through *alignment, coherence, continuity, focus, and scale)* quality across policies is possible. As this research has made clear that has not been the case in this context.

Chapter Close

This chapter has presented a consideration of the notion of quality through application of the research project's Conceptual Framework to the three extant policies derived from analysis of the data sets.

The framework was developed in this study by iteratively and recursively using the four coding methods to analyse Government STEM policy, which revealed repeating components (i.e., *dimensions and attributes*) in the online sourced data. It also offers a way of considering quality through a deep consideration of the relationship of each element across Federal, State

and Territory Government bodies. As an evidence-based framework, the value is to objectively identify a priority policy that has been designed for implementation and critique the quality, which is intended to impact school-based learning and teaching practices.

The use of harmony and tension as a window into the four aspects of the Conceptual Framework has offered insights into the framework through each element. The outcome has been that the quality of Policies 1, 2, and 3 largely exist in tension, which suggests a lack of overall policy vision and strategy.

Chapter 10

Study Conclusion

This chapter concludes the study through a summary of the outcomes in relation to the development of the Conceptual Framework and as a response to the research questions. Based on these outcomes, the limitations, implications, and recommendations emerging from this study are also considered.

Study Overview

Through the development of a Conceptual Framework, three Primary STEM Education priority policies of the Government of Australia were mapped using five *dimensions* (Chapters 4 to 6). Fidelity of the States and Territories' concurrent policies in relation to the National agenda (NIICA and NISA) was examined using five *attributes* (Chapter 7), which ultimately informed considerations of the quality of these policies. Augmenting deep policy analysis was the case-study (Chapter 8) with a leading Federal Government policy administrator. Through the discussion (Chapter 9), policy quality was considered using the concepts of harmony and tension aimed at discerning similarities and differences between the National policy *dimensions* and State and Territory policies mapped against the five *attributes*. Overall, policy tended to demonstrate ongoing tension rather than harmony, which is clearly a concern for nationwide school-based implementation and educational change.

Study Outcomes: Responses to the Research Questions

The aim of this thesis was to examine and understand how the Governments of Australia designed i.e., produced, processed, and presented (Althaus et al., 2014) STEM Education policies in relation to school-based Primary STEM Education. The study sought the ways in which policy, as a coherent whole, functioned across Federal, State and Territory borders.

Methodologically the study examined official Government policy texts (in relation to Primary STEM Education) based on an overarching research question and three sub-research questions outlined in Chapter 1. Responses to these questions are outlined below and are based on analysis of the extensive data sets collected for this study.

The overarching research question.

The overarching research question directing this study was: How is Primary STEM Education policy designed for school-based implementation? The data illustrated that Primary STEM Education policy was hierarchically designed by the Federal Executive Government through Prime Ministerial leadership, which required ongoing interaction with State and Territory portfolios, ministries, and agencies if school-based practices were to be influenced. However, analysis illustrated that although policy was designed using National agendas to create priority policies, these policies did not maintain fidelity across State and Territory jurisdictions thus limiting the ways in which the policies were presented and the manner and nature of the following actions.

In order to coherently and rigorously examine data sets, a Conceptual Framework was developed that offered an analytic guide, as well as a formal structure to how policy creation and implementation might be designed. By using the Conceptual Framework, the following four aspects were of prime consideration for understanding policy environment and practice:

1. positioning within the international STEM policy environment;

2. guidance provided by the Government of Australia STEM policy context;

3. connection with each of the *Policy Dimensions*; and,

4. relationship of *Policy Attributes* to Federal, State and Territory portfolios, ministries and agencies.

In applying this framework to existing policy (at the time of this study), the ability to inform the quality of implementation using school-based practices appeared to be lacking due to:

1. the limited extent of publically available policy data;

2. lack of a formalised evidence-based STEM Education policy framework; and,

3. differing concurrent National and State/Territory priority policy agendas.

Detailed analysis of this overarching research question was established by examination of the three sub-research questions.

Sub-research question 1.

The first sub-research question was: What are the priority policies of the Government of Australia? Based on an analysis of online sourced Government policy texts and documents, three priority Primary STEM Education policies of the Government were clearly evident. The policies, presented in order of priority, were:

1. Specialist STEM teachers (Chapter 4);

2. Students learning to code (Chapter 5); and,

3. School partnerships with STEM organisations (Chapter 6).

To determine these key policies, the content, Government agency, frequency, and relevance of key search terms/words were considered when undertaking searches of publicly available documents from the Government of Australia. In analysing these documents and texts, five policy *dimensions* were used to determine the priority policies intended to influence school-based primary STEM education. These five *dimensions* were:

1. *Priority action and issue;*

2. *Purpose rationale and objective;*

3. *Research citation and reference;*

4. *Initiative and budget;* and,

    5.   *Evaluative measure outcome and timeline*.

Each of the three noted priority policies were directly linked to the National STEM and STEM Education policy agendas, which comprised the NIICA (DPMC, 2014) and the NISA (DPMC, 2015). Through these two agendas, each policy was linked with the relevant documents of National Government portfolios and agencies.

The five *dimensions* became an important element of the Conceptual Framework and so were also an outcome of this study as analysis of the Government data did not locate an all-encompassing and evidence-based framed policy for implementation in practice.

Sub-research question 2.

The second sub-research question was: What is the policy fidelity? Fidelity between the Primary STEM Education policies of the Government of Australia was not evident in the data. A response to this question was determined by the connection, or lack thereof, between the National and State/Territory-based policies as demonstrated in Chapter 7. Through the data analysis of Policy 1, there was no evidence of policy fidelity across the layers of Government when the data was analysed using the following five policy *attributes*:

    1.   *Alignment;*

    2.   *Coherence;*

    3.   *Continuity;*

    4.   *Focus;* and,

    5.   *Scale.*

As indicated in Chapter 7, the *attributes* were viewed as a proxy for informing the nature of a policy as they offered as a window into the notion of quality in policy design.

Using the highest priority policy as an illustrative case, Policy 1 fidelity was mapped across the State and Territory Government data against that of the National Executive Government.

Through each *attribute*, fidelity was not evident for two key reasons. Firstly, because the National Government had limited data (i.e., the NISA) on the nature of the policy in relation to each *dimension*, and secondly, the State and Territory Governments had differing or competing policies.

As was the case with the dimensions, so too the *attributes* formed another important outcome of this study by creating a rigorous and systematic tool to determine the extent to which fidelity between the policies of the National agenda with those of the States and Territories may or may not exist. These *attributes* were similarly used to inform the development of the Conceptual Framework.

Sub-research question 3.

The third and final sub-research question was: How is Primary STEM Education policy framed for practice? This study showed that three priority policies were designed with the intention of impacting school-based practices through National agendas interacting with those by the State and Territory Governments. Chapter 9 offered deep analysis of the framing of policy and a consideration of quality the use of the concepts of harmony and tension. The data suggested that rather than being in harmony, policy tension was evident as both the *dimensions* and *attributes* revealed major discrepancies and variations across National and State/Territory Government Primary STEM Education policy.

Overall, the research highlighted a lack of policy quality (as determined through application of the Conceptual Framework) such that policy was in tension, which clearly has major implications for policy implementation and educational change.

Application of the Conceptual Framework to Policy 1, which was the highest priority and therefore used as an indicative case, highlighted short-term and disconnected policy (see,

Chapters 7 and 8), which was unlikely to be implemented by all schools in Australia (see, Chapter 9). This conclusion (i.e., existence of policy tension rather than harmony) was also inferred with regard to Policies 2 and 3 as a consequence of analysis of this indicative case.

Contributions to Knowledge

This study contributes to the knowledge base on Primary STEM Education policy in the Australian context in two specific and important ways:

1. through the formation of a methodology designed to source, analyse, and critique policy. This is important because a methodology that flexibly integrated two disciplines, Political Science and Education, was not evident prior to this study. This methodology is a valuable multi-discipline integrative framework, which could be a useful reference for similar types of studies in the future; and,

2. in proposing and explaining an evidence-based Conceptual Framework based on four aspects used to determine the nature of fidelity and determine the quality of a priority policy by the Government of Australia for school-based implementation. The development of such a framework has been noted in the review of research (Freeman, 2013, OACS, 2014; OECD, 2011; PC, 2016) as a recommendation based on concerns of policy fragmentation, disconnection, incoherence, obscurity, and inefficiency. The Government of Australia did not have an evidence-based STEM and/or STEM Education policy framework to inform policy at the time of this study.

Limitations of the Study

As indicated in Chapter 3, the six key limitations of this study are acknowledged and summarised below:

1. Access to STEM and STEM education policy, nationally and State/Territory-based, was limited to publicly accessible policy-based communications and documents.

2. The timeframes that bounded this study may have excluded some data.

3. The Government was without a formalized framework or single policy document detailing an all-encompassing and coordinated priority policy at the time of this study. Therefore, the ability to map the Context and to collect and analyse data of a priority policy was limited.

4. There was a reliance on policy from specific National and State/Territory Executive portfolios, ministries, and agencies related to the STEM and Education fields, this may have led to inadvertent exclusion of other areas that impacted the field.

5. An in-depth interview rather than several case studies was used to inform this study, which may be viewed as a limitation. However, due to the prominence and relatedness of the interviewee with the research aim and questions a single-case-study was determined in this instance.

6. This study sourced data from a range of Government agencies, including internationally, rather than drawing on research about school-based practices in Primary STEM Education. This could be seen to have limited 'practice-based' data across STEM and STEM Education policy formulation.

Implications

There are many implications emerging from this study, which are explained below in terms of their purpose and potential impact for three key audiences connected with this work: teachers; teacher educators; and, policy makers.

Teachers.

In order to bridge policy and practice in meaningful ways, there is a clear need for teachers to be in a position to understand the priorities for their school-based practice and how accompanying teacher professional development aligns with a given priority (in this case, in STEM). Further to this, there is also an imperative for meaningful school-based partnerships with STEM organisations. Therefore at the school level, policy formulation and implementation at governmental level should be such that planning, budgeting, and delivering expected outcomes is aided and supported at school level.

Teacher educators.

There is the need for teacher educators to work with Government policy researchers, and to shape responses to teacher preparation that align with course content, philosophy, intentions, and implications for teaching practice. Teacher education can link with a Government policy agenda, which educates on the fidelity and quality at teacher education level to have a real influence on what is happening and why. Also, teacher educators can contribute to the Government priority policy research-base, which can build on the evidence-base informing a quality policy within and across terms.

Policy makers.

This study highlighted the current tension in STEM Education policy. Policy Makers could be well justified in adopting a framework approach (i.e., along the lines of the Conceptual Framework developed through this study) to build evidence-based policy in order to better progress policy quality and ensure fidelity across different levels of Government.

The development and application of a research-based framework for policy formulation has implications for leadership and administration across Government that matters if meaningful educational change is to be effected.

Overall, and within an education system, teachers, teacher educators, and policy makers need to work from a shared knowledge base if policy is to seriously influence the quality of practice. The current study could serve as an impetus to approach future policy formulation to better realise the vision for STEM through Primary STEM Education.

Research Recommendations

Three recommendations for related research on Government Policy and Education is offered next.

Firstly, research on Government priority policy impacts on school-based teaching (and learning) practices is recommended. This research can build a body of evidence and theory that informs Government policy agendas. The research outcomes must be consistently communicated to key National, State, and Territory ministries and agencies to support policy development or quality. Also, research must be connected to school-based practices and the pedagogy of Primary STEM Education to support policy quality. Overall, research on how a policy on implementation has impacted STEM learning and teaching is essential for Government feedback and to continue to iterate policy quality over time.

Secondly, a study that builds and maintains a more easily searchable Government of Australia online data-base of priority policies using similar *dimensions* and *attributes* or a Conceptual Framework, which is publically accessible, interactive, and updated is recommended. Essentially, this data-base would be a website, which comprises an interactive and updated map of the Context, the priority policies, and the policy fidelity and quality by the Government. Also, the Government STEM and STEM Education policy framework and research informing a priority policy are included, which have informed these policies. This website could be commissioned and supported by the Government for development and maintenance by universities as part of an ongoing research project. This website would also enable researchers, policy makers, teachers, principals, administrators, and teacher educators to easily access and understand the policy context, priorities, fidelity and quality of the Government over time, which was a challenge encountered by this study. Through this website, these participants can be informed, engage, and contribute to Government policy quality with regard to the impacts on their respective practice over time.

Finally, research on the understanding of pre- and in-service primary teachers' understandings of Government of Australian policy on Primary STEM Education, which is administered to impact practice is recommended. Government policy is the basis to formalised education in Australia, a 'Government of Australia policy on Primary Education' unit for pre-service teacher education and a pathway of units for further academic research and practice could be the outcome of this study. This unit would enable formalised knowledge in the production, process, and presentation of Government policy designed for school-based learning and teaching practices. Also, further post graduate coursework opportunities could be researched and framed to support a specialisation in Government (STEM) Education policy and research for teaching and learning practice. This recommendation would enable teachers to understand the nature of how policy drives their practices, how to interact, and what constitutes a quality policy. Also,

teachers would be able to pursue careers in and contribute to education policy and research through this unit, which builds and provides Government and Education with policy and pedagogy experts. Teachers working in Government policy and policy research would make a beneficial contribution to policy quality.

Conclusion

This study led to the formulation of a conceptualised methodology, map, and framework for studying government policy. As a consequence, three priority policies emerged as Government priorities, each of which proving to be structured, understood and interpreted across levels of Government in different ways.. Thus, policy quality was found to be a concern due to a lack of an evidence-based framework, National leadership, and State and Territory Government fidelity across policies.

There is little doubt that in a political environment, Government policy formulation is quite a complex and dynamic system. However, if policy is to genuinely influence practice, then there needs to be an acceptable framework for policy construction to ensure quality outcomes.

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Appendices

Appendix 1

Students' 2015 Pisa Averaged Achievement Results on the First 26 Nations/Regions

Snapshot of performance in science, reading and mathematics

Countries/economies with a mean performance/share of top performers **above** the OECD average Countries/economies with a share of low achievers **below** the OECD average							
Countries/economies with a mean performance/share of top performers/share of low achievers not significantly different from the OECD average							
Countries/economies with a mean performance/share of top performers **below** the OECD average Countries/economies with a share of low achievers **above** the OECD average							

	Science		Reading		Mathematics		Science, reading and mathematics	
	Mean score in PISA 2015	Average three-year trend	Mean score in PISA 2015	Average three-year trend	Mean score in PISA 2015	Average three-year trend	Share of top performers in at least one subject (Level 5 or 6)	Share of low achievers in all three subjects (below Level 2)
	Mean	Score dif.	Mean	Score dif.	Mean	Score dif.	%	%
OECD average	493	-1	493	-1	490	-1	15.3	13.0
Singapore	556	7	535	5	564	1	39.1	4.8
Japan	538	3	516	-2	532	1	25.8	5.6
Estonia	534	2	519	9	520	2	20.4	4.7
Chinese Taipei	532	0	497	1	542	0	29.9	8.3
Finland	531	-11	526	-5	511	-10	21.4	6.3
Macao (China)	529	6	509	11	544	5	23.9	3.5
Canada	528	-2	527	1	516	-4	22.7	5.9
Viet Nam	525	-4	487	-21	495	-17	12.0	4.5
Hong Kong (China)	523	-5	527	-3	548	1	29.3	4.5
B-S-J-G (China)	518	m	494	m	531	m	27.7	10.9
Korea	516	-2	517	-11	524	-3	25.6	7.7
New Zealand	513	-7	509	-6	495	-8	20.5	10.6
Slovenia	513	-2	505	11	510	2	18.1	8.2
Australia	510	-6	503	-6	494	-8	18.4	11.1
United Kingdom	509	-1	498	2	492	-1	16.9	10.1
Germany	509	-2	509	6	506	2	19.2	9.8
Netherlands	509	-5	503	-3	512	-6	20.0	10.9
Switzerland	506	-2	492	-4	521	-1	22.2	10.1
Ireland	503	0	521	13	504	0	15.5	6.8
Belgium	502	-3	499	-4	507	-5	19.7	12.7
Denmark	502	2	500	3	511	-2	14.9	7.5
Poland	501	3	506	3	504	5	15.8	8.3
Portugal	501	8	498	4	492	7	15.6	10.7
Norway	498	3	513	5	502	1	17.6	8.9
United States	496	2	497	-1	470	-2	13.3	13.6
Austria	495	-5	485	-5	497	-2	16.2	13.5

Image retrieved from https://www.oecd.org/pisa/pisa-2015-results-in-focus.pdf

Appendix 2

TIMSS 2015 Mathematics performance trend by year four students in Hong Kong

Image retrieved from http://timss2015.org/timss-2015/mathematics/student-achievement/trends-in-mathematics-achievement/)

Trends in TIMMS Mathematics Grade Four Performances by Gender in Hong Kong

(Dark line= boys; Lighter line= Girls)

Image retrieved from http://timss2015.org/timss-2015/mathematics/student-achievement/trends-in-mathematics-achievement-by-gender/)

Appendix 3

PISA 2015 key findings for Singapore
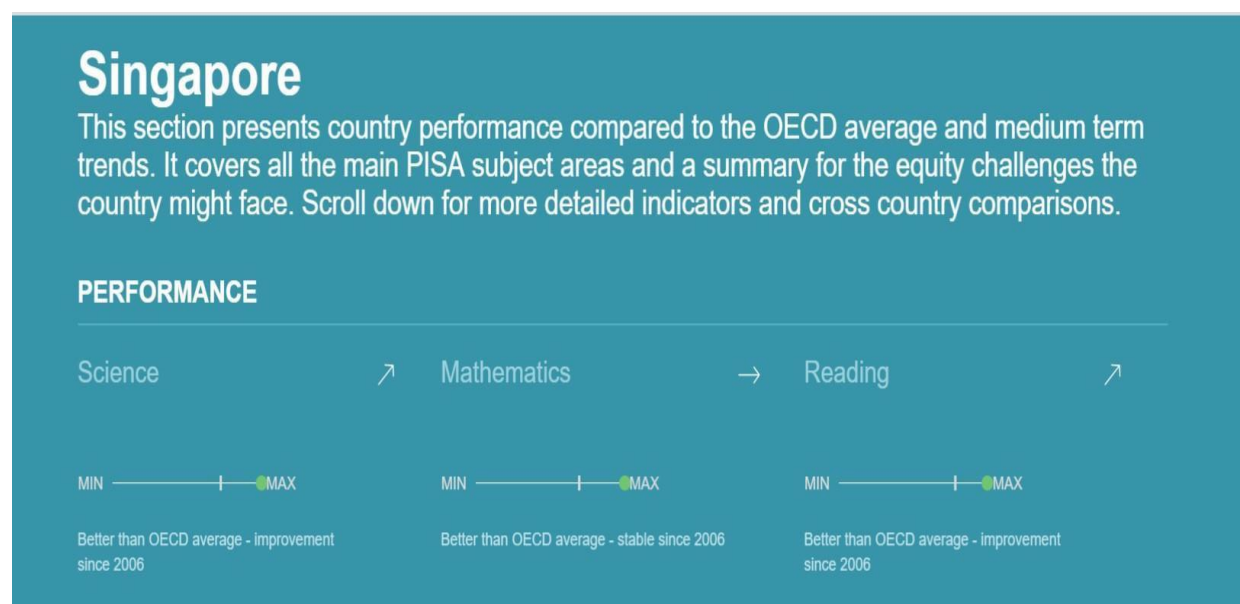
Image retrieved from http://www.oecd.org/pisa/pisa-2015-singapore.htm

Appendix 4

The Government of Australia Federal System

The Australian Constitution

The Australian Federal System of Government

PARTS:

| 1. **The Executive** |
| • *Ministerial policy administration* |
| • *Legal administration* |

| 2. **The Parliament** |
| • *Legislating aspects of executive policy* |
| • *Government forming, funding & inquiring* |

| 3. **The Judiciary** |
| • *Justice administration* |

Governor-General
• Including the Federal Executive Council

The Prime Minister & The Cabinet
• *Accountable to Parliament via The Ministry in administering law & policy*

National Ministerial Delegated Portfolios
• *Delineated policy administration*

National Ministerial Departments (including statutory agencies)
• *Delegated ministerial policy and/or legal administration*

State & Territory Governors
• Including State Executive Councils

Six States & Two Territories Premiers/Chief Ministers and Cabinets

State & Territory Ministerial Delegated Portfolios
• *Delineated policy administration*

6 States & 2 Territories Ministerial Departments (including statutory agencies)
• *Delegated ministerial policy and/or legal administration*

Appendix 5

Online Key Term/Word Search Results to Data Collection

Online AG Sites/Databases Searched	Document Type	Key-word(s), # Results, # Searched, Date Searched	Total#
Office of the Prime Minister, https://www.pm.gov.au/ Cabinet of Australia (No access to data for 20 yrs)	Media communications	STEM- 33, 0, 01.2017 STEM Education-15, 0,01.2017 Primary STEM Education-5,0,01,2017 STEM (in) school(s)-10,0,01.2017	0
Department of the Office of the Prime Minister and Cabinet. http://www.dpmc.gov.au/search/google/STEM%20education%20in%20schools	White paper, policy agendas, media communications	STEM- 194,7, 01.2017 STEM Education- 38,6 ,01.2017 Primary STEM Education- 10,3,01.2017 STEM (in) school(s)-112,6, 01.2017	7
Portfolio and Minister for Education and Training by the Office of the Minister: http://www.senatorbirmingham.com.au/Search-Results?Search=STEM+education	Media communications	STEM- 12,0, 01.2017 STEM Education- 101, 0, 01.2017 Primary STEM Education- 101,0.2017 STEM (in) school(s)-117,0, 01.2017	0
Department of Industry, Innovation, and Science	Budget, Corporate Plans, Annual reports, SoE, research, Strategy papers, committee reports, consultant reports, Agreements, media communications	STEM- 700,500, 01.2017 STEM Education- 500,500, 5, 01.2017 Primary STEM Education- 250, 250,5, 01.2017 STEM (in) school(s)- 210,210, 5,01.2017	5
Department of Education and Training	Budget, Corporate Plans, Annual reports, SoE, research, Strategy papers, committee reports, consultant reports, Agreements	STEM- 29, 17, 01.2017 STEM Education- 738, 738,23, 01.2017 Primary STEM Education- 743,743 ,01.2017 STEM (in) school(s)- 277, 277, 01.2017	23
The Liberal Party	Policy documents that feature STEM for TAS and SA only in this search in relation to the States and Territories by the National liberal party.	STEM- 41,5, 01.2017 STEM Education- 27,10, 01.2017 Primary STEM Education- 6,2,01.2017 STEM (in) school(s)- 20,10, 01.2017	5
The Labour Party	Policy position papers, policy plans	No search box on website, manual search in Google to include, labour party	6
http://www.aph.gov.au/Help/Federated_Search_Results?q=STEM	Budget, Corporate Plans, Annual reports, SoE, research, Strategy papers, committee reports, consultant reports, Agreements, media communications	STEM-6001, 2000,42, 01.2017 STEM Education- 2144,2144, 18, 01.2017 Primary STEM Education- 963, 963, 2,01.2017 STEM (in) school(s)- 1329,1329, 0, 01. 2017	18
http://www.austlii.e.du.au/cgi-bin/sinosrch.cgi?method=boolean&query=STEM+&meta=%2Fau&mask_path=au%2Flegis	Legislation- Bills, Acts, amendments, explanatory memorandum, financial frameworks, schedules	1. STEM-1,330, 1330,9, 01/2017 2. STEM Education- 3,3, 3, 01.2017 3. Primary STEM Education-0, 0,01.2017. 4. STEM Education (in) school(s)-0,0,01.2017	12
Australian Policy Online; http://apo.org.au/search/site/STEM?page=1	Research, Strategy papers, committee reports, consultant reports, Agreements	1. STEM-207, 207,10, 01/2017 2. STEM Education- 67,67,80, 01.2017	18

		3. Primary STEM Education-7, 0,01.2017.	
		4. STEM Education (in) school(s)-28,1,01.2017	
The Australian Government; http://www.australia.gov.au/	Budget, Corporate Plans, Annual reports, SoE, research, Strategy papers, committee reports, consultant reports, Agreements, media communications	1. STEM-12, 12, 9, 01/2017 2. STEM Education- 895,895, 01.2017 3. Primary STEM Education-1048,10481.2017 4. STEM Education (in) school(s)-405,405,1,01.2017	9
http://pandora.nla.gov/col/c12402	Searched database from 1996 to 01.2017	1. STEM:4240, 1500, X 01/2017 2. STEM Education: 4040,1500, X, 01.2017 3. Primary STEM Education:3,717, 1500,X,01.2017;4;STEMeducationinschools:4337,1500,1,01.2017	NA

Appendix 6

AUSTRALIAN GOVERNMENT STEM POLICY CONTEXT MAP

Executive National Government

Prime Minister & Cabinet Portfolio (PMCP)
- Prime Minister & Cabinet (PMC)
    - Department of the Prime Minister & Cabinet (DPMC)

Treasury Portfolio (TP)
- The Treasurer (T)
    - The Department of Treasury (DT)
        - Productivity Commission (PC)

Council of Australian Governments Portfolio (COAGP)
- Council of Australian Governments (COAG)
    - Education Council (EC)
        - Education Services Australia (ESA)
        - Australian Curriculum, Assessment & Reporting Authority (ACARA)

Industry, Innovation & Science Portfolio (IIS)
- Minister for IIS (MIIS)
    - Department for IIS (DIIS)
        - Commonwealth Science Council (CSC)
        - Innovation & Science Australia (ISA)
    - Australia's Chief Scientist (ACS)
        - Office Australia Chief Scientist (OACS)
            - STEM Advisory Group (STEMAG)

Education and Training Portfolio (ETP)
- Minister for Education & Training (MET)
    - Department of Education & Training (DET)
        - Australian Research Council (ARC)
        - Australian Institute of Aboriginal & Torres Strait Islander Studies (AIATSS)
        - Australian Institute for Teaching & School Leadership (AITSL)

Executive State & Territory Governments

Australian Capital Territory (ACT)
- Chief Minister, Treasury & Economic Development Directorate (ACTCMTEDD)
    - Treasury (ACTT)
    - Education Directorate (ACTED)
        - Teacher Quality Institute (ACTTQI)

Northern Territory (NT)
- Chief Minister & Cabinet (NTCMC)
    - Department of the Chief Minister & Cabinet NT (DCMC)
    - Department of Treasury & Finance (NTDTF)
    - Department of Education (NTDOE)
        - NT Board of Studies (NTBOS)
        - Teacher Registration Board (NTTRB)

Queensland (QLD)
- Premier & Cabinet (QLDPC)
    - Department of the Premier & Cabinet (QLDDPC)
    - Department of Treasury (QLDDT)
    - Minister for Innovation, Science & the Digital Economy (QLDMISDE)
        - Department of Science, Information Technology & Innovation (QLDDSITI)
        - QLD Chief Scientist (QLDCS)
            - QLD Chief Scientist Office (QLDCSO)
    - Minister for Education and Training (QLDMET)
        - Department of Education & Training (QLDDET)
        - QLD Curriculum & Assessment Authority (QLDCAA)
        - QLD College of Teachers (QLDCT)

Victoria (VIC)
- Premier & Cabinet (VICPC)
    - Department of the Premier & Cabinet (VICDPC)
    - Department of Treasury & Finance (VICDTF)
    - Department of Economic Development, Jobs, Transport & Resources (VICDEDJTR)
        - Lead Scientist (VICLS)
    - Minister for Education and Training (VICMET)
        - Department of Education & Training (VICDET)
        - Vic Curriculum & Assessment Authority (VICCAA)
        - Vic Institute of Teaching (VICIT)

New South Wales (NSW)
- Premier & Cabinet (NSWPC)
    - Department of the Premier & Cabinet (NSWDPC)
    - Treasury (NSWT)
    - Department of Finance, Services and Innovation (NSWDFSI)
        - Chief Scientist & Engineer (NSWCSE)
            - Office of the Chief Scientist & Engineer (NSWOCSE)
- Minister of Education (NSWME)
    - Department of Education (& Communities) (NSWDOE)
    - Education Standards Authority (NSWESA) (formerly BOSTES)

South Australia (SA)
- Premier & Cabinet (SAPC)
    - Department of Premier & Cabinet (SADPC)
    - Department of Treasury & Finance (SADTF)
    - Department for State Development (SADSD)
        - Chief Scientist (SACS)
- Minister for Education & Child Development (SAMECD)
    - Department for Education & Child Development (SADECD)
    - Teachers Registration Board of South Australia (SATRBSA)

Tasmania (TAS)
- Premier & Cabinet (TASPC)
    - Department of the Premier & Cabinet (TASDPC)
    - Department of Treasury & Finance (TASDTF)
- Minister for Education and Training (TASMET)
    - Department of Education (TASDE)
    - Teachers Registration Board (TASTRB)
    - Professional Learning Institute (TASPLT)

Western Australia (WA)
- Premier & Cabinet (WAPC)
    - Department of Premier & Cabinet (WADPC)
        - Chief Scientist (WACS)
            - Chief Scientist Office (WACSO)
        - Department of Treasury & Finance (WADTF)
    - Minister for Education (WAME)
        - Department of Education (WADE)
        - School Curriculum & Standards Authority (WASCSA)
        - Teacher Registration Board of WA (WATRBWA)

Appendix 6: Continued

This map shows the Government of Australia National and State/Territory Executive, portfolios, ministries and agencies with STEM policy communications, documents or texts related to Primary STEM Education, which is the studied Context. The listed portfolios, ministries and agencies comprise the Executive part of the Australian federal system of Government, which are prime ministerially delegated and organised to administer policy on each sector and sector areas of Australia (AG, 2017; National Commission of Audit, 2014). On average, between 16-19 National portfolios representing the all the sectors and sector areas have been defined by the prime minister of the elected government. For example, the National Education and Training (ET) portfolio and the ministry to administer policy actions within this sector and sector areas (e.g. Primary STEM Education) is determined on and delegated by the elected prime minister, and similarly is the case to each of the States and Territories by the elected State Chief Minister/Premier.

Subsequently, a selected National and State/Territory portfolio minister then delegates their respective portfolio sector and sector area(s) policy administration (development and implementation) to a ministerial appointed office, department, select and joint committees, and statutory enacted organisations (or agency).

In this study, agency is defined as:

1. An administrative unit created under the Public Sector Act 2009 (AustLII, 2009b);
2. A statutory authority that was accountable for the delivery of programs on behalf of the government (Government of South Australia, 2016, p.2); and,
3. The word agency has been used by the Government to refer to a ministerial department (Australian Government Solicitor, 2013).

For example, the National *Department of Education and Training* (DET), is the agency that has been delegated the policy administration in the areas of; childcare, early childhood education, school education, post-school, higher education, research grants, international education and academic research (DET, 2016). Through the National ET portfolio, the DET has been delegated to administer policy with action(s) for "improving Australia's future productivity and wellbeing" (The National Commission of Audit, 2014. p.1), which translates to addressing challenges, issues, and opportunities about national development.

In defining the Context, *The Constitution,* does not specify on how the National Executive Government Education policy is administered, for example, the administration of compulsory primary education within a State based primary school as presented by National initiatives and budgets to direct funds to the States and Territories (The National Commission of Audit (NAT), 2014). Traditionally, the State/Territory Governments have administered or developed and implemented their own Education policies within schools of each State/Territory jurisdiction rather than the National Government, and which has received National 'framed' funding. However, since the 1970s, the National Executive has been identified to have increased the amount and terms of funding directed to the States and Territories for compulsory education, which has been a concern raised by the States and Territories. The concerns include policy-based duplication and inefficiencies by National and State/Territory agencies administering similar and competing policies. For example, The NAT (2014), Recommendation 23 highlighted concerns on Education policy duplication and inefficiency by the National and States/Territories, and for Government to identify and remove policy duplication and inefficiency. This map and explanation of the National and State/Territory Executive portfolios, Ministries and agencies is the Context of this study, which the analysed data was sourced, analysed, and discussed.

Appendix 7

Generic List of the Types of STEM Policy Documents (Data) Collected for Analysis

National Executive Government	State/Territory Executive Governments
Memorandum	Strategy papers
Annual reports	Annual reports
White and green papers	Plans
Legislative consultations to Acts, Legislation by explanatory memorandums, schedules	Research reports
Committee reports	Committee reports
Action plan	Consultant reports
Proposal	Communiques
Ministerial papers	Agreements
Domestic policy papers	Meeting Minutes
National priority and interest documents	Research reports
Policy agenda	Department recommendations
Plan and Strategy papers	Hansard reports
Bills and explanatory memorandum	Auditor-General reports
National interest documents	
Cited consultants 'reports and research	
Election platforms	
Statute Book	
Briefing paper	
Grant allocations	
Regulation Impact Statements	
Departmental recommendations	
Administrative Arrangements Orders (AAO), Auditor-General and Progress reports	

Appendix 8

Data Sample: Word Method Coded Dataset

The word method in this study used the online software, WordCloud.com.au, count and order the frequency of words within an AG STEM policy document or text. For example, by accessing the website of the Office of the Australian Chief Scientist (OACS), *Transforming STEM teaching in Australian primary schools: everybody's business* (OACS, 2015) was coded, DOACS3. Based on the order of frequency, this code was used to inform the labelling and classifying of key terms, resulting in the following record:

Order	Frequency	Word/Term
1	57	STEM
2	52	Australian
3	44	teachers
4	34	education
5	32	science
6	30	Education
7	29	Science
8	28	mathematics
9	26	teaching
10	24	primary

During this study codes were recoded onto Excel spreadsheets, which included the, OACS, policy document. Included with the codes were linked classifications that contained the website address from where each document was sourced and a description of which part of the context had published the collected data. The word method was used to decipher or decode from amongst the accessible data and within collected data for relevance to this study, by a process that was a beginning in the formation of the data set and identified with a label to enable movement on to the next analytical method for further definition.
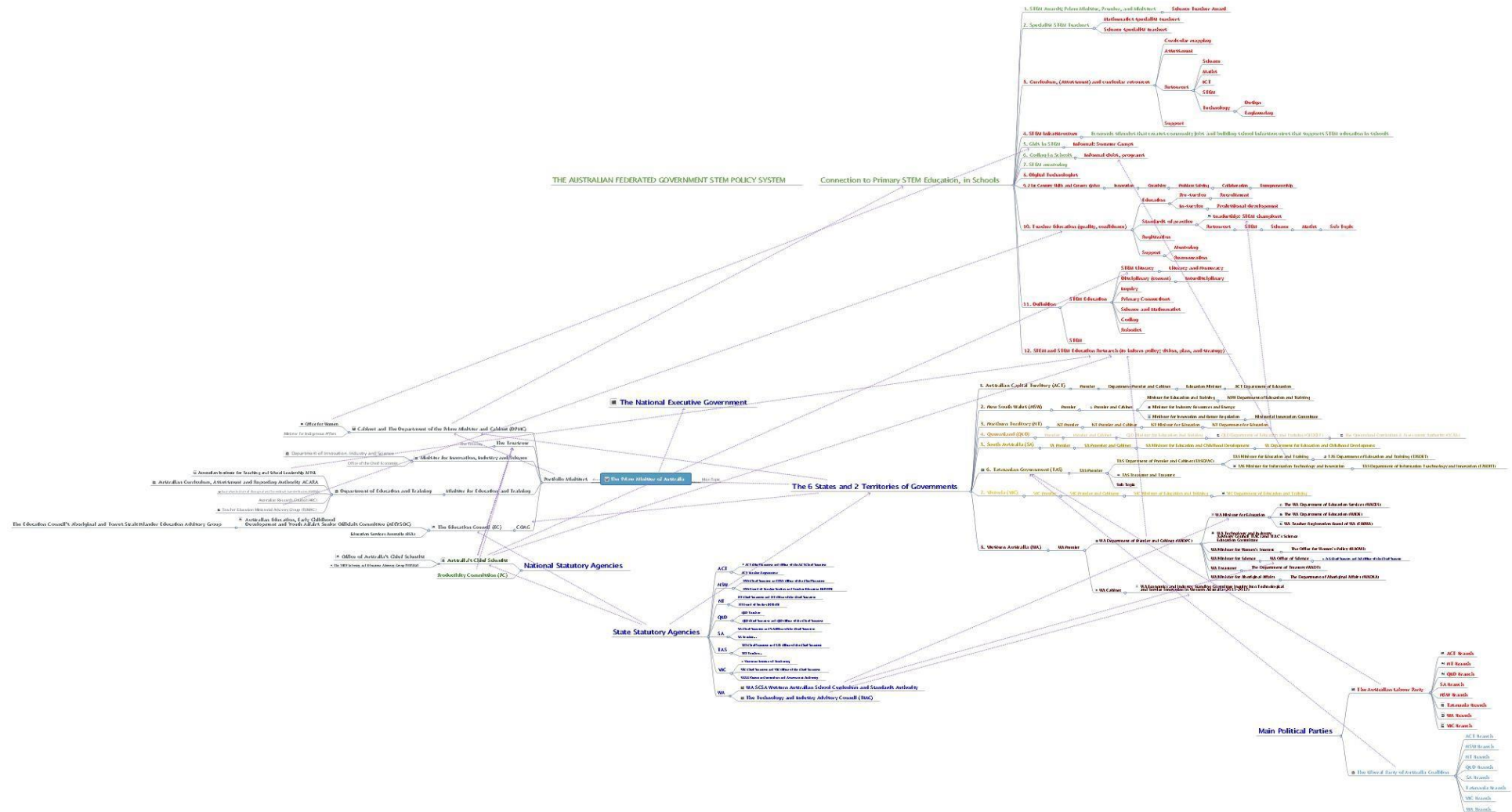
Appendix 9

Data Sample: Line Method Coded Dataset

The, DOACS3, coded document was read in sentence order identifying the ten key word/terms in the document/text. A sentencing

containing, as key term was highlighted, copied, and noted on the relevance to an Excel spreadsheet

#	Freq	Term	Description (copied sentence from text, and RN= researcher's note)
1	57	STEM	In this paper the acronym STEM was used to describe the STEM subjects taught in Australian primary schools: science, mathematics and technology (which can include engineering) (RN definition of STEM by OACS); An individual's knowledge and academic background in STEM was strongly linked to their capacity to teach it (RN research reference from Hattie's research).; A prestigious National public-private scholarship could also be established to encourage students to become STEM specialist teachers through the completion of a degree in a STEM discipline followed by appropriate pedagogical training and employment (RN OACS recommendation); Graduates report a lack of preparedness to teach STEM (RN OACS determined issue to address); TRANSFORM STEM EDUCATION IN PRIMARY SCHOOLS (RN OACS determined priority); Currently only a minority of Australia's primary school teachers have an educational background in a STEM discipline (RN OACS determined research outcome); Over time, we can expect to have access to far greater STEM expertise in schools (RN OACS determined purpose). In the short term, all primary teachers should have access to specialist STEM teachers as co-teachers, coordinators, mentors, and providers of sustained professional development (RN OACS determined purpose); Their role will be to ensure that all students demonstrate appropriate skills in STEM subjects at the end of primary school (RN in this sentence 'their' relates to school and university Environments to determine). ; The most successful Australian STEM Education initiatives have been based on evidence, had a large reach, and combined professional learning with mentoring and curriculum resources; A National professional development programme in STEM, built by universities, the teaching profession, agencies, and education authorities in close collaboration, will learn from and share what works in every jurisdiction and Environment and achieve consistent success. Education authorities, industry, universities and others are developing their own approaches and resources for STEM Education, in a vast array of disconnected, duplicating and competing programmes. We must implement change, for every school, through a National approach that targets everybody's investment in Primary STEM Education in line with the evidence of student need and program impact.; A STEM Education Leadership Taskforce reporting to the COAG Education Council can be the focal point for National engagement in STEM Education — coordinating industry and education providers in the delivery of STEM Education initiatives, evaluating these, and ensuring that every school participates.; The Taskforce would: ` Set a National minimum curriculum and standards in STEM for primary school pre-service teachers ` Identify, evaluate, develop and coordinate teaching practices and resources ` Nationally coordinate and provide professional development for teachers ` Develop and implement a comprehensive programme for principals and STEM leaders ` Ensure that teachers in every school have access to STEM specialist teachers. Getting primary school teaching right was vital to securing Australia's STEM pipeline, equipping students with the creative problem solving, critical thinking, active learning and quantitative skills they need for a future dependent on STEM. (RN OACS STEM and STEM Education policy recommendations as initiatives in programs and therefore subsequent funding and evaluation measures to ascertain extent of alignment, coherence, quality and scale. Also regard these OACS recommendations of initiatives to interviewing representatives with questions on the STEM policy Environment; on whether and the extent that these OACS recommendations have been developed)

Appendix 10

Data Sample: Axial Method Coded Dataset

(Wisemapping.com: cloud software tool used to code & store this data)

Appendix 11

Thematic Method Questioning Framework: One of Five frames used to form the Conceptual Framework of this study

Appendix 11: Continued

Thematic Method Questioning Framework Two of Five

Thematic Method Process 2 of 5

Thematic Question Level;

Word, Line & Axial Method Coded Text;

Thematic Code Level (label &classify);

1. Why is this a priority with connection to primary STEM education by schools in this agency's (e.g; DPMC) policy document/communication (e.g; the NISA) based on the five key terms?

Requiring that **new primary school teachers graduate with a subject specialisation**, with priority for science, technology, engineering and maths (STEM) (DPMC, 2015a, p.5)

2. Category level 2

AG STEM Policy Priority

3. What is the purpose of this priority, e.g; requiring that pre-service primary teachers graduate with a specialisation in STEM?

4. New Category level 2

AG STEM Policy Purpose

6. New Category level 3

Rationale | Objective

5. What is an AG STEM policy purpose based on the five key terms used in this artefact by the source?

7. How does this then compare with the word, line, and axial analysed artefacts of the data, which are similar and different with the research question from the context of this study?

8. Thematic question and code level completed on this artefact. Progress to this thematic method using this question and code structure on another word, line, and axial coded artefact to further code informing on this developing theme to saturation point

Appendix 11: Continued

Thematic Method Questioning Framework Three of Five

Thematic Method Process 3 of 5

Thematic Question Level;

1. What connects to primary STEM education by schools in this agency's (e.g; DPMC) policy document/communication (e.g; the NISA) based on the five key terms?

3. How has this document used these term/words?

5. What is an AG STEM policy initiative and budget?

7. How does this compare with the word, line, and axial analysed artefacts of the data, which are similar and different with the research question with the research question?

Word, Line & Axial Method Coded Text;

Requiring that **new primary school teachers graduate with a subject specialisation**, with priority for science, technology, engineering and maths (STEM) (DPMC, 2015a, p.5)

Thematic Code Level (label &classify);

2. Category level 1

4. Category level 2

6. Category level 3

Specialist STEM Teachers

AG STEM Policy Initiative & Budget

Project   Budget

8. Thematic question and code level completed on this artefact. Progress to this thematic method using this question and code structure on another word, line, and axial coded artefact to further code informing on this developing theme to saturation point

Appendix 11: Continued

Thematic Method Questioning Framework Four of Five

Thematic Method Process 4 of 5

Thematic Question Level;

Word, Line & Axial Method Coded Text;

Thematic Code Level (label &classify);

1. What connects to primary STEM education by schools in this agency's (e.g; DPMC) policy document/communication (e.g; the NISA) based on the five key terms?

Requiring that **new primary school teachers graduate with a subject specialisation**, with priority for science, technology, engineering and maths (STEM) (DPMC, 2015a, p.5)

2. Category level 1

Specialist STEM Teachers

4. Category level 2

AG STEM Policy Research

3. How has this document used these term/words?

6. Category level 3

| Citation | Reference |

5. What is AG STEM policy research?

8. Thematic question and code level completed on this artefact. Progress to this thematic method using this question and code structure on another word, line, and axial coded artefact to further code informing on this developing theme to saturation point

7. How does this compare with the word, line, and axial analysed artefacts of the data, which are similar and different with the research question?

Appendix 11: Continued

Thematic Method Questioning Framework Five of Five

Thematic Method Process 5 of 5

Thematic Question Level;

Word, Line & Axial Method Coded Text;

Thematic Code Level (label &classify);

1. What connects to primary STEM education by schools in this agency's (e.g; DPMC) policy document/communication (e.g; the NISA) based on the five key terms?

Requiring that **new primary school teachers graduate with a subject specialisation**, with priority for science, technology, engineering and maths (STEM) (DPMC, 2015a, p.5)

2.Category level 1

Specialist STEM Teachers

3. How has this document used these term/words?

4. Category level 2

AG STEM Policy Evaluative Measure

5. What is an AG STEM policy evaluative measure?

6. Category level 3

| Target | Timeline |

7. How does this compare with the word, line, and axial analysed artefacts of the data, which are similar and different with the research question?

8. Thematic question and code level completed on this artefact. Progress to this thematic method using this question and code structure on another word, line, and axial coded artefact to further code informing on this developing theme to saturation point

Appendix 12

Data Sample: Thematic Method Coded Dataset

Appendix 13

Case-Study Interview Protocol

Interviewee: Henri (Pseudonym)

Interview type: Voluntary Semi-Structured Interview Protocol

Interviewer: Lisa Fazio PhD Student Education Faculty Monash University, 2017

Dear (Henri),

Thank you for participating in this interview. I would like to discuss your views on 5 aspects of

STEM Education development in Australia from your perspective as Chief Scientist.

The five areas are:

1. STEM policy Priority

2. STEM policy Purpose

3. STEM policy Research

4. STEM policy Initiatives and budget

5. STEM policy Evaluative measures

In each of these areas, I would like to hear your views on , what, how and why you

developed/determined or actioned on each; as well as, how you think the work was administered

and your views on advice as to how any aspects of that work might be done differently and/or

improved in the future.

In turn, I will like to cover each of the fives aspects by discussing your reflections on the how, why,

and the future development of each.

Thank you,

Lisa

Appendix 14

Case-Study Dataset

Code:				
1/2word/line	2axial	3thematic	TEXT from notebook coding	Findings
Science	National minister	Focus Action	My argument is we should have science taught in an interesting way. I think that the minister at the time talked about making science compulsory (pg1, p13)	Action (Henri): Recommended science taught in an interesting way Action (Minister): science compulsory Difference actions in same National ministry
Science education Science literacy	All people/all ministries/agencies	Purpose Rationale statement	Pg2, 13	The reason for science education to realise scientific literacy
Science/ science education	As above	issues	P1 and p2, 3	Issue climate change impacts, ethical issues
Social licence	Tony Blair	vision	P14,15	Need a social compact on STEM and STEM education that is research based and framed for administering policy with relation to practice
STEM Vision and Strategy	Sir Henry Parkes	Vision and strategy	Pg, 1, 2, 3,4, 38	Single all-encompassing and coordinated STEM Enterprise policy framework
Specialist STEM teachers	State Governments: QLD, SA, VIC. National: DPMC, OACS	Focus Coherence disconnection	P18-19 21 AGREEMENT: it's disappointing…	The policy in implementation with a generalist female teacher workforce, definition of the policy actions by the National and State government agencies
Policy framework	COAG EC National government	Action Initiatives incentives	P22-23	Policy process in action
Policy administration process	National Chief Scientist	Leadership as: Passion Persistence Patience Follow through i.e. genuine interest in STEM and STEM Education	P24-25	Policy process in action Genuine interest in STEM and STEM Education
Education	AG National and States governments	Initiative and budget (funds allocation) Continuity Focus scale	P25-26 "2% pa efficiency dividend"	Policy budget reappropriated and discontinuation, short terms
Political leadership	PM	Initiative and budgets	P26-27	Leadership across governments to administer a policy with practice

Policy action	Ministries	Action	P27	Policy that is implemented is a result of a minister or ministerial leadership
Priority policy	Ministries	Priority	P27	Policy that is the highest priority get implemented, which occurs only by Ministerial leadership
School-based STEM Education STEM teaching (and learning)	USA federal government AG	Context Environment Funding focus alignment	P28-29,30 "change the way STEM taught in schools…""nobody is together"	Discussion on the nature of a priority policy for implementation. Funding to 'change' STEM education in schools
Policy quality	Governments	STEM definition STEAM/STEM Context	P30-31, 32 "ST&M" "fundamentally not done as well…" "teachers…""fault is the system"	Implications with practice quality by teachers to work within a unaligned government or context on STEM and STEM Education
Specialist STEM teachers	Government teachers	Coherence Coherent system of policy to practice	Pg32-34	STEM teacher quality: confidence, teacher skilled, knowledge and understands STEM context that is inspiring affects students interest to learn STEM
Pre-service teacher education	Universities	Pre-service teacher education and training program quality	p.34	The quality of pre-service teacher education programs is limited because of universities
Policy quality	AG	Alignment	"p35-37 if we see a problem then we set up more than one way…)	Too many policies to address an issue rather than an all-encompassing and co-ordinated policy approach.
Teaching quality	AG Teach for Australia	Policy Programs Alignment Focus Scale Evaluation measure Outcomes timeline	Pg 37-39 "discrepancies in the system"	Teacher registration teacher incentives, Funding to programs over the various and longer terms of governments to a single shared vision and strategy in the approach
Policy quality		Purpose rationale Economic social focus coherence	P52- 53	Economic rationale focus of policy
Policy quality	National States sectors	Alignment Research Coherence Strategy Framework Focus Scale Continuity	P66-73 "social centralist planning" p73	The process and strategy for a quality policy for implementation as specialist STEM teachers by a framework (see image drawn on file)

Policy quality	AG	Focus Coherence Issues Alignment actions	P74-75	Policy limited alignment and coherence has impacts within practice quality that needs to be reconciled prior to implementation across the AG system
Policy quality	Scientists, AG, agencies, PM, DPMC, Cabinet, ISA,	Research Citation and reference Vision Strategy Focus	P76-77 No scientists	Limited academic based research and experience to STEM and STEM Education informing policy for implementation. Focussed on economy and jobs as the vision to Australia. Links with research cited and reference to policy quality focussed on an economy and jobs.

Appendix 15

Policy 2: Students Learning to Code

Government of Australia (Context): Policy Dimensions	
Priority Policy 2: Students Learning to Code	
1. Priority	Action: Support all Australian students to embrace the digital age by promoting coding and computing in schools (DPMC, 2015, p. 4)
	Supporting the teaching of computer coding across different year levels in schools (DPMC, 2015, p. 4)
	The Government will foster further student engagement with… (STEM)… (DPMC, 2014, p. XIV)
	Issue: Too few Australian students are studying science, maths and computing in schools – skills that are critical to prepare students for the jobs of the future (DPMC, 2015, p. 4)
	A key foundational requirement is that we have people with sound basic STEM capabilities. (DPMC, 2014, p. 46)
2. Purpose	Rationale: Science, maths and computing in schools — skills that are critical to prepare our students for the jobs of the future (DPMC, 2015, p. 4)
	Objectives: Year 5 students learning to code by online computing challenges. (DPMC, 2015, p. 13)
3. Research	Citation: *Not evident*. However, a highlighted paraphrase as: "The Foundation for Young Australians predicts that today's young people will hold as many as 17 different jobs, in five different careers" (NISA) (DPMC, 2015a, p. 12)
	Limited or indirect cited paraphrasing noted to the OACS (2014) within the (NIICA) (DPMC, 2014)
	Referenced: *Not evident* (NISA) (DPMC, 2015), and referenced (NIICA) (DPMC, 2014)
4. Initiative & Budget	Project: Equipping young Australians to create and use digital technologies:
	Year 5 (and 7) students to learn coding through online computing challenges;
	Supporting and upskilling our teachers to implement the digital technologies curriculum through online learning activities and expert help; (DPMC, 2015, p. 13)
	Funds: $51m funded to 2019 (DPMC, 2015, p. 13) (bundled to three objectives)

5. Evaluative Measure	Outcomes: *Not evident*, however noted to the action as: Year 5s to learn coding by online computing challenges, and the implementation of the ACARA AC Technologies-Digital Technologies learning area by teachers in all schools (DPMC, 2015, p. 13)
	Timelines: Unspecified on, however noted as: 2015-2019 based on funds allocation

Appendix 16

Policy 3: School Partnerships with STEM Organisations

Government of Australia (Context): Policy Dimensions	
Policy 3: School Partnerships with STEM Organisations	
1. Priority	Action: Equipping Australians with the skills needed for high wage, high productivity jobs (DPMC, 2015,p. 12) Issue: Priority Issue The coming decades some jobs will be lost to automation but many other new jobs will be created in both new and existing industries. (DPMC, 2015, p. 12)
2. Purpose	Rationale: *Not evident* and designed as: [S]tudents to be successful entrepreneurs, hold a diverse number of jobs or work across a number of industries. (DPMC, 2015, p. 12) Objectives: *Not evident* and designed as: Preparing our workforce for the jobs of the future (DPMC, 2015, p. 13) and; New initiatives…in…STEM partnerships. (DPMC, 2015, p. 13)
3. Research	Citation: *Not evident*. However, a highlighted paraphrase was highlighted as: "The Foundation for Young Australians predicts that today's young people will hold as many as 17 different jobs, in five different careers" (NISA) (DPMC, 2015a, p. 12) Referenced: Unreferenced (NISA) (DPMC, 2015)
4. Initiative & Budget	Project: Equipping young Australians to create and use digital technologies…Scientists and ICT professionals in classrooms (DPMC, 2015, p. 13) Funds: $51m funded from 2016 to 2019 (DPMC, 2015, p. 13) (bundled to three initiatives)
5. Evaluative Measure	Outcomes: Scientists and ICT professionals in classrooms (DPMC, 2015, p. 13) Timelines: *Not evident*, however noted as: 2016-2019 based on the allocated funds shown in the NISA to this initiative and budget (DPMC, 2015, p. 12)

Appendix 17

NT Dataset: Policy 1

Dataset 3:NT	
Government of Australia (Context): Policy Dimensions: Specialist primary STEM teachers (Policy 1)	
Coded Dataset (Data type, , description, AG agency, date, online link/sourced): AG STEM policy document, (NTDOE, 2016), https://education.nt.gov.au/ data/assets/pdf_file/0006/228939/DOE_StrategicPlan_2016-18_WEB_new.pdf; https://education.nt.gov.au/ data/assets/pdf_file/0019/453106/DoE-annual-report-2016-17.pdf (NTDOE, 2017) (annual report)	
Priority	The action(s) and the actioning issue that is a priority determined and presented by the Context for school-based implementation.
i. Action (s)	To improve the way science, technology, engineering and mathematics (STEM) is taught in our schools (NTDOE, 2017, p. 62) (Annual report 2016-2017
ii. Issue(s)	The plan provides the strategic direction for education and children's services in the Northern Territory for the next three years. It supports the Government's Framing the Future agenda of improving the social and economic circumstances of people in the Northern Territory, particularly in remote communities and building a strong society with a robust economy and prosperous outlook. (NTDOE, 2016, p. 2).
Purpose	The evidence-based rationale statement and objective(s) on why the action and issue is a priority of national interest, for school-based implementation.
i. Rationale	Our Strategic Plan reflects Government's Framing the Future priorities and sets out the goals and strategies to achieve our vision to educate young Territorians to become confident and capable global citizens. Our goals and strategies are translated into actions through division and directorate plans; into business unit and school plans; and then into individual staff plans.(NTDOE, 2016, p.8)
ii. Objective	Enhance the capability of educators and other school staff to provide the highest quality teaching, learning and training programs. (NTDOE, 2016, p.21)
Research	The nature of the evidence-base cited and referenced of a priority policy, which is designed for school-based implementation.
i. Citation	*Not evident*
ii. Referenced	*Not evident*
Initiative & Budget	The evidence-based project(s) and allocation of funds directed for school-based implementation to administer the policy framed priority action and issues, and realise the purpose.
i. Project(s)	The department visited 40 Northern Territory government schools, including 13 remote schools, and three libraries demonstrating technology, providing professional development for teachers and facilitating lessons for students in STEM. (NTDOE, 2017, p.62)
ii. Funds	*Not evident*

Evaluative Measure	The extent that evidence-based outcomes and a timeline on the policy framed actions and issues that are evaluated on the implementation impacts, which is relied on to inform the development and progress of the policy over the ministerial and agenda changes of the Government.
i. Outcome	*Not evident*
ii. Timeline	*Not evident*

Appendix 18

QLD Dataset: Policy 1

Dataset 4: QLD	
Government of Australia (Context): Policy Dimensions: Specialist primary STEM teachers (Policy 1)	
Coded Dataset (Data type, , description, AG agency, date, online link/sourced): AG STEM policy document, A strategy for STEM in Queensland state schools (SSQSS), (QLDDET, 2016), http://advancingeducation.qld.gov.au/SiteCollectionDocuments/schools-of-the-future-stem-strategy.pdf	
Priority	The action(s) and the actioning issue that is a priority determined and presented by the Context for school-based implementation.
i. Action (s)	1.Giving every state school access to a specialist STEM teacher 2. Offering targeted Step into STEM Teaching Scholarships for high-achieving preservice STEM educators 3. Creating opportunities for professional learning for teachers in STEM…and practical resources to support classroom practice. (SSQSS) (QLDDET, 2016, p.2)
ii. Issue(s)	In primary schools - where our students are below the national average in science–most Australian teachers do not have a tertiary background in the major traditional sciences. (QLDOCD, 2013, p.11); and, Our challenge is to ensure we prepare every young Queenslander to take advantage of the many opportunities a knowledge-based economy offers and become the entrepreneurs of tomorrow. (SSQSS) (QLDDET, 2016, p.1)
Purpose	The evidence-based rationale statement and objective(s) on why the action and issue is a priority of national interest, for school-based implementation.
i. Rationale	Science, technology, engineering and mathematics (STEM) touch every aspect of today's world, and the innovations that emerge from these fields underpin the global economy…Our teachers are critical to the success of our plan for STEM. Supporting teachers to innovate and engage with cutting edge science and teaching practice will transform the teaching of STEM in every state school (QLDDET, 2016, p.1)
ii. Objective	1.Giving every state school access to a specialist STEM teacher 2. Offering targeted Step into STEM Teaching Scholarships for high-achieving preservice STEM educators 3. Creating opportunities for professional learning for teachers in STEM…and practical resources to support classroom practice. (SSQSS) (QLDDET, 2016, p.2)
Research	The nature of the evidence-base cited and referenced of a priority policy, which is designed for school-based implementation.
i. Citation	1. Increasing demand for STEM graduates in the workforce 2. Fewer Australian students enrolled in STEM fields compared with developed countries (QLDDET, 2016, p.1)
ii. Referenced	1 Craig, E. et al., 2011. No Shortage of Talent: how the global market is producing the STEM skills needed for growth, Accenture Institute for High Performance.

	2 OECD, 2011. Over-Qualified or Over-Skilled: A review of existing literature, OECD Social, Employment and Migration Working Papers, No 121. 3 Marginson, S. et al., 2013. STEM Country Comparisons: International comparisons of science, technology, engineering and mathematics (STEM) education, Australian Council of Learned Academies, Melbourne. 4 Office of the Chief Scientist 2014, Science, technology, engineering and mathematics: Australia's future, Australian Government, Canberra. (SSQSS) (QLDDET, 2016, p.2)
Initiative & Budget	The evidence-based project(s) and allocation of funds directed for school-based implementation to administer the policy framed priority action and issues, and realise the purpose.
i. Project(s)	Unidentified, however noted and attributed to the Student engagement is also enhanced by programs that provide specialised training and support for both primary and secondary teachers. Professional development for teachers and educators is essential. (SSQSS) (QLDDET, 2016, p.2)
ii. Funds	*Not evident*
Evaluative Measure	The extent that evidence-based outcomes and a timeline on the policy framed actions and issues that are evaluated on the implementation impacts, which is relied on to inform the development and progress of the policy over the ministerial and agenda changes of the Government.
i. Outcome	*Not evident*, however noted and attributed as: Giving every state school access to a specialist STEM teacher (SSQSS) (QLDDET, 2016, p.2)
ii. Timeline	*Not evident*

Appendix 19

NSW Dataset: Policy 1

Dataset 2: NSW	
Government of Australia (Context): Policy Dimensions: Specialist primary STEM teachers (Policy 1)	
Coded Dataset (Data type, , description, AG agency, date, online link/sourced): AG STEM policy communication, STEM) http://www.stem-nsw.com.au/leading-stem (NSWDOE, 2017); https://www.nsw.gov.au/your-government/the-premier/media-releases-from-the-premier/encouraging-maths-and-science-at-school/ (NSWPMC, 2016)	
Priority	The action(s) and the actioning issue that is a priority determined and presented by the Context for school-based implementation.
i. Action (s)	Fostering quality teaching and leadership in STEM (STEM webpage Leading STEM) (NSWDE, 2017, p.1); In a NSW first, future primary school teachers are being trained as science and maths specialists to engage younger students in STEM (science, technology, engineering and mathematics) subjects (NSWPMC, 2016)
ii. Issue(s)	Primary teachers are currently trained as generalists in a range of subjects…[as trained Specialists in STEM to]Give young students more confidence in maths and science, so they're well prepared for high school and future careers (NSWPMC, 2016)
Purpose	The evidence-based rationale statement and objective(s) on why the action and issue is a priority of national interest, for school-based implementation.
i. Rationale	A vibrant capacity in science, technology, engineering and mathematics (STEM) is pivotal to increasing our nation's productivity. (STEM) (NSWDOE, 2017, para.2); These specialists will help give young students more confidence in maths and science, so they're well prepared for high school and future careers," Mr Baird said. (NSWDPMC, 2016)
ii. Objective	Fostering quality teaching and leadership in STEM. (STEM) (NSWDOE, 2017, para.2)
Research	The nature of the evidence-base cited and referenced of a priority policy, which is designed for school-based implementation.
i. Citation	Australia's STEM teachers at all levels, from primary to tertiary, must be equipped to deliver course content with confidence and inspiration, and develop all students to their full potential. Curricula and assessment criteria should prioritise curiosity-driven and problem-based learning of STEM - STEM as it is practised - alongside the subject specific knowledge that STEM requires." Professor Ian Chubb, Chief Scientist Science, Technology, Engineering and Mathematics: Australia's Future 2014 (STEM) (NSWDE, 2017, p.homepage1)
ii. Referenced	National STEM School Education Strategy; Science, Technology, Engineering and Mathematics: Australia's Future; Melbourne Declaration on Education Goals for Young Australians (STEM) (NSWDE, 2017, p.STEMResources1)
Initiative & Budget	The evidence-based project(s) and allocation of funds directed for school-based implementation to administer the policy framed priority action and issues, and realise the purpose.
i. Project(s)	The NSW Department of Education has initiated a number of STEM projects during 2015 and 2016: Stage 3 Integrated STEM Project; Stage 4 Integrated STEM Project (NSWDOE, 2017, p.1)

ii. Funds	*Not evident*. Noted on "The NSW Government is also investing $20 million during this term of Government to upgrade 50 science labs in NSW public schools" (NWSDPMC, 2016).
Evaluative Measure	The extent that evidence-based outcomes and a timeline on the policy framed actions and issues that are evaluated on the implementation impacts, which is relied on to inform the development and progress of the policy over the ministerial and agenda changes of the Government.
i. Outcome	i. Outcome Unstated, however, the implied outcome is: "The first group of graduates with a specialisation in maths and science will be eligible to teach in NSW schools from the end of 2017," Mr Piccoli said. (NSWPMC, 2016)
ii. Timeline	ii. Timeline *Not evident*, however the 2019-2020 budget has Unstated evidence of funded support (NISA) (DPMC, 2015a, p,16)

Appendix 20

VIC Dataset: Policy 1

Dataset 7: VIC	
Government of Australia (Context): Policy Dimensions: Specialist primary STEM teachers (Policy 1)	
Coded Dataset (Data type, , description, AG agency, date, online link/sourced): AG STEM policy communication, VICDET, (2015; 2016), https://www.education.vic.gov.au/Documents/about/educationstate/specialist.pdf; https://www.education.vic.gov.au/about/programs/learningdev/vicstem/Pages/default.aspx?Redirect=1	
Priority	The action(s) and the actioning issue that is a priority determined and presented by the Context for school-based implementation.
i. Action (s)	Ensuring an adequate supply of teachers with contemporary content knowledge in STEM subjects, and the pedagogical skills to stimulate their students' interest and learning. (VICDET, 2016, p.5)
ii. Issue(s)	Victoria, 1. Falling behind the world's top performing countries in STEM participation and achievement 2. Lacking skills required by the technology and knowledge industries (VICDET, 2016, p.1)
Purpose	The evidence-based rationale statement and objective(s) on why the action and issue is a priority of national interest, for school-based implementation.
i. Rationale	Victorian students' achievement in maths and science has stalled, with fewer high performers and a drop-off in student achievement and engagement from years 4-9. There's also a gender gap in participation that favours boys. Teaching quality is one of the most important factors for effective learning in maths and science. Improvement in teaching effectiveness is closely linked to improvement in student learning. Building the STEM skills of our teachers will help address these challenges while giving employers the confidence to grow, explore and innovate knowing they can call on a highly skilled, adaptable workforce in the future.
ii. Objective	Teachers and educator who are able to excite children and young people about STEM, and demonstrate the relevance of STEM learning (VICDET, 2016, p.11)
Research	The nature of the evidence-base cited and referenced of a priority policy, which is designed for school-based implementation.
i. Citation	*Not evident*
ii. Referenced	ABS (2011) Census of Population Housing NAPLAN (2015) Numeracy Achievement PISA (2012) Mathematics Literacy (15 year olds)
Initiative & Budget	The evidence-based project(s) and allocation of funds directed for school-based implementation to administer the policy framed priority action and issues, and realise the purpose

i. Project(s)	New funding for the Primary Maths and Science Specialists initiative will train 200 primary school teachers as maths and science specialists in 100 of Victoria's most disadvantaged government primary schools.
ii. Funds	The $27 million Primary Maths and Science Specialists initiative will provide 200 Primary Maths and Science Specialists to improve the teaching of maths and science in 100 disadvantaged government schools across the State. Two Primary Maths and Science Specialists in each of the 100 schools will work both in class and directly with fellow teachers to provide professional learning support as well as building up their confidence in teaching these subjects. In this way, all students in these schools will have access to better teaching in the crucial STEM subjects. The suite of $3 million supporting STEM initiatives will also support the roll-out of the new Victorian curriculum in primary and secondary schools.
Evaluative Measure	The extent that evidence-based outcomes and a timeline on the policy framed actions and issues that are evaluated on the implementation impacts, which is relied on to inform the development and progress of the policy over the ministerial and agenda changes of the Government.
i. Outcome	More students will excel in mathematics and scientific literacy, and develop strong critical and creative thinking skills (VICDET, 2016, p.5)
ii. Timeline	1. Over five years for Year 5 25% or more students will be reaching the highest levels of achievement in mathematics 2. Over 10 years, there will be a 33 per cent increase in the proportion of 15 year olds reaching the highest levels of achievement in scientific literacy 3. Over 10 years, more students will reach the highest levels of achievement in critical and creative thinking (VICDET, 2016, p.5)

Appendix 21

WA Dataset: Policy 1

Dataset 8:WA	
Government of Australia (Context): Policy Dimensions: Specialist primary STEM teachers (Policy 1)	
Coded Dataset (Data type, , description, AG agency, date, online link/sourced): AG STEM policy communication, WADOE (2015), https://www.education.vic.gov.au/Documents/about/educationstate/specialist.pdf	
Priority	The action(s) and the actioning issue that is a priority determined and presented by the Context for school-based implementation.
i. Action (s)	High quality teaching (WADOE, 2015, p.2) Strengthen the expertise of teachers in STEM through a combination of short and long term initiatives that will: 5. Provide support through professional learning opportunities and high quality resources; 6. Enables supportive partnerships with external STEM Education providers; 7. Further develops STEM teacher undergraduate programs; 8. Attracts high level STEM graduates to the profession and retain them. (Murdoch University, 2011, p.8); 9. Enhance the capability of the existing STEM Education workforce through developing mechanisms for more coordinated, systematic and sustained provision of discipline-specific teacher professional learning, mentoring and resource development; 10. Provide incentives to attract additional high quality applicants into pre-service education in areas of STEM teaching shortages, currently mathematics, physics and technology education; 11. Enhance the capacity of STEM Education service providers to deliver discipline-specific teacher professional learning and curriculum resources needed by science, mathematics and technology teachers; and, 12. Projects initiated as outcomes of this report should be formally evaluated and include a dissemination strategy. (Edith Cowan Institute for Education Research, 2014, p. 4) (WATIAC)
ii. Issue(s)	1. Concern about the availability of teachers with requisite STEM expertise; 2. Substantial challenges resulting from out of field teaching and the requirements of the new Australian curriculum; and, 3. Absence of integrated strategies to build and strengthen the capacity of the STEM teaching workforce. (Edith Cowan Institute for Education Research, 2014, p. 4); and, 4. The challenge is for these high quality practices to be evident in every school and every classroom. (WADOE, 2015, p.4)
Purpose	The evidence-based rationale statement and objective(s) on why the action and issue is a priority of national interest, for school-based implementation.

i. Rationale	As the impact of highly effective teaching is cumulative, even relatively modest increases in effectiveness can make big differences to students' learning. Research paints a clear picture of what highly effective teachers do – and we have large numbers of these teachers in our schools. Expert teachers are observing their colleagues teach, giving feedback to help them improve, and welcoming them into their classrooms so they can see great teaching in action. Expert teachers are also learning themselves by examining the impact of their own teaching strategies and comparing it with others in the search for more powerful teaching strategies. (WADOE, 2015, p.4)
ii. Objective	Teachers are adopting more evidence-based approaches in their teaching practices to deliver high quality instruction.(WADOE, 2015, p.3)
Research	The nature of the evidence-base cited and referenced of a priority policy, which is designed for school-based implementation.
i. Citation	WADET: *Not evident.* STEM-WA (2015) STEM Education proposal for national application, highlighted research by the: Commonwealth Government (2015); Department of Industry, Innovation, Science, Research and Tertiary Education; Higher Education Statistics Data Cube (n.d.); OACS (2014), PISA (2012), TIMSS (2012); and, TEMAG (2014). The TEMAG (2014) noted research: Higher education providers equip all primary pre-service teachers with at least one subject specialisation, prioritising science, mathematics or a language. (WA Steering Committee, 2015, pp. 8-9)
ii. Referenced	WADET: *Not evident.* STEM-WA (2015) STEM Education proposal for national application, research reference list was *not evident.*
Initiative & Budget	The evidence-based project(s) and allocation of funds directed for school-based implementation to administer the policy framed priority action and issues, and realise the purpose
i. Project(s)	*Not evident*
ii. Funds	*Not evident*
Evaluative Measure	The extent that evidence-based outcomes and a timeline on the policy framed actions and issues that are evaluated on the implementation impacts, which is relied on to inform the development and progress of the policy over the ministerial and agenda changes of the Government.
i. Outcome	We want all teachers to have the same effect as our best teachers. (WADOE, 2015, p.4). Also, indirectly stated as: 1. Proportion of teachers assessed as proficient against the Australian Professional Standards for Teachers. 2. Extent to which graduate teachers are supported to achieve proficiency against the Australian Professional Standards for Teachers. 3. Extent to which professional learning is available and accessible to staff. 4. Survey information from schools on relevance and effectiveness of school support services. 5. Extent to which parents and students are satisfied with the quality of teaching. (WADOE, 2015, p.6)
ii. Timeline	*Not evident*, however designed as by 2019 due to the date of the *STRATEGIC PLAN FOR WA PUBLIC SCHOOLS 2016–2019* (WADOE, 2015).

Appendix 22

ACT Dataset: Policy 1

Dataset 1:ACT	
Government of Australia (Context): Policy Dimensions: Specialist primary STEM teachers (Policy 1)	
Coded Dataset (Data type, , description, AG agency, date, online link/sourced): AG STEM policy document, NISA, (DMPC, 2015), https://www.innovation.gov.au/page/National-innovation-and-science-agenda-report	
Priority	The action(s) and the actioning issue that is a priority determined and presented by the Context for school-based implementation.
i. Action (s)	Quality Teacher Recruit, develop, retain and reward quality teachers, and maintain sustainable teacher workloads. (ACTED, 2018, p.47); and, Inspirational teaching and leadership prioritises quality teaching; leadership capacity; and supporting teaching and learning. (ACTED, 2017, p.12)
ii. Issue(s)	Ensuring an overarching professional capability strategy that addresses the breadth of skills that schools need to address a complex and ever changing education environment now and into the future; strengthen and empower schools to meet the needs of their community; shape the culture of the organisation and capture national reforms and local level needs. (ACTED, 2017, p.22); and, Meeting challenges experienced in filling vacancies within the specialisations of STEM, early childhood and special education. (ACTED, 2017, p.23)
Purpose	The evidence-based rationale statement and objective(s) on why the action and issue is a priority of national interest, for school-based implementation.
i. Rationale	Quality teachers and effective school leaders are important factors in student achievement and ACT public schools have some of the best. Great Teachers by Design and Great Teaching by Design provide evidence-based frameworks for improving instructional leadership capability and excellence in teaching. (ACTDE, 2018, p.47)
ii. Objective	Target the individualised learning needs of school leaders and other key personnel to ensure both confidence and capability in working within the Student Resource Allocation Program environment. (ACTED, 2017, p.23)
Research	The nature of the evidence-base cited and referenced of a priority policy, which is designed for school-based implementation.
i. Citation	*Not evident.*
ii. Referenced	*Not evident*
Initiative & Budget	The evidence-based project(s) and allocation of funds directed for school-based implementation to administer the policy framed priority action and issues, and realise the purpose.
i. Project(s)	Increase teaching expertise and effectiveness – Build leadership capacity of current and future leaders

	– Support teaching and learning. (ACTED, 2014, p.9)
ii. Funds	*Not evident*
Evaluative Measure	The extent that evidence-based outcomes and a timeline on the policy framed actions and issues that are evaluated on the implementation impacts, which is relied on to inform the development and progress of the policy over the ministerial and agenda changes of the Government.
i. Outcome	Local site selection, underpinned by the National Professional Standards for Teachers, is now embedded as a key classroom teacher recruitment strategy. This has improved contextual fit and enhanced principal accountability for building workforce profiles that target the educational needs of their specific student cohort. In over 80 local processes conducted from July 2016 to May 2017, outcomes delivered a mix of permanent officer transfers, new appointments and long term contracts. The Directorate provides state of the art training facilities for all staff at the Hedley Beare Centre for Teaching and Learning. In addition, the Directorate quarantines $1.46 million in professional learning funds annually to support the professional development needs of principals and teaching staff. Professional learning funds comprise the Principal Professional Learning Fund, the Teachers Professional Learning Fund and the provision of teacher scholarships.
	By transferring to new settings throughout their careers, classroom teachers and school leaders gain broad experience and contribute to renewal of school communities through incorporation of new perspectives. An annual transfer round creates this opportunity for teaching classification staff. In the 2016 transfer round there were 577 classroom teacher, 41 School Leader C and nine School Leader B positions advertised.
	The Directorate liaises closely with the ACT Teacher Quality Institute (TQI) and Access Canberra to ensure compliance with professional teaching registration requirements, including that all school based staff have current Working with Vulnerable People clearances; record and reflect on 20 hours of professional learning each year in the TQI teacher portal; and perform 20 days of teaching per annum. (ACTED, 2017, p. 47)
	Developed and launched the New Educator Support Plan to strengthen the implementation of supports for beginner teachers. (ACTED, 2018, p.39)
	Teachers are being supported to deliver science, technology, engineering and mathematics (STEM) education through the thriving Centre for Innovation and Learning. (ACTED, 2018, p.7)
ii. Timeline	*Not evident*, however designed to 2021 based on the new *Strategic Plan 2018-2021: A Leading Learning Organisation.* (ACTED, 2018, p. 18)

Appendix 23

SA Dataset: Policy 1

Dataset 5: SA	
Government of Australia (Context): Policy Dimensions: Specialist primary STEM teachers (Policy 1)	
Coded Dataset (Data type, , description, AG agency, date, online link/sourced): *DECD preschool to year 12 STEM Learning strategy*, (STEMLS), (SADECD 2016), https://www.education.sa.gov.au/sites/g/files/net691/f/decd-stem-strategy-2016.pdf	
Priority	The action(s) and the actioning issue that is a priority determined and presented by the Context for school-based implementation.
i. Action (s)	Build expertise in STEM teaching and learning across all years of public education (STEMLS) (SADECD, 2016, p.5)
ii. Issue(s)	South Australian STEM education provides every student with the chance to develop the capabilities they will need, as our future innovators and problem-solvers. This is particularly important for students who are currently under-represented in STEM education such as girls, students from low-socioeconomic backgrounds, and Aboriginal learners. (STEMLS) (SADECD, 2016, p.3) While Australia remains competitive in mathematics and science, international assessment data demonstrate that Australia needs to do more if we are to achieve sustained improvement in mathematics and science. Hon Susan Close MP, Minister for Education and Child Development. (STEMLS) (SADECD, 2016, p.3)
Purpose	The evidence-based rationale statement and objective(s) on why the action and issue is a priority of national interest, for school-based implementation.
i. Rationale	The economic case for STEM is clear. Between 2006 and 2011 in Australia, the number of people in positions requiring STEM qualifications grew 1.5 times faster than all other occupation groups.2 Over the past 10 years, the number of people employed in STEM occupations in South Australia has increased on average by 2.3% per year compared with the state average annual rate of growth of 0.9%.3 It is a world-wide trend that the fastest growing industry sectors require STEM skills. (SADECD, 2016, p.3)
ii. Objective	By 2020 the State Government will: develop and build capacity to provide cutting edge STEM teaching and learning. (STEMLS) (SADECD, 2016, p.5) By 2020 there will be 500 primary teachers with a STEM specialisation. (SADECD, 2016, p.7) Every primary school in South Australia will have a minimum of one teacher with a Science, Technology, Engineering and Mathematics (STEM) specialisation by 2019. (SADPC, 2017, para.2)
Research	The nature of the evidence-base cited and referenced of a priority policy, which is designed for school-based implementation.
i. Citation	Cited (next)
ii. Referenced	1.PwC, A Smart Move https://pwc.docalytics.com/v/a-smart-move-pwc-stem-report-april-2015 2. Australian Government, Office of the Chief Scientist, Stem Skills In The Workforce: What Do Employers Want? http://www.chiefscientist.gov.au/wp-content/uploads/OPS09_02Mar2015_Web.pdf

	Information supplied by the Department of State Development, August 2016.
	3. PwC, A Smart Move https://pwc.docalytics.com/v/a-smart-move-pwc-stem-report-april-2015
Initiative & Budget	The evidence-based project(s) and allocation of funds directed for school-based implementation to administer the policy framed priority action and issues, and realise the purpose.
i. Project(s)	A professional learning program (SADECD, 2016, p.7)
ii. Funds	*Not evident*
Evaluative Measure	The extent that evidence-based outcomes and a timeline on the policy framed actions and issues that are evaluated on the implementation impacts, which is relied on to inform the development and progress of the policy over the ministerial and agenda changes of the Government.
i. Outcome	By 2020 there will be 500 primary teachers with a STEM specialisation. To achieve this, a professional learning program will be designed in early 2017 and delivered to a trial cohort, evaluated by the end of 2017 and delivered to all remaining teachers in 2018 to 2020. All primary schools will be represented in the professional learning program. (SADECD, 2016, p.7) Children and young people report greater engagement in STEM learning and critical and creative thinking (SADECD, 2016, p.9)
ii. Timeline	As above and "The actions set out in this strategy are ambitious. The Department for Education and Child Development will implement the components progressively over the next 4 years." (SADECD, 2016, p.9)

Appendix 24

TAS Dataset: Policy 1

Dataset 6: TAS	
Government of Australia (Context): Policy Dimensions: Specialist primary STEM teachers (Policy 1)	
Coded Dataset (Data type, , description, AG agency, date, online link/sourced): AG STEM policy document, , (TASDE, 2018), https://stem.education.tas.gov.au/; https://stem.education.tas.gov.au/framework/	
*Definition of STEM	In Tasmanian Government schools, Science, Technology, Engineering and Mathematics (shortened to 'STEM') education is defined as a planned, intentional, interdisciplinary approach to teaching and learning. STEM approaches highlight connections between the learning areas of Science, Mathematics and Technologies (which can include engineering) and the broad capabilities and dispositions learners will need in a rapidly changing world. (TASDE, 2018. Para.1). Retrieved from: https://stem.education.tas.gov.au/ (*Note: Government of Australia (Context): Policy Dimensions)
Priority	The action(s) and the actioning issue that is a priority determined and presented by the Context for school-based implementation.
i. Action (s)	*Not* evident, however designed to "We connect children, young people and adults with high quality learning and supported transitions, so they can develop the skills and knowledge to be lifelong learners (TASDE, 2017,p.1); and, Equip our learners with knowledge, skills and capabilities to enhance their futures through integrative, project based, real world and transdisciplinary learning. (TASDE, 2018, p.1) https://stem.education.tas.gov.au/framework/
ii. Issue(s)	*Not evident*
Purpose	The evidence-based rationale statement and objective(s) on why the action and issue is a priority of national interest, for school-based implementation.
i. Rationale	*Not* evident, however noted to "Education has a moral imperative to prepare learners for an increasingly globalised world in which technology is dramatically altering the nature of work and daily life. In this complex environment, connecting knowledge and skills across discipline areas is vital." (TASDE, 2018. Para.2). Retrieved from: https://stem.education.tas.gov.au/
ii. Objective	*Not evident*, 2017; however noted to "create opportunities for the teaching of STEM through an integrated approach to science, technology, engineering and mathematics teaching and learning". (TASDE, 2018, p.1) https://stem.education.tas.gov.au/framework/
Research	The nature of the evidence-base cited and referenced of a priority policy, which is designed for school-based implementation.
i. Citation	Interdisciplinary approaches to curriculum blend the content and key ideas from the respective subjects in the Australian Curriculum to address a problem or challenge. The areas are drawn upon in planning through a backward design process (e.g. Wiggins and McTighe, 2004). (TASDE, 2018. Para.3). Retrieved from: https://stem.education.tas.gov.au/
ii. Reference	*Not evident*, TASDET, 2017; Referenced 2018 on a website: Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA) *2008 Melbourne Declaration on Educational Goals for Young Australians*; Roslyn Prinsley and Ewan Johnston, 2015, Office of the

	Chief Scientist, *Transforming STEM teaching in Australian primary schools: everybody's business*; Effects of integrative approaches among STEM subjects on students' learning', Becker, K. and Park, K., *Journal of STEM Education* Volume 12 – Issue 5 & 6, July-September 2011, cited in PriceWaterhouse Coopers, 2015; Ellen Kumata, consultant to Fortune 200 companies, as quoted by Tony Wagner, Tony Wagner's Seven Survival Skills – as defined by business leaders in their own words, cited *in A smart move – Future-proofing Australia's workforce by growing skills in science, technology, engineering and maths (STEM)*; Foundation for Young Australians, 2015, *New Work Order Report – Ensuring young Australians have skills and experience for jobs of the future, not the past*.(TASDE, 2018. Para.3). Retrieved from: https://stem.education.tas.gov.au/
Initiative & Budget	The evidence-based project(s) and allocation of funds directed for school-based implementation to administer the policy framed priority action and issues, and realise the purpose.
i. Project(s)	*Not evident*, however noted and attributed to The STEM Framework is based on research into international best practice STEM education models and local consultation. The framework's goals, objectives and principles align with the National STEM School Education Strategy and are relevant to the Tasmanian context. STEM education is based on the following principles…, (TASDE, 2018, p.1) https://stem.education.tas.gov.au/framework; and, Tasmania 1. Introduction to STEM - Primary 2. Next steps STEM –Primary Programs for; primary teachers (including Early Years – Year 6) who wish to develop STEM approaches in alignment with the STEM Framework. (TASDETPLI, 2014 p.1).
ii. Funds	*Not evident*
Evaluative Measure	The extent that evidence-based outcomes and a timeline on the policy framed actions and issues that are evaluated on the implementation impacts, which is relied on to inform the development and progress of the policy over the ministerial and agenda changes of the Government.
i. Outcome	*Not evident*
ii. Timeline	*Not evident*