Enhancing Interdisciplinary Teaching and Learning through Guided Assessment Design

by

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Abstract

Interdisciplinary teaching and learning has been proposed as an effective pedagogical method for enhancing students' understanding and abilities within, between and across disciplines, as well as a useful strategy for enabling a variety of skills necessary for the modern world (ACARA, 2017c; Griffin et al., 2017; IBO, 2017c; Partnership for 21st Century Learning, 2015). Multiple resources are available for teachers that provide guidance in planning and enabling interdisciplinarity in the classroom. Guidance for *assessment* of interdisciplinary learning, however, are scarce. Since assessment is a key element in the teaching and learning process (Black & Wiliam, 2010; Earl, 2006; Hattie & Timperley, 2007; Rowntree, 1987), this scarcity of practical interdisciplinary assessment resources is a challenge for the implementation of interdisciplinary pedagogy.

This thesis addresses this challenge through the creation of an interdisciplinary assessment framework. The research process focuses on the research question, *how can interdisciplinary planning, teaching and learning be enhanced through assessment design?* The intended outcome was a pedagogical framework that could support teacher practices of interdisciplinary curriculum design and assessment.

The interdisciplinary framework was designed with reference to two goals. The first goal was for the framework to be theoretically defensible by aligning it with contemporary conceptual knowledge related to interdisciplinary quality. The second goal was for the framework to be translatable within diverse classroom contexts, ensuring it was both accessible and enabling for classroom teachers. Checkpoints for these research goals, that the framework be theoretical rigorous, accessible and enabling, are embedded throughout the research.

Educational design research was the methodology used that meant that the generation of the framework was iterative, eliciting contributions from the conceptual literature and teacher voice in the revision and improvement processes. Participating teachers who were already involved in the implementation of classroom-based interdisciplinary approaches from early middle school through to senior high school years were recruited from four schools in the Adelaide (South Australia) metropolitan area.

The research process resulted in a co-creation with the participating teachers of a comprehensive pedagogical framework, rather than a simple assessment tool. An additional unintended research outcome was the uncovering of contextual factors that have significant influence on the implementation of interdisciplinary pedagogies. These contextual factors related to schools'

organisational structures such as timetabling and existing assessment practices, as well as the conceptual gap in teacher thinking that arises when innovative curriculums are introduced.

This research confirms that interdisciplinary planning, teaching and learning can be enabled and enhanced through assessment design and presents a comprehensive pedagogical framework for interdisciplinary classroom practice. The framework is a resource that is theoretically defensible, accessible and enabling for teachers, and can be adapted to the variety of challenges that arise in diverse classroom contexts.

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Of course, any errors in the thesis are all mine.

Declaration of original authorship

I certify that this thesis:

1. Does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and
2. To the best of my knowledge and belief, does not contain any material previously published or written by another person except where due reference is made in the text.

Shani Sniedze-Gregory

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Chapter 1 – Introduction

Aim of the thesis

The focus of this research thesis is the planning processes and assessment design required for interdisciplinary curriculum approaches in middle and secondary years of education. Central to the research is the design of a practical framework to support teachers to introduce interdisciplinary approaches in the classroom. The methodology for this research, Educational Design Research was significant in that it enabled a collaborative and iterative approach. Research collaborators were key stakeholders, namely, a selected group of middle years teachers from different school contexts.

All theses are unique despite the commonalities that can be observed across different fields of inquiry. This thesis exists perhaps on the outer edge of the commonalities found in the field of research into educational assessment. The thesis describes research that is active and interventionist, though not yet implemented in the classroom, and explains a relatively new methodology that contributes to its uniqueness. The methodology, Educational Design Research, is intertwined throughout the life of the research. It supports a developmental process that achieves a final, visible product, but gives as much consideration to the product's potential context as it does to the product itself.

The aim of this thesis, therefore, is to report the complexity of the research intent, findings and implications as clearly as possible without oversimplifying the intricacies of the research. This introduction chapter provides an overview of this complexity and prepares the reader for the insights to follow.

The research challenge

Modern curriculum initiatives indicate that education for the 21st century should help students develop a variety of skills and capabilities, including literacy, numeracy, communication, creativity, critical thinking, collaboration, independence, global awareness and the ability to transfer learning to new contexts and new challenges that arise (ACARA, 2017c; IBO, 2017c; Partnership for 21st Century Learning, 2015). Griffin and colleagues (2017) explain that the capacity to transfer these types of skills beyond the immediate learning context are necessary in order to enable students to "address problems that we do not yet know about" and "prepare students for jobs that do not yet exist" (p. 33). This idea of ensuring students are prepared for emergent challenges and opportunities through flexible ways of thinking is further supported by authors in a range of academic and popular

literature (for example, Bentley & Savage, 2017; Claxton, 2008; Couros, 2015; Fox et al., 2017; Robinson & Aronica, 2015; Strober, 2011; Zhao, 2016b).

Yates (2017), however, warns that curriculum design that merely focuses on skills and capabilities risks "producing a fairly shallow curriculum … that fails to connect deeply with underpinning knowledge and learning" (p. 92). This implies that a rigorous curriculum, or what could be considered as such, would focus on both enabling 21st century skills *and* connecting deeply with 'underpinning knowledge and learning'.

An interdisciplinary approach to curriculum is a reasonable response to Yates' (2017) caution. Interdisciplinary teaching and learning requires students to consciously integrate disciplinary knowledge, concepts and skills to solve a problem, create a solution, explain phenomena or generate further questions (Boix Mansilla & Gardner, 2003; Repko, 2012). This purposeful integration of disciplines requires both a grounding in individual disciplines *and* the ability to transcend the disciplinary organisation of knowledge. Interdisciplinarity enables students to engage in knowledge building and knowledge creation through the integration of disciplinary knowledge, concepts and skills in the process of addressing a challenge.

The initial intent of this research was to investigate whether interdisciplinary advocates' claims of enhanced educational benefits were valid, that interdisciplinary approaches were indeed a useful way of enabling disciplinary depth while encouraging 21st century skills. This intent, however, required an assessment tool and upon investigation, it appeared that methods to assess interdisciplinary learning in schools were scarce. What was found were theoretical references regarding what might constitute 'quality' in an interdisciplinary endeavour (Boix Mansilla, 2012b; Boix Mansilla, Duraisingh, Wolfe, & Haynes, 2009; Boix Mansilla & Gardner, 2003; Clarke & Agne, 1997; Fogarty & Pete, 2009; Huutoniemi, 2012; Lattuca, Knight, & Bergom, 2013; Martin-Kniep, Feige, & Soodak, 1995; Vasquez, Sneider, & Comer, 2013; Wolfe & Haynes, 2003). The ideas contained in these studies however were not easily transferable to a school classroom context, particularly those from the university sector. Suggestions from school-based researchers included specific classroom-based examples, but these were either not generalisable to other contexts or did not correlate with acknowledged quality interdisciplinary practice. A full review of this issue, that existing resources for interdisciplinary pedagogy are difficult to transfer across education sectors and difficult to transfer to other classrooms, is provided in Chapter Two of this thesis, the Literature Review.

In addition, the perceived lack of guidance relating to interdisciplinary assessment methods in the school context elicited concern that a current method for quality assurance in interdisciplinarity was

lacking. Assessment is a key element in the teaching and learning process as it enables critical judgement about teaching and learning purposes, design, feedback and outcomes (Black & Wiliam, 2010; Earl, 2006; Hattie & Timperley, 2007; Rowntree, 1987). In the context of developing the research question, this concept illuminated the dilemma of whether quality interdisciplinary approaches could be implemented effectively in a classroom if there were no method of determining 'quality' or the achievement of its intended outcomes.

Following the early identification of this scarcity of interdisciplinary assessment resources, ones that might be enabling for teachers in assessment design and judgement of interdisciplinary quality, the intent of the research changed. Although it still seemed appropriate to investigate whether interdisciplinary approaches to curriculum were a valid method of achieving the goals of education for the 21st century, a prior concern emerged, namely, the need for an assessment tool to support such an investigation.

The intent of the research was therefore modified to focus on the development of an interdisciplinary assessment resource that could address the perceived resource gap in interdisciplinary teaching and learning. The new resource would need to be one that aligned with acknowledged best practice and that would be useful for teachers in a diverse range of classroom contexts. The research intended to draw upon current literature that identifies interdisciplinary quality and to transfer those ideas of quality into an implementation process for diverse classroom contexts. Subsequently, it was intended for the new resource to be used to identify quality interdisciplinarity in a classroom setting and then potentially be used in future research to determine whether an interdisciplinary approach is indeed useful for 21st century education goals.

Research question

The research question focused on the notion of drawing on best practice as proposed in the theoretical literature on interdisciplinary learning and educational quality and transforming it into a usable framework that can be adapted and applied in diverse school settings. This generated the research question:

How can interdisciplinary planning, teaching and learning be enhanced through assessment design?

This question has, in turn, defined the goal of the research, to develop a theoretically defensible model that would be accessible to teachers in schools. The research used acknowledged scholarship regarding the characteristics of interdisciplinary purpose and learning design, effective educational assessment and existing guidance on interdisciplinary assessment to develop an enabling

pedagogical model that is demonstrably theoretically effective as well as accessible and adaptable for classroom teachers.

Teacher voice

Challenges embedded within the research question include that the interdisciplinary teaching, learning and assessment resource needed to be accessible and enabling for classroom teachers. To address the research question, it would therefore be necessary to converse in-depth with a range of teachers on multiple occasions, while sharing drafts of the interdisciplinary assessment model. The research context was therefore purposefully targeted to address this question effectively and efficiently by including the teacher voice.

Two other factors were considered to support the in-depth, face-to-face conversational environment. Firstly, to enable meetings with teachers to be face-to-face the research context was local. Secondly, the selection of participants was purposefully targeted to engage with teachers who had experience in using interdisciplinary approaches so that the design process in the development of the framework could benefit from their practice-informed feedback.

The research was carried out in collaboration with 14 teachers across four schools in the Adelaide (Australia) metropolitan area. The volunteer teachers had classes ranging from year 6 to year 11, covering the early middle school years through to senior high school. Each of the schools used the Australian Curriculum (up to year 10) and the South Australian Certificate of Education (years 11-12). Three of the schools used the International Baccalaureate Middle Years Programme (years 6-10).

The findings from the research, therefore, reflect the perspectives of teachers' educational needs in curriculum design and implementation within these contexts.

The researcher

The concepts introduced to this point are each directly relevant to the principal researcher. I first perceived a lack of interdisciplinary assessment resources about 15 years ago while working for the International Baccalaureate Organization (IB) in curriculum and assessment development. The IB Middle Years Programme particularly requires explicit implementation of interdisciplinary approaches, yet the IB was also struggling to find or create interdisciplinary resources for its teachers. Ten years later there still appeared to be a dearth of assessment resources. Researchers within Harvard Project Zero in collaboration with the IB had extended their own provisions (Boix Mansilla, 2010) but from a classroom teaching perspective there was still little practical assistance for anyone wishing to implement an interdisciplinary approach, even less so for those teachers outside of the IB world.

Before my sojourn with the IB, I was a classroom teacher of languages and the humanities in middle and secondary school, working with students from years 6 to 12. My experiences from this era impressed upon me the critical importance of assessment in every lesson – how could I teach effectively if I did not know what quality looked like from multiple perspectives? How could students internalise and improve upon their learning if they had no concept of educational quality? How could any of us know if our efforts were successful without an evaluation plan?

Coming straight from a Master of Education research project, the educational research space seemed to be the best place to interrogate how the interdisciplinary assessment conundrum could be addressed. As educationalists look towards the remaining 80 or so years of the 21st century, we need innovative ideas that expand existing curriculum options. Interdisciplinarity in the middle and senior years appears to be one curriculum innovation that may be useful. It needs consolidation of existing advice and expansion of resourcing, however, hence the generation of this research. This is research that looks to the future while drawing upon experience from the past, conducted by a researcher with direct experience in each of the fields it draws upon: curriculum and assessment development, educational research and, most importantly, classroom teaching, adding one more teacher voice to the 14 clear voices that come through.

Significance

The centrepiece of this research is the interdisciplinary planning, teaching, learning and assessment framework (Chapter Six). It is a unique model that has been developed by teachers for teachers. It is intended that the framework will contribute to enabling and supporting interdisciplinary teaching and learning in middle- and secondary-school classrooms, providing teachers with a single resource that guides them through an entire interdisciplinary pedagogical cycle. The interdisciplinary assessment components within the framework also have the potential to be used in future research to examine the extent to which claims made about interdisciplinary approaches to the curriculum (for example, Boix Mansilla, 2012b; Klein, 2002b; Repko & Szostak, 2017; Strober, 2011) are valid.

This thesis describes in detail the data gathered and processes used in generating the interdisciplinary planning, teaching, learning and assessment framework. The research process analysed and synthesised existing theoretical knowledge and gathered data from a variety of researchers and teachers in fields related to interdisciplinarity, assessment, interdisciplinary assessment and Educational Design Research. It is back to these fields of knowledge that the thesis will contribute, in terms of both the synthesised framework and the theoretical and practical implications of its creation and use.

Thesis organisation

This thesis outlines the academic background to the research and the Educational Design Research methodology that facilitated the development of an interdisciplinary assessment tool. The thesis describes engagement with volunteer teachers that examined how acknowledged, quality interdisciplinarity practice could be transferred into classroom practice and be depicted in an explicit curriculum process that might be usefully scaled up to other classrooms and schools.

Educational Design Research, like other contemporary research methods such as grounded theory, presents challenges in reporting that diverge from the traditional reporting style found in many theses. The findings from conversations with the teachers are deeply embedded in the ongoing, iterative methodology, informing the development process of the interdisciplinary assessment tool and its subsequent expansion into a planning, teaching, learning and assessment framework. In keeping with the characteristics of the methodology, the thesis presents the method in detail, enabling the embedded and connected nature of the methodology and findings to be accessible, and enabling the replicability of the study to be clearly visible.

To present the research coherently this thesis is organised as follows.

Chapter One, *Introduction*, has introduced the focus of research presented in this thesis. It has provided an overview of the research problem, intention, significance and the importance of teacher voice.

Chapter Two, *Literature Review*, is presented in three sections, each with a specific focus. These sections are, namely, interdisciplinarity, assessment and interdisciplinary assessment. The first section introduces the notion of interdisciplinarity as a teaching and learning practice and as a subset of an "integrated curriculum". It defines various types of integrated curriculum and subsequently defines interdisciplinarity in relation to these types and for the purposes of the thesis. In this section the discussion considers the aims, design processes and practices of interdisciplinary curricula, including how interdisciplinarity is enacted in the classroom and how it might be enabled. It also addresses the philosophical and practical challenges to interdisciplinary planning, teaching and learning.

The second section introduces the conceptual notions of educational assessment as an integral aspect of the planned, taught and learned curriculum. This section discusses the various purposes of assessment and the processes, benefits and challenges of embedding assessment as an integral element within the curriculum. Educational assessment is a broad field, so this section also

addresses the challenge of making assessment advice coherent and accessible for classroom practitioners.

The third section integrates the two previous fields of study and considers the current scholarship related to educational assessment in an interdisciplinary context. It examines the paradox that traditional notions and practices of assessment are often reductionist whereas interdisciplinary planning, teaching and learning embraces complexity. This section reviews existing models to generate an analysis of interdisciplinary assessment and provide support to the research premise that the development of a new interdisciplinary assessment resource would be useful for classroom teachers. It is this analysis that leads to the formation of the research question:

How can interdisciplinary planning, teaching and learning be enhanced through assessment design?

The subsequent generation of the research goal, to develop a theoretically defensible model for interdisciplinary assessment that was also accessible to teachers in schools, concludes the chapter.

Chapter Three, *Methodology*, introduces the ontological and epistemological perspectives, relativist and constructivist respectively, through which the research was conducted. The nature of Educational Design Research is discussed, including how this methodology acts as a research framework that aims to close the gap between research and practice. The chapter explains how Educational Design Research is an iterative process, incorporating three phases that are populated with smaller design cycles (Figure 1.1) that organise the research methods.

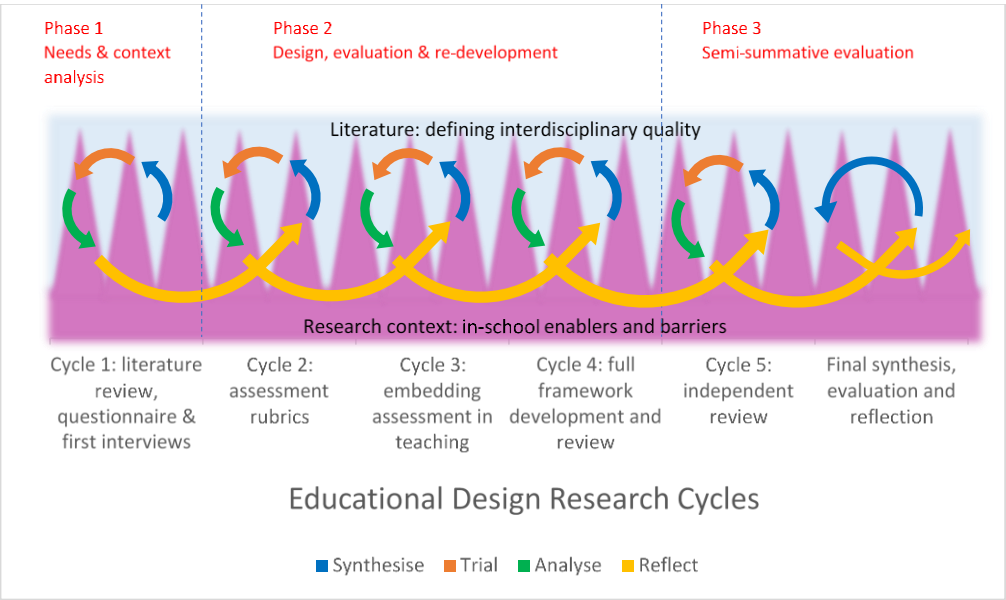

Figure 1.1: Educational Design Research process, immersed in the literature and research contexts

The Methodology chapter goes on to describe these research methods in detail, including the literature analysis, the survey questionnaire and teacher interviews used for data collection. The chapter describes the research contexts in detail, including a comprehensive description of the schools and volunteer teachers involved in the research, providing an insight into the teacher voices that contributed and the contexts in which they were located. Methods for analysis of the data collected is also described. Data was coded through three critical elements that judged whether the interdisciplinary framework was *rigorous* (according to acknowledged best practice), *accessible* (to teachers in the classroom) and *enabling* (teachers can integrate best practice into the classroom). These three elements were specifically designed to address the research question. The Methodology chapter concludes with considerations related to research quality, credibility, limitations and ethics.

Chapter Four, *Prototype Synthesis*, begins by outlining the structure by which the findings are reported in both Chapters Four and Five. Both of these are *findings* chapters that disaggregate the Educational Design Research process in relation to the research contexts, purpose and outcomes. Chapter Four describes the research outcomes – the framework prototypes – from the very first development stages to the penultimate interdisciplinary framework. These are the prototypes that are generated in each *Synthesise* stage of the design cycles (Figure 1.1) and demonstrate how the framework evolved over the course of the research until the end of Cycle 5.

Chapter Five, *Data Collection and Analysis*, presents the data collected in the *Trial* stages of the design cycles, followed by the analysis and decisions made during the *Analyse* and *Reflect* stages (Figure 1.1). This chapter explains how the findings from the literature review, questionnaire and ongoing interviews were analysed. It also presents the reasoning that contributed to the confirmation of the need for the research and the development of each framework prototype. The two findings chapters, in essence, elaborate on 'what we created' (Chapter Four), 'what we found' and 'how we used what we found' (Chapter Five). This organisational style for the research outcomes and findings is designed to facilitate replicability and is reflective of the style shown by McKenney (2001), whose design study process was adapted for this research.

Chapter Six, *Research Outcome*, showcases the contribution of this research to interdisciplinary curriculum. It presents the final version of the interdisciplinary planning, teaching, learning and assessment framework that the research process was able to generate.

Chapter Seven, *Discussion, Evaluation and Reflection*, is organised by the themes of 'implications', 'challenges' and 'integration'. The implications of the framework itself are discussed first, as well as implications from the framework development process. The 'implications' theme considers whether the framework is *rigorous*, whether it aligns with existing scholarship on assessment,

interdisciplinarity and interdisciplinary assessment. The conceptual and contextual challenges to interdisciplinary curriculum are then discussed. These were challenges that arose from the school contexts and that were reported by the volunteer teachers. The chapter discusses the ways the contextual challenges have influenced the design of the framework, and how these challenges impacted the potential of the framework to be *accessible* and *enabling* for the intended audience, classroom teachers. The chapter concludes with a reflection on the integration of research into practice, and the interpretation of findings as they relate to the contexts included in this research.

Chapter Eight, *Conclusions and Recommendations*, summarises the recommendations arising from the discussion in Chapter Seven. These recommendations are based on five ideas, namely, (1) the value of the research findings, (2) the value of the framework in interdisciplinary planning, teaching and learning and the need for a validation study, (3) the importance of allocating time and resources to increase teachers' conceptual understandings of interdisciplinary curriculum, (4) the need for explicit identification of the contextual barriers that have the potential to emerge in any school change process and (5) the potential need for a new definition of interdisciplinarity. The chapter concludes with a reflection on the impact of Educational Design Research and the relationship between the research outcome and the flow of the research itself.

This introductory chapter has alluded to the thesis journey to come. Chapter Two, the literature review, begins this journey with an exploration and analysis of existing research literature in the fields of interdisciplinarity, assessment and interdisciplinary assessment and identification of how this research might contribute to these fields.

Chapter 2 – Literature Review

This chapter presents the initial literature review that underpins the generation of the research questions. The review is divided into three sections. Section one, interdisciplinarity, clarifies terms for use in this research. It provides an overview of current philosophies and practices in interdisciplinary teaching and learning. Section two provides an overview of current literature that theorises on what might be considered best practice in educational assessment. Section three concludes the review by providing an overview of existing guidance on interdisciplinary assessment. It analyses this existing literature and considers its applicability to interdisciplinary classroom practice in the compulsory school years. This analysis of the interdisciplinary assessment literature is integrated with the first phase of the research process. It not only identifies the gap in the literature but acts as a base for the first phase of the Educational Design Research process.

There were two reasons for this approach to structuring the literature review. Firstly, an understanding of interdisciplinarity and assessment as *separate* entities was necessary to understand what needs to be considered in regard to assessment in the context of interdisciplinary teaching and learning. This dual focus in the review of relevant theories and research findings supports the generation of a depth of knowledge of these two fields of study, which can then be conceptualised as an integrated field of study, with connections and disconnections investigated. Secondly, it was envisaged that existing theory and practice from the fields of interdisciplinarity, assessment and interdisciplinary assessment could be extrapolated and used in creating an interdisciplinary planning, teaching, learning and assessment tool.

Section one – interdisciplinarity

Interdisciplinarity is represented in diverse ways in current literature and it requires greater clarity. Section one discusses the difficulties in defining the concept of interdisciplinarity and how these difficulties can impact classroom practice. The section concludes with a discussion of the challenges to implementing interdisciplinarity in the classroom.

Depictions of interdisciplinarity

Curriculum planning involves the organisation of knowledge into manageable components so that students can acquire and practice specific content and skills. The components then need to be re-integrated into a larger whole to bring coherence and situate the knowledge in context. This idea of curriculum (re)integration is not new. Educators have been discussing the need to separate and then re-integrate knowledge for some time (Martin-Kniep et al., 1995; Rhoten, Boix Mansilla, Chun, & Klein, 2006) and this is supported by literature from more recent times (for example, Boix Mansilla &

Gardner, 2003; Hayes Jacobs, 1997; IBO, 2017a; Klein, 2005; Newell, 1994; Repko, 2012; Schleicher, 2017, among many others in this review).

Under the umbrella term of *curriculum integration*, there are multiple and diverse methods for integrating curriculum, starting with a simple level of ensuring that disciplinary content is coherently integrated with prescribed standards, through to a highly complex level where interdisciplinarians collaborate as a layered interdisciplinary team (Fogarty & Pete, 2009, pp. 10-12). Along this continuum of curriculum integration, there is a corresponding range of terminology in use that needs to be defined to give structure and context to this research. Newell (2010) states that it is critical that definitions are rigorous due to the potential flow-on effects: different definitions give us different conceptions of interdisciplinarity, giving rise to different pedagogical decisions, different intellectual activities and ultimately, different learning outcomes. Ensuring precise conceptual descriptions regarding the nature of interdisciplinarity, therefore, is a key requirement at the beginning of this research.

Differences in ideas of curriculum integration have generated terms such as interdisciplinary, multidisciplinary, transdisciplinary, cross-disciplinary and convergence, with some of these terms being used differently and interchangeably in different contexts. A brief overview of the terminology challenges is followed by clarification of how the term *interdisciplinary* is used in this thesis.

Disciplinary

At its most basic level, a discipline can be defined as "academic studies that focus on a self-imposed limited field of knowledge" (Cohen & Lloyd, 2014, p. 189). Disciplines are the main means used to organise knowledge (Center for the Study of Interdisciplinarity, 2012). They inscribe an essential knowledge and concept base, inquiry methods, forms of communication and distinct ways of thinking (Boix Mansilla & Gardner, 2008; Nissani, 1997). Each discipline has its own community of experts (Nissani, 1997) who determine its epistemological and ontological foundations and boundaries and review new ideas and research findings (Jacobs, 2013). These modern conceptions of a discipline encompass and refine older definitional criteria, as proposed by Heckhausen (1972), that a discipline has a material field, subject matter, theoretical integration, its own methods, analytical tools and levels of application and historical contingencies (pp. 83-86).

Frodeman (2013) states that through subdividing knowledge into disciplines it is implied that, "the connections *within* an area of knowledge [are] more essential than the connections *across* areas of knowledge, or between knowledge producers and the larger societies" (p. 1923). Further "speciation" into new sub-disciplines reinforces these connections within disciplinary boundaries (Cohen & Lloyd, 2014, pp. 194-195). Cohen and Lloyd (2014) discuss the ongoing evolution of

academic disciplines, arguing that while disciplines are a useful organising tool they need to evolve in response to changes in the academic environment and respond to the risk that disciplinary boundaries might constrain thought (Harriss, 2002). Lattuca (2002) and Repko (2012) reinforce the idea that disciplinary boundaries should not be seen as finite or rigid, but as flexible and porous, enabling interdisciplinary opportunities where they arise.

These ideas define the concept of disciplinarity in this thesis. Even though it is understood that disciplinary boundaries are flexible and, in some cases, ill-defined due to their ongoing evolution, in this research the term *discipline* is used to denote the categorisation of knowledge, concepts and ways of thinking and acting that is commonly expressed in school curricula. In addition, the disciplines are considered as building blocks for interdisciplinary endeavours.

The following descriptions of terminology regarding the juxtaposition and concurrent focus on more than one discipline elaborate current attempts to define the varying forms of collaboration and integration of these disciplinary building blocks. They are defined in order to situate interdisciplinarity with respect to other forms of integrated curriculum.

Cross-disciplinary

The term cross-disciplinary is located at the simplest point on the continuum of connection between disciplines. This terminology is used as a general description for connections, conversations or collaborations that cross over disciplinary boundaries. Graff (2015) provides examples of "conversations" across disciplines (p. 147) while Hulme and Toye (2006) define cross-disciplinary as "any analysis or recommendation based on questions, concepts or methods of more than one academic discipline"(p. 1086). Stokols and colleagues (2010) consider it to be an overarching term that includes multidisciplinary, interdisciplinary or transdisciplinary collaboration. Szostak (2015), describes cross-disciplinary as a "general term" that refers "to any activity that involves two or more academic disciplines" and can range from "[juxtaposed] disciplinary insights … to much more integrative or socially inclusive approaches". The Australian Curriculum (ACARA, 2017b) uses a similar term, *cross-curricular*, to denote concepts that need to be addressed throughout the curriculum, however, here there is no requirement[1] for disciplinary collaboration or integration.

The term *cross-disciplinary* remains at a general, descriptive level. Any collaboration that involves more than a cross-disciplinary conversation or an ongoing awareness of contributions from other

[1] While the Australian Curriculum states that, "Deep knowledge, understanding, skills and values… will enable advanced learning…[and]…provide the foundation for interdisciplinary approaches to innovation and complex problem solving" (ACARA, 2012, p. 14), they leave the choice of whether to integrate any disciplines to the individual school (ACARA, 2012, pp. 13, 26).

disciplines tends to use one of the following terms, either in addition to or instead of cross-disciplinary, to clarify the specific style of disciplinary collaboration.

Multidisciplinary

Multidisciplinary learning, a synonym for *pluridisciplinary* learning (Duguet, 1972, p. 12), draws on knowledge and skills from different disciplines, but each discipline maintains its boundaries and does not modify its usual disciplinary approaches (Choi & Pak, 2006; Graybill et al., 2006; Klein, 2002b). Disciplines are complementary but juxtaposed and students may be left to uncover connections on their own (Klein, 2002b). Repko (2012) suggests that some courses and projects labelled *interdisciplinary* are often multidisciplinary as they lack the purposeful integration necessary for interdisciplinary learning.

The notion of *multidisciplinary* is the clearest of all terms as it communicates the concept of multiple disciplines working towards a common purpose. Disciplinary conceptual or methodological boundaries remain intact to address that purpose.

Transdisciplinary

In contrast to the notion of multidisciplinarity, transdisciplinarity is perhaps the least clear of the integrated-curriculum terms. In earlier writings, it was proposed that transdisciplinary interactions would eventually lack disciplinary boundaries at all, though the attainability and practicality of this was also questioned (Piaget, 1972, p. 138). More contemporary conceptions of transdisciplinarity still maintain this idea of transcending disciplinary boundaries, though with different ideas regarding how the disciplines interact. For example, Alvargonzález (2011) posits multiple, combined images of transdisciplinarity, stating that it enables "transcending the disciplines, going across and through the different disciplines, and beyond each individual discipline" (p. 388). Nicolescu (2002, in Toft & Joubert, 2005) builds upon this idea of *across and through*, arguing that transdisciplinary approaches draw upon expertise from both inside and outside disciplines to enable mutual knowledge building for the generation of solutions for problems or issues. Others (IBO, 2010; Vasquez et al., 2013) argue, however, that the key element of transdisciplinarity is the transcendence factor, a factor that is enabled by using themes that both cross *and* transcend disciplinary boundaries. Transdisciplinary themes are addressed from different perspectives, with multiple disciplines, so students can use their knowledge in the real world (IBO, 2010).

Szostak (2016) comments that a transdisciplinary theme could also be represented by real-world stakeholders who may or may not be part of a transdisciplinary research team. Lattuca, Knight and Bergom (2013) agree, stating that "transdisciplinarity often refers to scholarship that transgresses the boundaries between academia and communities outside academia" (p. 727). In this instance, the

focus of transdisciplinary learning is on the theme, problem or issue and, through this, disciplinary and contextual boundaries are de-emphasised.

The commonality that runs through these varying definitions, however, is that in the educational context there needs to be a driving theme or external challenge as a focus for transdisciplinarity, rather than a focus on the mastery of individual disciplines themselves. The idea of disciplinary grounding or depth is absent. This is not suggesting that disciplinary grounding or depth is never present, but it is not described as a vital element as it is in interdisciplinarity (Boix Mansilla, 2005). *Transdisciplinarity* does not centre itself in the disciplines, rather, it selects concepts, skills and expertise from various disciplines to the extent needed by the inquiry at hand.

Interdisciplinary

Interdisciplinary literally means *between the disciplines* (Daly, Brown, & McGowan, 2012; Karlqvist, 1999) and this broad definition may explain some of the various uses of the term. Often *interdisciplinary* is used descriptively or loosely whenever more than one discipline is involved (Jacobs & Frickel, 2009), regardless of the disciplinary combination. Boix Mansilla and Gardner (2003) and Repko and Szostak (2017) attempt to bring order to its use by proposing that, in the educational context, *integration* is the key characteristic of interdisciplinary learning. When disciplinary knowledge, concepts and skills are *integrated* for the purpose of solving a problem, creating a solution, explaining phenomena or generating further questions, then true interdisciplinarity is achieved (Boix Mansilla & Gardner, 2003; Repko & Szostak, 2017).

Extending from the idea of integration, Nissani (1995) identifies levels of richness of interdisciplinary endeavours and places them on a continuum according to a) the number of disciplines involved, b) the conceptual and methodological distance between the disciplines and c) the novelty of disciplinary combination, as well as d) the degree of integration. These four elements are invaluable in enabling a complete picture of an interdisciplinary endeavour, while emphasising that any position on the continuum is purely descriptive and not a qualitative judgement (Nissani, 1995, p. 125): the disciplinary combinations should be judged on their ability to support the inquiry at hand rather than against an external scale. Strober (2011) supports this idea and further elaborates that interdisciplinarity should be seen as a *complement* to disciplinary learning rather than as a substitute. Klein (2012) further expands these levels of interdisciplinary richness into a taxonomy of interdisciplinarity, illustrating how different purposes and goals for interdisciplinary collaboration generate methodological, theoretical, instrumental and critical interdisciplinarity sub-categories.

It must be noted that while the field of compulsory education has begun to define types of disciplinary integration through forms of integrated curriculum, the term interdisciplinary is

increasingly used by the field of medicine to denote collaboration between medical specialists and by universities to denote collaboration between disciplinary specialists. A representative snapshot of terminology-based alerts on Google Scholar shows that these collaborations dominate the 'interdisciplinary' research literature[2]. In addition, although *interdisciplinary* is rarely defined in the medical literature, there are clear indications that the medical concept of interdisciplinarity refers to the notion of *effective team working* (Grant, Parry, & Gregoric, 2016; Neumann et al., 2010), where medical professionals work as a team to treat a patient or investigate a medical issue based on the assumption that, "…no single clinician is likely to have the necessary skills to achieve optimal results alone" (Neumann et al., 2010, p. 5). In the medical field, integration occurs within the patient and the notion of interdisciplinarity is that of *networked experts* (Susskind & Susskind, 2015) working as a treatment team. This increase in the use of the term in other fields indicates a need for educational research to be clear in its own use.

To summarise, the term *interdisciplinary* is used in different ways in different fields, from the general, descriptive notion of disciplines being juxtaposed for a purpose, through to tightly defined definitions that specify the need for *integration* or *effective team working* for a collaboration to be termed as such. As this research is clearly grounded in the field of compulsory education, the definition used in this thesis has been taken from experts in the education field. That is, interdisciplinary teaching and learning occurs when disciplinary knowledge, concepts and skills are consciously integrated to solve a problem, create a solution, explain phenomena or generate further questions (Boix Mansilla & Gardner, 2003; Repko & Szostak, 2017). These three components – disciplines, deliberate integration and purposeful outcome – are the defining elements of interdisciplinarity in the educational context.

Convergence

A more recent development that builds upon interdisciplinary teaching and learning is the notion of *convergence*. Convergence aims to take interdisciplinarity one step further by integrating interdisciplinary expertise from multiple interdisciplinary fields, generating a comprehensive framework that can address challenges at the nexus of these fields. Through convergence, the aim is to develop an *ecosystem of integration and collaboration* that connects fields of interdisciplinary research and generates the possibility of new paradigms (National Research Council, 2014). It builds

[2] Terminology-based alerts audited for three months between October and December 2016. "Interdisciplinary" related to medical and health sciences collaborations 37% of the time, science and engineering collaborations 27%, humanities collaborations 24% and education 12%. Less than half of the education-related alerts were relevant to the compulsory school (students ≤16 years of age) setting or relevant to interdisciplinary curriculum concerns.

upon Susskind and Susskind's (2015) idea of *networked experts*, embedding the experts in a matrix of collaboration. Convergence, therefore, presents the idea of a web of interdisciplinary nodes that interconnect to address complex challenges and involves layers of integrated interdisciplinarity.

Summary

Interdisciplinarity is just one type of integrated curriculum. It is clearly different from other types of integrated curriculum where disciplines interact but are not necessarily integrated (cross-, multi- and trans-disciplinary) or where complex hubs of interdisciplinarity exist, each integrating with the other, as in convergence. Some authors depict interdisciplinarity as a Venn diagram (for example, IBO, 2017a), however, Figure 2.1 revises and elaborates on this depiction to show the differences between curriculum integration styles referred to in this thesis. The different styles can be distinguished by the extent of permeability of disciplinary boundaries (how amenable disciplines – or perhaps their teachers – are to integration), the disciplinary depth required and whether the disciplines are deliberately integrated.

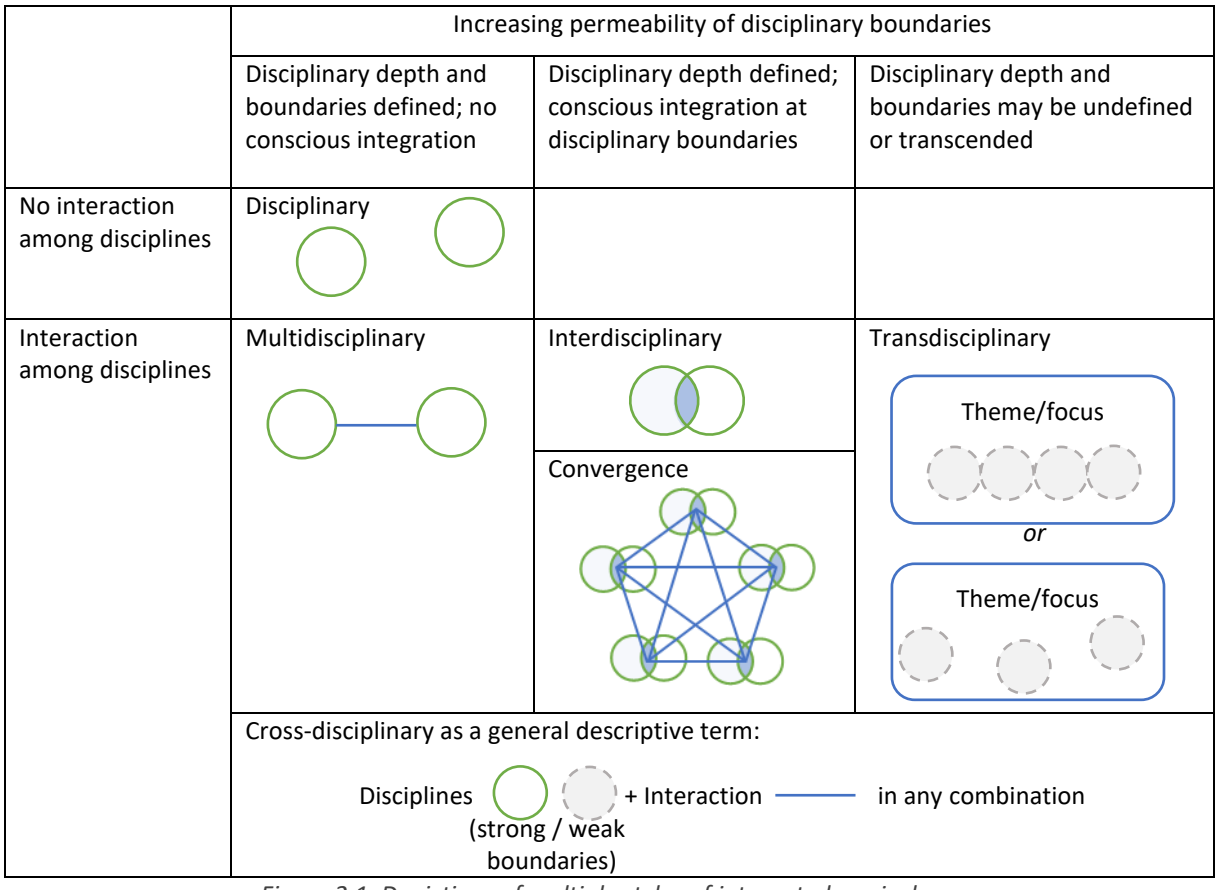

Figure 2.1: Depictions of multiple styles of integrated curriculum

While there are various and at times conflicting uses of the terminology for integration within curriculum, there was an obvious need to define *interdisciplinary* for the purposes of this research (Newell, 2010). Based on the literature reviewed here, it was determined that *conscious and*

deliberate integration of disciplines for a specific purpose encompasses the prevailing definitions. Even though some authors (Klein, 2012; Nissani, 1995) show us how to create further levels of richness of interdisciplinarity, the common factor is still the *conscious integration of disciplines* to address a challenge or problem (Boix Mansilla & Gardner, 2003; Klein, 2012; Nissani, 1995; Repko & Szostak, 2017; Repko, Szostak, & Buchberger, 2014). This may be through one teacher or one student working alone, or, by multiple teachers or multiple students collaborating to design an interdisciplinary unit, solve a problem or address a challenge.

Interdisciplinary aims and benefits

The aims of combining disciplines in education and research are to solve "real world or complex problems, to provide different perspectives on problems, [and] to create comprehensive research questions" (Choi & Pak, 2006, p. 351). Through interdisciplinary study it is intended that students discover the interconnectedness of knowledge in order to prepare students for further academic study and for life in an increasingly interconnected world (Boix Mansilla, 2010; IBO, 2017a). In the Australian context, this interconnectedness is part of the broader aim of enabling students to live and work successfully in the 21st century (ACARA, 2012). This is particularly relevant at the secondary school level where knowledge is often contained within disciplinary silos. To meet these 21st century educational goals, students must learn to integrate disciplines in new and creative ways (IBO, 2017a).

Nissani (1997) posits that there are threefold benefits of interdisciplinary study. Firstly, he states that interdisciplinarity inspires growth in knowledge creation, involving the bringing together of previously unrelated ideas. Secondly, he posits the social benefits, describing how new insights can bring about social change while preserving unity of knowledge and the need for effective communication. Thirdly, he explains how interdisciplinarity brings personal rewards of a greater flexibility and freedom of thought and avoidance of intellectual tunnel vision (Nissani, 1997, p. 203). Boix Mansilla (2010) argues that through interdisciplinary study, students have the opportunity to develop and refine skills such as synthesis, transfer, critical thinking, creative thinking and making complex thinking visible. Frodeman and Rowland (2009) argue that, within an interdisciplinary learning context, metacognitive abilities are engaged, as students take note of their own learning strategies and consider ways to address the problem at hand, including challenging disciplinary boundaries.

Some researchers combine both the aims and benefits of interdisciplinarity, proposing that if the aims are realised, then students will gain the resulting benefits. The International Baccalaureate [IB] Organization (IBO, 2017a) states that students need to be educated for a "complex and highly

interconnected world": to do this, they need to be empowered to "integrate disciplines in novel and creative ways" (p. 2). Tomlinson and colleagues (Tomlinson et al., 2009) explain that a school-based curriculum built on deliberate interdisciplinary connections will enable students to build "breadth of knowledge" and "[uncover] new relationships among ideas" (p. 21). Martin (2009) supports these notions, explaining how students benefit from grappling with complex, contrasting ideas in order to imagine new and better solutions.

In a broad survey of universities that offer interdisciplinary programs, Rhoten, Boix Mansilla, Chun and Klein (2006) identify the outcomes expected of students in such programs, such as critical thinking, problem solving and analytic skills, as well as disciplinary depth and the ability to integrate diverse knowledge (p. 11). Repko and colleagues (Repko et al., 2014) build upon these ideas further into the context of what students need in the real-world, including the ability to deal with the complexity of nature, society, a globalised workplace, the need for systems-thinking, as well as needing both disciplinary and interdisciplinary concepts and skills (p. 4). Boix Mansilla and Jackson (2011) agree that these types of complex global competencies can indeed be achieved through interdisciplinary approaches.

The aims of interdisciplinary teaching and learning are therefore to help students see connections across disciplines, to enable metacognitive awareness of the broader curriculum and to show how disciplines can be used as tools in a variety of situations and combinations. If these aims are realised, then the potential benefits to students described above can be gained. These benefits are considered in the literature to be quality interdisciplinary learning outcomes and they generate two research challenges.

The first challenge in interdisciplinary educational research is to verify the claims of educational benefit arising from interdisciplinarity. Some of the research reviewed gives detailed explanations of how quality learning is demonstrated in the interdisciplinary classroom (for example, Boix Mansilla & Jackson, 2011; Boix Mansilla, Miller, & Gardner, 2000; IBO, 2014a; Kim & Stogdill, 2018). These examples, however, are small in scale and while they describe students' cognitive advancements, there are no elements presented for comparison to any expected advancement. In one study that did have a control group, the assessment was conducted using purely disciplinary criteria with no assessment of interdisciplinary benefit (Spintzyk, Strehlke, Ohlberger, Gröben, & Wegner, 2016). While the aims of interdisciplinary teaching and learning are clear, the challenge of monitoring and evaluating these aims appears complex.

This leads to a second research challenge. There needs to be a robust and theoretically defensible classroom implementation of interdisciplinary teaching and learning concurrent with an assessment

process for a rigorous evaluation of the educational benefits of interdisciplinary learning to occur. The following is a review of the current literature that provides advice regarding the implementation of interdisciplinarity and the existing challenges therein.

Interdisciplinarity in the classroom context

There are diverse pedagogical approaches promoted as being enabling of interdisciplinary teaching and learning in the classroom. These include instructional approaches that use interdisciplinarity as an explicit goal and instructional approaches that require the integration of multiple disciplines to achieve other goals. The following is an overview of how interdisciplinary planning, teaching and learning might appear in various classroom contexts. In this section of the literature review, the difficulties in defining interdisciplinarity, as well as the scarcity of empirical evidence that interdisciplinary approaches enable the benefits described, continue to be manifested.

Two important elements in integrated interdisciplinary programs are thematic instruction and a focus on process skills (Hartzler, 2000, in Hattie, 2009). These give purpose to the implementation of interdisciplinary curricula. Boix Mansilla (2010) agrees that interdisciplinary teaching and learning must be purposeful and not be an end in itself. The integration of multiple disciplines should be a tool to generate more-complex understandings and outcomes where a single-disciplinary approach may not suffice. Boix Mansilla's argument is supported by Jacobs (2013), although he cautions that while some points of interdisciplinary dialogue are effective, others are not. Jacobs argues that sometimes deeper exploration *within* a discipline is needed rather than integration within other fields. This need to judge the extent of disciplinary depth in relation to interdisciplinary exploration is a tension that requires attention within interdisciplinary curriculum. This tension must be addressed when engaging in interdisciplinary study and a clear *purpose* for interdisciplinarity must be established.

Multiple examples of interdisciplinary purpose are described in the reviewed literature and include the purposes of aesthetic or literary synthesis, personal expression, seeking practical solutions to complex problems, complex explanations, contextualisation, transfer of disciplinary skills and philosophical critique (Boix Mansilla, 2010, 2012b; Frodeman, 2013; Nikitina, 2006; Repko et al., 2014). Examples of aesthetic or literary synthesis focus on artistic expression with external inspiration or an external audience: artistic or literary concepts and methods are integrated with another non-artistic discipline(s) to appeal to a mass audience (Boix Mansilla, 2010, 2012b). Examples of personal expression, or personal resonance, are similar but with an endogenous focus: artistic or literary concepts and methods are integrated with another non-artistic discipline(s) to reflect a personal connection (Boix Mansilla, 2010). A practical solution might be generated from an

interdisciplinary inquiry into a problem or challenge (Boix Mansilla, 2010; Nikitina, 2006). Examples of complex explanations use disciplinary integration to generate and communicate understanding of concepts that cross disciplinary boundaries and show how different disciplines contribute to common ideas (Boix Mansilla, 2010; Nikitina, 2006; Repko et al., 2014). Examples of contextualisation embed material from one discipline in the culture of a second discipline to generate an enhanced perspective of a given phenomenon (Boix Mansilla, 2010; Nikitina, 2006). Examples of transfer of disciplinary skills (also known as crossover tooling), employ a concept or skill from one discipline to enhance learning in another, for example, when artistic observational techniques and drawing skills are used as tools by a scientist (Boix Mansilla, 2010).

Finally, there are two ways in which philosophy can contribute to interdisciplinary purpose. It can be deliberately integrated with other disciplines or it can be used as an integrating lens through which to view the interrelatedness of knowledge and disciplines. Either way, there are clear justifications for using philosophy to enable interdisciplinary teaching and learning. The first approach, integration with other disciplines, is exemplified by Frodeman (2013), who asserts that current techno-scientific advances are generating philosophical and ethical questions at an increasing rate. Rather than addressing these questions in a disciplinary fashion, he argues that philosophy should be de-disciplined and integrated with other disciplines to address complex issues, suggesting that philosophy could often be the integrating element. The International Baccalaureate *Theory of Knowledge* syllabus (IBO, 2013) exemplifies the second approach when it asks students to view individual disciplines through a philosophical lens, emphasising the philosophical connections between disciplines and the broader interconnectedness of knowledge.

Repko, Szostak and Buchberger (2014) support these notions of purposefulness, though they emphasise that interdisciplinary purposes fit somewhere within Klein's (2012) taxonomy of interdisciplinarity. For example, instrumental interdisciplinarity is seen "as a way to solve complex practical problems" while critical interdisciplinarity "questions disciplinary assumptions and ideological underpinnings … [and sometimes] aims to replace the existing structure of knowledge" (Repko et al., 2014, pp. 36-37). Teachers (or students) would therefore need to determine where an interdisciplinary purpose is located within the taxonomy. The categories within Klein's (2012) taxonomy of disciplinarity would be a useful starting point for teachers in an interdisciplinary classroom, and the resources reviewed above can be placed into these categories (Figure 2.2).

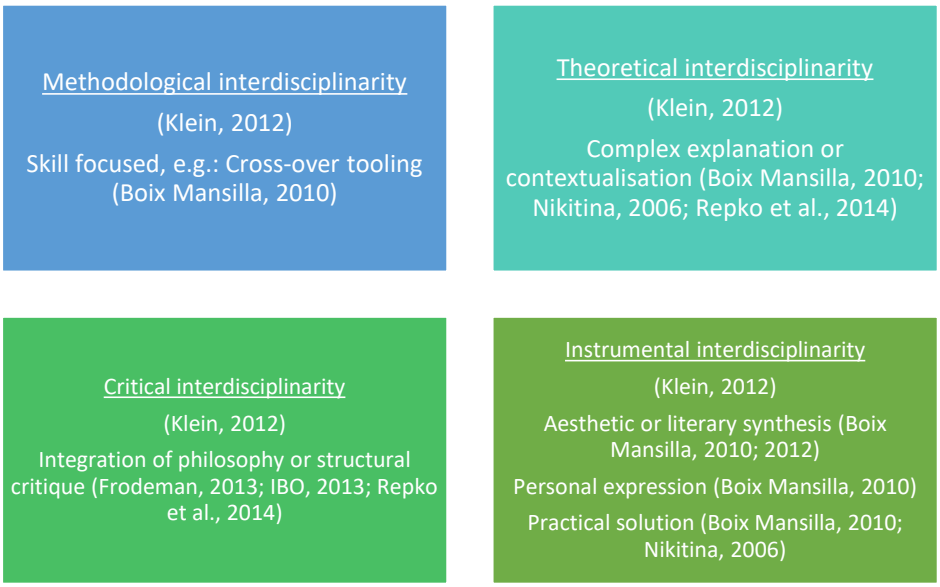

Figure 2.2: Interdisciplinary purposes, organised via sub-sections of Klein's (2012) taxonomy of interdisciplinarity

Once the purpose for interdisciplinary study has been established, it can be enacted in the classroom through a range of teaching and learning approaches. Three of the most comprehensive examples of how planning might proceed in an interdisciplinary context are shown in Table 2.1. Vasquez, Sneider and Comer (2013) describe planning strategies for an integrated approach to STEM (given that they are deliberately integrating selected STEM disciplines for a purpose, it is included as an interdisciplinary example here). Repko, Szostak and Buchberger (2014) and the International Baccalaureate (IBO, 2014a, 2016a, 2017a) describe planning strategies for what they describe as interdisciplinary approaches.

Table 2.1: Planning processes for integrated or interdisciplinary teaching and learning

Vasquez, Sneider and Comer (2013, pp. 139-146)	**Repko, Szostak and Buchberger** (2014, pp. 202-263)	**International Baccalaureate** (IBO, 2014a, 2016a, 2017a)
Section A: Identify desired results 1. Identify the content standards for the unit or lesson 2. Identify big ideas and concepts, knowledge and skills 3. Identify essential questions – what will elevate thinking, foster inquiry and build understanding? 4. Establish what students will know and be able to do as a result of the unit or lesson	**Step 1** – State the research question to define the research problem, maintain its complexity and capacity to be researchable from an interdisciplinary perspective **Step 2** – Justify using an interdisciplinary approach: the problem is complex and reflects an unsolved issue or unmet need, important insights come from two or more disciplines, no single discipline will comprehensively address the problem	**MYP interdisciplinary planner section 1**[3]: 1. Establish the purpose of the unit 2. Develop a statement of inquiry and, … 3. …inquiry questions that reflect decisions above 4. Determine a performance of understanding that connects with all the above, uses the prescribed assessment criteria and provides opportunities to move between disciplinary and interdisciplinary understanding 5. Determine which approaches to learning (process skills) students will use
Section B: Determine acceptable evidence for assessment Create multiple, ongoing assessment opportunities throughout the learning experiences. This might include formative, summative, rubric use, self- and peer-assessment, assessment tools	**Step 3** – Identify relevant disciplines: connect the problem to phenomena typically studied by disciplines, then decompose, externalise and reflect on the disciplinary grounding **Step 4** – Conduct a literature search: find quality disciplinary input to the problem **Step 5** – Critically analyse the disciplinary insights	**MYP interdisciplinary planner section 2**: 1. Determine how the disciplines will ground the integration 2. Determine what teaching strategies, learning experiences, formative assessment and differentiation will (or might) occur
Section C: Design interdisciplinary learning activities How will disciplines be integrated? How will students engage with the disciplines? How will the learning experiences be meaningful and relevant? How will activities be differentiated to suit all students' needs?	**Step 6** – Reflect on how the interdisciplinary approach has enhanced understanding	**MYP interdisciplinary planner section 3**: Reflect on the decisions above before, during and after conducting the unit of study

[3] Although the sections and sub-sections are numbered for ease of use, "any aspect might provide the point from which teachers begin their planning and self-evaluation" (IBO, 2016a, p. 2)

The three examples in Table 2.1 are representative of the guidance available in making broad planning choices for interdisciplinary curriculum and aim to assist teachers in the curriculum planning cycle. These examples are based on an assumption that written curriculum should acknowledge the taught and assessed curriculums, as these three curriculum elements (written, taught, assessed) are interrelated and have mutual influence (Graves, 2008). The examples shown in Table 2.1 support the notion that planning for interdisciplinarity needs to begin with establishing and justifying the interdisciplinary purpose. The guidance then continues to prompt teachers in a variety of planning and teaching choices including which disciplines will contribute to the interdisciplinary endeavour, how these disciplines will integrate and how interdisciplinary learning might be demonstrated.

At this point, however, a gap is beginning to appear in the resources available for teachers who wish to enact an interdisciplinary curriculum, particularly resources that acknowledge the interdependence of written, taught and assessed curriculum components. The planning choices that lead to assessment are rarely supported by exemplars of assessment and there is little acknowledgement of how this written guidance might need modification when influenced by the taught and assessed curriculums. For example, Vasquez and colleagues (Vasquez et al., 2013) speak of creating assessment opportunities throughout learning experiences and give examples of assessment tools types that might help teachers assess. Repko and colleagues (Repko et al., 2014) speak of critically analysing and reflecting on interdisciplinary insights and understanding. Neither of these examples address the backwash effect of assessment and reflective practice on teachers' planning. The International Baccalaureate (IBO, 2014a, 2016a, 2017a) provides some assessment feedback to planning but their assessment criteria focus only on disciplinary content and interdisciplinary process skills and do not extend to assessment of interdisciplinary purpose or the claimed benefits of interdisciplinarity. This limitation is discussed further in section three of this chapter from the perspective of interdisciplinary assessment.

Other approaches that can support interdisciplinary purpose

Complementary methods for determining an interdisciplinary purpose for an interdisciplinary endeavour are available, even though proponents of these methods do not necessarily provide guidance on the written, taught and assessed components needed for effective planning. Interdisciplinary purpose can be sought through concept-, inquiry-, problem- or project-based learning, or through a variety of other lenses. The common thread in each of these teaching and learning approaches is that they provide the means through which interdisciplinary purposes can be addressed and may even provide the interdisciplinary purpose itself, for example, to understand a complex concept or problem. It must be noted, however, that these complementary teaching and

learning approaches are not exclusively interdisciplinary, and they can equally be used in a disciplinary classroom or with other forms of integrated curriculum (multidisciplinary or transdisciplinary, for example). This is where these pedagogical approaches interact with the definitional challenges surrounding interdisciplinarity in that the approaches might be described as interdisciplinary but the extent to which they are, or are not, is highly dependent on the style of classroom implementation.

The following overviews explain each approach with reference to both the disciplinary and interdisciplinary contexts. While not exhaustive, the range of approaches to be briefly examined here are concept-, inquiry-, problem-, project- and other perspective-based learnings.

Erickson and Lanning (2014) state that a *concept-based* curriculum is

> "…inquiry driven and idea-centred. It goes beyond the memorization of facts and skills, and adds the critical third dimension of concepts and deeper, conceptual understandings. These conceptual understandings transfer through time, across cultures and across situations, which supports the ability to see patterns and connections between similar ideas, events or issues." (Erickson & Lanning, 2014, p. 2)

This description is equally applicable to both disciplinary and interdisciplinary classrooms. Fogarty and Stoehr (2008), however, argue that a distinguishing element of concept-based learning is the need to involve multiple disciplines and to cross disciplinary boundaries, implying that a concept-based curriculum is better when it is part of an integrated curriculum. *Inquiry-based* learning is organised around a central question that engages students, establishes the learning purpose and is designed to provoke curiosity in students and sustain their interest throughout the period of learning centred on the question (IBO, 2017c). Similarly, *problem-based* learning is an approach where students address "an authentic and complex problem that has a number of possible 'solutions'" (Chambers, 2007). It is a form of constructivist learning in which students, with guidance, attempt to solve a problem that necessitates an extension of their existing knowledge and skills. *Project-based* learning may involve students addressing concepts, inquiry questions or problems and is therefore closely related to the learning approaches described above. The distinguishing feature of project-based learning is that it emphasises "learning by doing" (Lin, 2017, p. 1) and that the project would conclude with a product (Brassler & Dettmers, 2017) that addresses the designated educational purpose.

Each of these learning approaches, concept-, inquiry-, problem- and project-based learning, can potentially be used in either disciplinary or interdisciplinary classrooms. When curriculums are

organised around concept development, inquiry, problem solving, or project works, an *opportunity* for interdisciplinary teaching and learning is enabled, even though it is not required. In these contexts, teachers and students might integrate disciplines to generate more-complex understandings, inquiries, problem solutions or products. Through using the concept-, inquiry-, problem- or project-based approaches, interdisciplinary teaching and learning approaches may be implemented in the classroom, depending upon the teaching and learning decisions taken.

In addition to the four established teaching and learning approaches outlined above, approaches from other perspectives are emerging that Larmer (2015) identifies as "x-based learning". Examples include arts-based learning or case-based learning. Larmer (2015) states that many of these x-based learnings either have commonalities with problem-based learning or they have a specific context, skill or artefact that focuses the learning. Two examples of this idea are elaborated below.

Object-based learning uses an artefact, or artefacts, as a central point of inquiry. Similar to concept-, inquiry- and problem-based learning, it provokes curiosity in students. Objects "have the power to help students cope with challenging aspects of the curriculum, … [and strengthen] learning, as the sense of touch can lead to a more memorable learning experience" (Chatterjee & Duhs, 2010, p. 1). Chatterjee (2010) writes about the potential for museum objects to be used as a central focus of study, encouraging students to think like a historian, geologist or zoologist, while bringing in other disciplines to situate the object in context. The object provides a meaningful purpose for integration of disciplines and through multiple, integrated disciplines, students can engage with an object in-depth.

A recent development in education has been the emergence of STEM, an acronym representing the disciplines of Science, Technology, Engineering and Maths (English, 2016; Holmes, Gore, Smith, & Lloyd, 2016). This acronym can be extended to STEAM, which also incorporates the Arts (for example, in Quigley, Jamil, & Herro, 2017) and there are other popular extensions on this acronym theme (for example, ACSA, 2016; Davis, 2017). STEM disciplines are now being promoted as crucial to 21st century learning, although there is often no further justification than generic statements like, "current…jobs are at high risk of being affected by computerisation or technology" (PricewaterhouseCoopers, 2015, p. 4), or, "jobs of the future will require a high level of technological literacy" (Australian Government, 2016, p. 9). Even though some assert that STEM is indeed interdisciplinary (Vasquez et al., 2013, p. 4), it is used by others as a general acronym to refer to the four disciplines regardless of integrative considerations (Australian Government, 2016; PricewaterhouseCoopers, 2015). STEM as an instructional approach, however, is not inherently integrated or interdisciplinary and its nature is highly dependent on how it is implemented in

schools. The key challenge with integrated or interdisciplinary STEM is that interdisciplinary teaching and learning begins with a purpose (Boix Mansilla & Gardner, 2003; Klein, 2012; Repko & Szostak, 2017). Therefore, if the interdisciplinary purpose has a need for STEM disciplines to address the challenge at hand, then interdisciplinarity may be achieved. If this interdisciplinary purpose is not present however, students might find they are engaged in other forms of curricular integration, for example, multidisciplinary or transdisciplinary study, or simply non-integrated, disciplinary STEM.

These challenges described in object-based learning and STEM apply to other x-based (Larmer, 2015) learnings. Similar to concept-, inquiry-, problem- and project-based learning, these approaches provide a clear *opportunity* for interdisciplinarity, however, teachers and students must still deliberately choose to integrate multiple disciplines to enable an enhanced outcome.

Collaborative vs individual interdisciplinary study

Interdisciplinary study can be carried out either by individuals or teams (Repko, 2012; Rhoten et al., 2006). It appears more common, however, for collaborative interdisciplinary study to occur at the university level where team members contribute their own disciplinary specialisation when collaborating on a joint project (Borrego & Newswander, 2010; Hulme & Toye, 2006; Neumann et al., 2010; Pooley et al., 2017). In contrast, younger learners are more likely to engage in individual interdisciplinary study, when they are making interdisciplinary connections with material that is new to them (IBO, 2017a). This also extends into the university years where students might engage in interdisciplinary capstone courses (for example, Phillips & Doyle, 2011; University of Phoenix, 2017). Hayes Jacobs (2017) emphasises the need for teachers to collaborate with students to co-design interdisciplinary investigations. The resulting interdisciplinary endeavour, however, can be implemented as a collaborative or individual study. Whether interdisciplinary study is individualised or collaborative depends on the purpose of the integration.

To paraphrase Roy (1979, in Nissani, 1997), concepts, questions, problems and objects do not come in discipline-shaped boxes. The concept, question, problem, object, or other focal point, all give a focus to the learning, that requires knowledge, conceptual understanding and skills drawn from multiple disciplines as appropriate. Deliberate integration of these disciplines is then necessary for interdisciplinarity to occur and this may happen collaboratively or through individual study. Each of the learning approaches outlined above provides an *opportunity* to work with multiple disciplines in an interdisciplinary manner. The challenge for teachers, if they choose interdisciplinarity, is that they must be intentional in identifying the interdisciplinary possibilities, opportunities and purposes (see Figure 2.2) that emanate from these learning approaches.

Challenges

The challenges to adopting an interdisciplinary approach to learning are the inspiration for this research. The implementation of quality in interdisciplinary teaching and learning is a cyclical challenge. Firstly, it requires that teachers are provided with resources that describe what constitutes quality interdisciplinarity. For resources to be developed, however, some form of interdisciplinarity must be enacted in the classroom. This cyclical challenge is compounded by a paucity of supporting evidence for benefits of interdisciplinarity and organisational resistance to interdisciplinary implementation. The following discussion further elaborates these challenges.

Paucity of supporting evidence

A key concern that arises from the extant justifications of interdisciplinarity is a seeming paucity of supporting evidence for the claims made regarding the benefits of interdisciplinary learning. Studies that have attempted to identify the educational benefits of interdisciplinary learning tend to be highly context-specific and while disciplinary achievement is shown to improve through an interdisciplinary approach (for example, Spintzyk et al., 2016), generalisation of the results is not possible. It remains uncertain whether it is the integration of disciplines that has contributed to academic progress. There are certainly examples and case studies of interdisciplinary teaching practices and student work that exemplify its successful implementation in a variety of classroom settings (Boix Mansilla & Jackson, 2011; Boix Mansilla et al., 2000; Carmichael & LaPierre, 2014; Drake, 2007; Godinho & Shrimpton, 2008; IBO, 2014a; Li & Zhai, 2018; Mohlhenrich, Samsonau, & Spencer, 2018; Rényi, 2000; Spintzyk et al., 2016). There are also ideas of what might indicate interdisciplinary quality (Boix Mansilla & Duraising, 2007; Boix Mansilla et al., 2009) and examples of rubrics for assessment of different aspects of interdisciplinary student work (Clarke & Agne, 1997; Drake, 2007; Fogarty & Pete, 2009; IBO, 2016b, 2017a). Despite these efforts, the question remains whether these examples of practice are enough to support the claims regarding the educational efficacy of interdisciplinarity. Even though interdisciplinary approaches to the curriculum are not yet definitively shown to enable enhancements in learning, there is a growing body of literature that provides examples and case studies of its educational potential.

Evidence to justify the claims for the educational value of interdisciplinarity is critical if curriculum organisations are to require teachers to use interdisciplinary approaches. In the Australian context, the Australian Curriculum (ACARA, 2017a) states that cross-curriculum work is necessary, includes cross-curricular priorities (ACARA, 2017b) and *encourages* teachers to use the learning areas as a base from which to launch interdisciplinary work (ACARA, 2012, pp. 13-14, 26). They also identify the General Capabilities, namely, literacy, numeracy, ICT literacy, critical and creative thinking, personal

and social capability, ethical understanding and intercultural understanding, as "interdisciplinary skills" (ACARA, 2016). There is no compulsion, however, to use interdisciplinary approaches at all (ACARA, 2017a). In contrast, the International Baccalaureate (IB), puts considerable store on the interdisciplinary approach to teaching and learning and mandates the inclusion of one interdisciplinary unit per year per year level throughout the middle years of schooling. The IB provides a specific guide to interdisciplinary teaching and learning (IBO, 2017a) and offers an optional interdisciplinary e-assessment for students in the final year of the IB Middle Years Programme (IBO, 2016c) despite the paucity of evidence that interdisciplinary approaches do yield the benefits claimed. Australian schools that offer the IBMYP, therefore, have high expectations placed on them by the IB regarding an interdisciplinary approach to the curriculum.

Threats to disciplinary organisation

In addition to the scarcity of empirical evidence, implementation of an interdisciplinary approach to the curriculum implies that significant changes must be made within schools, leading to a range of challenges.

It is interesting and perhaps somewhat concerning to note that the challenges faced by universities that were implementing interdisciplinary courses 45 years ago are still the challenges experienced in schools and universities today. These challenges include teachers' established disciplinary, content-oriented mindset, the linear and siloed nature of prevailing structures and processes used to progress students through an education system and a lack of resources for change, including the need for teacher professional learning in interdisciplinary approaches (Briggs & Michaud, 1972).

Disciplinary influence and control reside with those who have authority within the disciplinary environment (Weingart, 2012). Given that disciplines provide the structural building blocks of school and university curricula, the members of those disciplines realise that their professional influence as well as funding is at risk if the discipline is not continually strengthened within its own boundaries (Weingart, 2012). This contributes to a mindset where disciplines retreat into themselves, resulting in a non-collaborative, disciplinary mindset. For disciplinary specialists who are interested in collaborative interdisciplinary work, there is a fear that integration of disciplines will lead to superficial coverage of disciplinary concepts or skills. Indeed, Golding (2009) tells us that, at university level, some forms of interdisciplinarity do not need disciplinary depth at all but that a basic awareness across disciplines will suffice. While this is contrary to much of the literature that emphasises the need for disciplinary grounding in interdisciplinary work (for example, Boix Mansilla et al., 2009), this misconception prevails.

Assessment of interdisciplinary learning has its own inherent challenges, and these are addressed in detail in section three of this chapter. The strong influence of disciplinary assessment practices on interdisciplinary assessment, however, is a significant challenge. In the absence of clear, practical guidance for assessment of interdisciplinary work, teachers often minimise curriculum change by reverting to disciplinary assessment approaches they are familiar with, despite the fact that these strategies do not adequately address interdisciplinary goals (Rhoten et al., 2006). Indeed, teachers are often required to assess against disciplinary objectives as part of their professional and organisational accountabilities (Mohlhenrich et al., 2018). These disciplinary assessment strategies are often reductionist and "not as well-suited as they might be to measure the complexity, ambiguity and multiplicity of skills and aptitudes involved in the creation of new meanings, explanations, or products via interdisciplinary synthesis and integration" (Rhoten et al., 2006, p. 14).

Timetabling structures can compound these challenges by giving both teachers and students a visual and time-based representation of disciplines that reinforce their socialisation into the siloed disciplinary culture (Weingart, 2012). Here, the timetable acts as an indirect barrier to collaboration between both teachers and disciplines. In addition, timetabling practices themselves can contribute to difficulties in implementing innovative curriculum. Liddicoat, Scarino and Kohler (2017) describe the influence of timetabling priorities, detailing how timetabling processes constrain disciplines into linear modules, perpetuating the disciplinary silo.

Lack of impetus for change

Implementation of interdisciplinary approaches to the curriculum necessitates change, including targeted resources to support that change. Black, Harrison, Lee, Marshall and Wiliam (2003) state that new curriculum innovations require personal change and may mean that teachers need to rethink their role and practice (p. 80). Duignan (2012) argues that schooling needs a paradigm change to enable effective pedagogies, rather than focusing on narrow testing measures, however, he cites Breton and Largent (1996, in Duignan, 2012) in explaining that paradigms are difficult to change. When a certain paradigm prevails, even when anomalies arise "most people hope that these will just go away … 'We don't need a new paradigm, ...we just need to make the one we have work better'" (Duignan, 2012, p. 26). Dinham (2016) also problematises change in the context of teacher professional learning and places people in the categories of *enthusiasts*, *watchers* and *blockers*, stating that while watchers may be swayed by convincing evidence and argument, blockers are likely to resist change regardless of any evidence. The paucity of evidence described earlier compounds this challenge, perhaps restricting the implementation of interdisciplinary approaches to the most enthusiastic of enthusiasts only.

Duignan (2012) also reflects that in the current political climate, schools exist in a state of tension, torn between testing/accountability measures and demands for effective pedagogies (p. 23). While interdisciplinary approaches could be included in a list of 21st century pedagogies, more research is needed to determine whether they could also support accountability measures or improve test results, given that success in supporting accountability measures is often linked to resourcing (Zhao, 2016a). The lack of interdisciplinary assessment resources contributes to this challenge, namely, if interdisciplinarity is not assessed, it is not held accountable, and if it is not accountable it is not implemented.

The challenges listed here further highlight a gap that is beginning to emerge in this literature review. There is a perceived scarcity of research into interdisciplinary practice, particularly that which could provide supporting evidence to claims of benefits of interdisciplinarity, as well as a scarcity of research centred on implementation and assessment of interdisciplinary approaches. A key challenge is that teachers are being asked to implement interdisciplinary curriculums (ACARA, 2012, 2016; IBO, 2017a) with few resources to support this change. The further challenges of changing practice in schools include disrupting a disciplinary mindset and disciplinary organisation to provide an additive, interdisciplinary curriculum layer, managing accountability demands and providing resources to further teacher education.

Section one – summary

Section one of this literature review focuses on interdisciplinarity. The section reviews relevant literature that addresses how interdisciplinarity is defined and depicted, describes the aims and claimed benefits of interdisciplinarity, the potential pedagogical approaches for implementing interdisciplinarity in the classroom and the perceived challenges to implementation. A key challenge identified was that most of the pedagogical approaches reviewed do not acknowledge the interdependence of the written, taught and assessed components of curriculum, and its importance.

The literature reviewed on interdisciplinarity showed that there is strong support for a clear purpose that drives an interdisciplinary curriculum approach. Examples of these purposes have been described and organised within Klein's taxonomy of interdisciplinarity (Klein, 2012), in Figure 2.2. The reviewed literature on complementary pedagogical approaches to interdisciplinarity is useful but highly dependent on context and the extent to which teachers choose to implement an interdisciplinary approach.

The review of challenges to interdisciplinarity conclude that teachers are being asked to implement interdisciplinary curriculums (ACARA, 2012, 2016; IBO, 2017a) with few resources to support this significant change. Even though resources that describe written- and taught-curriculum examples of

interdisciplinarity are sufficiently available, resources that demonstrate the practicalities of the assessed curriculum remain scarce. This scarcity reveals the cyclical challenge of implementing interdisciplinarity in the classroom. When assessment resources are scarce, benefit claims cannot be investigated, and interdisciplinary approaches enacted in the classroom will subsequently be limited.

This research is focused upon the development of a method to assess interdisciplinary teaching and learning, namely, to strengthen resources in the domain of the assessed component of curriculum. It builds upon the indications in this first section of the literature review that imply a need for further resources that emphasise the interrelatedness of the written, taught and assessed curricula and ensure that resourcing for each of these components is balanced.

To strengthen resources in the domain of the assessed component of curriculum, two further areas of knowledge need to be investigated. One is educational assessment practice used in the years of schooling to which interdisciplinary approaches are aimed. The other is a detailed investigation of what interdisciplinary assessment resources already exist. A review of the literature on educational assessment aims to ground the development of an assessment resource in quality practice and assist in the critique of existing resources. Therefore, section two of this literature review discusses theoretical notions of educational assessment. This is followed by section three, which presents and critiques existing interdisciplinary assessment resources with a view to supporting the development of a new resource as the central goal of this research.

Section two – theoretical construction of assessment

This section of the literature review considers educational assessment as a field of research. It reviews what is meant by assessment, the purposes and functions of assessment, how assessment can be embedded in the teaching and learning process and the challenges in doing so.

Educational assessment is a broad field of study, as exemplified in reviews of the field by Jackel, Pearce, Radloff and Edwards (2017). The aim of this literature review section is to draw from literature in the field of assessment to illuminate key ideas within educational assessment research. These ideas might then be useful in identifying and critiquing existing interdisciplinary assessment models and in the subsequent development of a new model for interdisciplinary assessment. While this literature review section, therefore, gives a broader overview of assessment as relevant to the research purpose, it also attempts to stay within the boundaries of teaching and learning in the compulsory years of education and within the boundaries of the research.

Terminology

Assessment, in the context of this thesis, refers to the information-gathering processes employed by teachers to illuminate the level of learning a student has achieved at any given point in time and that provides information that can be used to modify teaching and learning (Black & Wiliam, 2010). While a variety of terms are used to describe these information-gathering processes, for example, *evaluation* or *classroom assessment*, these alternative terms are used sparingly and as descriptive synonyms in this thesis.

Finding a coherent approach

Placing theoretical and research-based conceptions of assessment into a coherent framework that enables principles of quality assessment to be applied in practice is a challenge. Rowntree's (1987) five dimensions of assessment, however, provide an existing framework for this purpose. These five dimensions of assessment are:

1. *Why assess?* (Define the purpose of assessment)
2. *What to assess?* (Define the desired assessment outcome and plan backward from this point)
3. *How to assess?* (Ensure visibility of teaching and learning throughout)
4. *How to interpret?* (Make sense of the outcome)
5. *How to respond?* (Communicate feedback) (Rowntree, 1987).

These enduring dimensions provide a reputable guide to quality assessment practice that continue to be confirmed in more-recent scholarly literature. While there are more recent writings on developing quality assessment practice, often in the narrower context of summative or formative assessment (for example, Black et al., 2003; Black & Wiliam, 2010; Earl, 2014; Hattie, 2012; Hattie & Timperley, 2007; Sharratt & Fullan, 2012; Wilson & Murdoch, 2006), the overarching principles outlined by Rowntree (1977, 1987) still stand and are still clearly evident in guiding current notions of assessment design (for example, in Ridden & Heldsinger, 2014; Stiggins & Chappuis, 2012).

It is relevant that Rowntree's (1987) description of thirty years ago is still in use and while research and writing on small-scale assessment considerations abound (for example, task and rubric creation, interpretation of test data), writing on the overarching purposes and effects of assessment is scarce. Rowntree laments that much of the discourse about assessment "gloss[es] over more fundamental questions about whether what we are doing is the right thing, and offer[s] simply a technical prescription for doing it better" (Rowntree, 1987, p. 2). This notion of questioning the why of assessment before considering the what and the how provides a purposeful approach to assessment.

The five dimensions of assessment, although considered separately in detail by Rowntree (1987), are clearly inter-related and operate as an interdependent cycle within the broader framework of assessment considerations (see Figure 2.3).

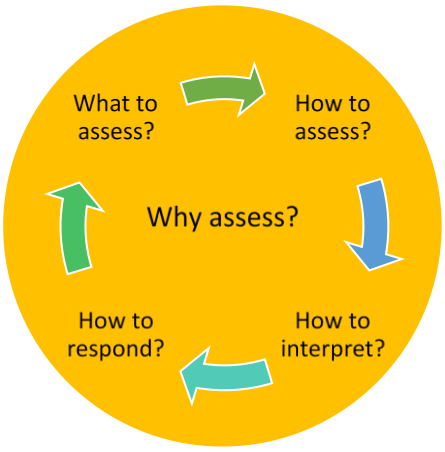

Figure 2.3: Rowntree's five dimensions of assessment (1987) depicted as an interdependent cycle

The sub-cycle of what to assess – how to assess – how to interpret – how to respond is often, in practice, considered separately from the dimension of 'why assess'. Indeed, the 'what' and 'how' of assessment often operate for multiple cycles before teachers reflect upon the bigger picture of 'why'. This larger purpose of assessment has a strong influence, however, as observed by Rowntree

(1987), particularly when considering the interrelatedness of assessment with the written and taught curriculums:

> *"I found that in every chapter, whatever I was writing about – aims and objectives, the design of learning experiences, the sequencing and structuring of knowledge, the evaluation and improvement of teaching – questions of assessment kept rearing their heads and threatening to dominate the discussion."* (Rowntree, 1987, p. 1)

This concept that assessment is interdependent with the written and taught curriculums needs to be maintained throughout the more intricate discussion of assessment below.

Why assess

A popular concept of assessment is its inevitability in education, *doceo ergo censeo*[4], but its justification and purposes remain largely tacit. Rowntree's dimensions attribute the 'why' or the purpose for assessment as the most important, stating that teachers ought to justify why assessment is necessary and carefully consider the expected effects (Rowntree, 1987, p. 11). Others agree that assessment of student learning is fundamental to effective teaching practice (Black & Wiliam, 2010; Earl, 2014; Ridden & Heldsinger, 2014; Wilson & Murdoch, 2006) and that it includes a variety of purposes that influence the choice of formats and serve various audiences (Earl, 2014).

Defining these purposes of assessment is important in ensuring transparency in teaching and learning. Four purposes for assessment are described by various authors as formative, summative, diagnostic and definitional and are discussed further below. Hayward (2015), however, reflects that while these distinct purposes are useful, it is important not to lose sight of the key idea that "assessment *is* learning" (p. 38). Rowntree recommends interrogating assessment purpose(s) further to determine what impact assessment results will have, what these results will be used for, and poses the guiding question, "Who benefits [from this assessment]?" (Rowntree, 1987, p. 15). Defining the purpose of assessment gives direction to learning, which is exemplified by Hattie's (2012) notion of how desired results and success criteria change when the assessment purpose is different.

Earl (2014) states that there are various purposes for assessment that have changed little over the years. She argues that while assessment has *summative*, *formative* and *diagnostic* purposes that can exist together, their inherent differences can also generate tension (Earl, 2014, pp. 2-3). In addition to these three purposes, Rowntree (1987) notes the *definitional* importance of assessment, namely, if an object is actively rewarded through assessment then it will be prioritised. Orrell (2010, p. 103)

[4] I teach therefore I assess.

concurs that through designing assessment tasks, we define what is important to learn and how it will be learnt. A brief description and discussion of these assessment purposes and functions, summative, formative, diagnostic and definitional, continues below. This provides a foundation for determining the assessment purpose(s) for interdisciplinary teaching and learning.

Summative assessment

Summative assessment occurs at the end of a sequence of learning, where teachers (or examiners) make final judgements on a product or a task. Its purpose is to identify what students have learnt, their strengths and weaknesses (Earl, 2006) and inform a report on the outcomes (Wilson & Murdoch, 2006) to students, parents, teachers or other stakeholders. Its core purpose is the assurance of attainment of the core learning goals. Results from summative assessments are used as a form of academic sorting for students (Black et al., 2003; Earl, 2014) for entry to further levels of education and other privileges. In the last 40 years, it has also become a method for measuring accountability within schools (Earl, 2014, p. 14).

The main challenge with summative assessment is that it is an end-of-learning judgement. While this attribute is useful for the purposes identified above, in itself it has limited potential as a tool for learning or for academic improvement for individual students (Wilson & Murdoch, 2006). Tests are sometimes isolated from the learning context and classroom teachers may not have control over the assessment method (Black et al., 2003). Students perceive summative results, particularly grades, as final statements on their abilities in a certain context, accept them and move on, without considering that assessment results themselves can provide useful feedback to shape their future learning activities (Butler, 1988).

Formative assessment

Formative assessment is described as assessment *for* learning (Earl, 2006) and occurs *during* the teaching and learning process. Its purpose is specifically to provide feedback that can guide pedagogical adjustments, differentiate for different learning pathways and improve learning outcomes (Earl, 2014; Wilson & Murdoch, 2006). Hattie (2012) explains that formative assessment provides feedback for both students and teachers, in that,

> "[teachers can adjust] how they teach, how they consider what success looks like, how they recognize students' strengths and gaps, and how they regard their own effects on students … [it provides] students with feedback so that they can learn how to self-regulate and be motivated to engage in further learning" (Hattie, 2012, pp. 125-126).

Formative assessment includes the notions of peer- and self-assessment (Black et al., 2003; Hattie, 2012). Feedback from formative assessment can be beneficial to learning when used "by students in assessing themselves and each other" (Black et al., 2003, p. 2). Earl (2014) sub-categorises such student involvement as "assessment *as* learning" (pp. 28-29) and distinguishes it from assessment *for* learning, which has a teacher-student focus. Both assessment *for* learning and assessment *as* learning, however, fall under the umbrella of formative assessment.

To engage in peer- and self-assessment, students must internalise a deep understanding of the learning objectives and success criteria (Black et al., 2003, pp. 7-9). They need to know where their current learning is at in relation to the key learning objectives so that they can bridge the gap between where they are and where they need to be (Hattie, 2012; Hattie & Timperley, 2007). This identification of a gap between the learning goal and current performance and the subsequent action taken to close the gap, are the defining features of formative assessment (Sadler, 1989, p. 121). There is general agreement that formative assessment is located within a teacher-student partnership. Effective teachers guide students in knowing what quality looks like, so that gap identification and closing of the gap can be carried out (Black et al., 2003; Black & Wiliam, 2010; Hattie, 2012; Hattie & Timperley, 2007; Sadler, 1989; Wilson & Murdoch, 2006).

Diagnostic assessment

Diagnostic assessment, as the term itself indicates, is aimed at providing a diagnosis of the status of students' learning in terms of development towards the learning goal at a given point in time. It is most commonly used to gather data early in the learning process so that teachers can "determine instructional starting points" (Sharratt & Fullan, 2012, p. 203). Diagnostic assessment can highlight what students already know and help teachers make key decisions about how to proceed (Sharratt & Fullan, 2012; Wilson & Murdoch, 2006), including personalising the curriculum (Ridden & Heldsinger, 2014).

Depending on how it is utilised in the classroom, diagnostic assessment could come from summative or formative activities, either of these, or from a purely diagnostic assessment exercise. For example, teachers can take data from a summative test and use it for diagnostic purposes (Ridden & Heldsinger, 2014), or, teachers may gather information at necessary points in a learning sequence to diagnose student progress (or lack thereof) and formatively adjust teaching and learning activities as needed (Earl, 2014; Wilson & Murdoch, 2006). The focus of diagnostic assessment, however, is on gathering data to inform and adjust teaching practices.

Definitional function of assessment

Assessment also has a definitional function, namely, that which is actively rewarded through assessment defines for students what is valued in that learning space (Orrell, 2010; Rowntree, 1987). The "backwash effect" of assessment on curriculum (Torrance, 2012) is that it shapes students' understanding of what matters most by what is assessed (Orrell, 2010). In other words, "the test *becomes* the curriculum" (Koretz, 2017, p. 115). Curriculum standards or what is valued within a discipline becomes defined through assessment practices (Rowntree, 1987).

The definitional function of assessment is largely tacit and indirect and may not necessarily align with what teachers intend the curriculum to achieve. Despite any intent, however, it is clearly a consequence of assessment design choices (Rowntree, 1987).

Summary

To summarise the four assessment purposes or functions, *diagnostic* assessment elicits data on existing student capabilities that can be used to inform teaching. *Formative* assessment enables coaching and pedagogical adjustments throughout the learning process, as well as providing the opportunity for students to engage with assessment practices. *Summative* assessment provides an assurance of learning through generating final judgements on quality when a learning task is complete. The *definitional* function of assessment informs teachers and students about what is important to learn. Table 2.2 displays this summary.

Table 2.2: Purposes and functions of assessment

Assessment outcome	**Purpose or function of assessment**
Assessment for learning	Formative (ongoing adjustment of teaching and learning strategies)
Assessment as learning	Formative (student self- and peer-assessment)
Assessment of learning	Summative assurance of learning
Assessment for teaching	Diagnostic
Assessment as value statement	Definitional

Understanding and acknowledging the potential limitations of each assessment approach is critical for effective practice. A significant limitation of assessment is that it may curb academic risk-taking and encourage students to conform to the assessment context rather than take risks or demonstrate their learning in alternative and creative ways (Torrance, 2012). As Kohn (2006) explains, when

students know their work is being actively monitored, “they tend to think less deeply, avoid taking risks and lose interest in the learning itself” (p. 12).

Assessment purposes and functions and their tacit limitations are important to consider and explicitly address when designing any new system of assessment. These cautions are important considerations in this research.

What to assess

The second dimension, deciding upon the desired outcome and planning backward from that point, is the *what* of assessment (Rowntree, 1987). This dimension includes decisions on what a student will demonstrate or produce as a visible expression of the learning that is planned and involves teachers making decisions about learning activities that will assist students in achieving the learning goal(s) (Sadler, 1989).

The general principle of planning with the end or purpose in mind (Covey, 1989) has been more recently adapted to educational curriculums through Wiggins and McTighe’s (2005, p. 17) “backward design” process. The work of Wiggins and McTighe (2005) is particularly well known in this context, but support for the idea of ‘backward design’ is clearly evident in other recent literature (Hattie, 2012; IBO, 2017c; Sharratt & Fullan, 2012; Wilson & Murdoch, 2006). Backward design is where the desired educational outcome and what might be considered as acceptable evidence for that outcome are considered first and the learning, teaching and assessment processes are devised backward from this point. Backward design, planning with the assessment in mind and the notion that the ‘what’ of assessment should align with learning goals (IBO, 2017c; Wiggins & McTighe, 2005; Wilson & Murdoch, 2006) are educational principles that are widely supported in the current educational assessment literature (Ridden & Heldsinger, 2014; Sharratt & Fullan, 2012; Stiggins & Chappuis, 2012). Hattie (2012) perhaps states it best as,

> “Learning starts with the teacher (and preferably also the student) knowing the desired results (expressed as success criteria related to learning intentions) and then working backwards to where the student starts the lesson(s)” (Hattie, 2012, p. 93).

How to assess

The third dimension, ‘how to assess’ ensures the visibility of teaching and learning throughout so that judgements can be made (Rowntree, 1987). This dimension particularly incorporates notions of formative assessment (Black et al., 2003; Earl, 2014), the need for learning to be visible (Hattie, 2009, 2012; Ritchhart, Church, & Morrison, 2011), the need for students to have a range of opportunities to demonstrate their learning over time (Nuthall, 2004; Ridden & Heldsinger, 2014)

and the need for teachers and students to engage in explicit and helpful feedback practices (Black & Wiliam, 2010; Hattie & Timperley, 2007). In the context of designing a new model for interdisciplinary assessment, it is necessary to understand what quality interdisciplinarity might look like so that this visibility can be enabled in the context of day-to-day teaching and learning.

The 'how to assess' dimension reinforces the idea of the interrelationship between assessment and the planning-teaching-learning process (Graves, 2008; Hattie & Timperley, 2007; Ridden & Heldsinger, 2014) and that, even though it is an inherently complex undertaking, assessment should drive instruction (Sharratt & Fullan, 2012, p. 94) and enhance and support the learning process itself (Earl, 2014, p. 50; Wilson & Murdoch, 2006, p. 4). It is important to note that these researchers recognise this interrelationship as assessment being an iterative, dialogical information-gathering process that ensures quality and requires deliberate alignment with teaching and learning (Figure 2.4).

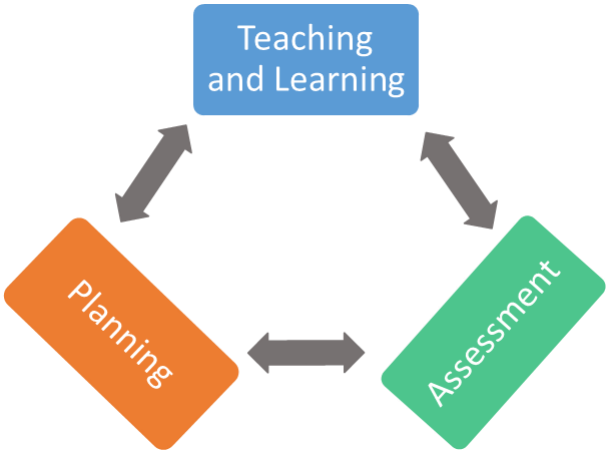

Figure 2.4: Interrelationship between assessment and the planning-teaching-learning process

There are significant implications if assessment is to be recognised as intertwined with teaching and learning processes, particularly involving decisions on how learning is assessed. These decisions on assessment directly influence the planned and taught elements of a curriculum.

Ridden and Heldsinger (2014) state that learning cannot be assessed directly; it happens in the minds of students and therefore needs to be made visible so that assessment can occur (pp. 9-10). Hattie (2009) concurs and argues that in order to monitor, assess and give feedback on any aspect of learning, the learning in question must be apparent in some form. This visibility might begin through noticing and articulating thought processes and then progress to questioning, constructing, understanding, clarifying and documenting thinking (Ritchhart et al., 2011). The goal of learning task design is to make students' thinking visible through assessable solutions, explanations, products and portfolios of evidence. The implication is that teachers' assessment designs should provide students

opportunities to demonstrate their thinking and learning so that diagnostic, formative and summative assessment can proceed (Earl, 2014).

Effective assessment includes a range of assessment strategies throughout a period of learning to generate a comprehensive and accurate picture of student progress (Earl, 2014; IBO, 2017c; Nuthall, 2004; Ridden & Heldsinger, 2014). Nuthall and Alton-Lee's (1995) research on classroom achievement tests supports the conclusion that any one assessment task could not possibly reflect a student's full range of knowledge or ability (p. 220). Any once-off recording of classroom activities would not necessarily be representative of students' perceptions or abilities over time (Nuthall, 2004; Ridden & Heldsinger, 2014). Teaching and learning are "continuous, cumulative processes" and assessment of student's learning needs to be more than "occasional … or sampled observations" (Nuthall, 2004, p. 296). The overall aim of making learning visible is to "create a multi-dimensional image of a student's thinking by viewing it from a number of perspectives", rather than multiple assessments from the same perspective (Ridden & Heldsinger, 2014, p. 30).

The preceding review reinforces the notion that assessment is embedded in the planning, teaching and learning process and this has significant implications when decisions are made regarding 'how to assess'. If teachers are to gain a comprehensive picture of their students' abilities and progress, students require opportunities to express their learning through a variety of activities and contexts, over a period to provide this visibility.

How to interpret

Rowntree's (1987) fourth dimension, 'how to interpret', relates to making sense of the learning outcome. This dimension involves teachers "explaining, appreciating, and attaching meaning" to the assessment events and products (Rowntree, 1987, p. 11). Students may also be involved in interpreting assessment information as part of assessment *as* learning practices (Earl, 2014).

Guidance on 'how to interpret' relates to both elements of performance as well as relative performance quality, namely, what has a student done and how well did they do it? A commonly used guide for performance elements is Bloom's revised taxonomy for performance in the cognitive domain (Krathwohl, 2002), which can be adapted to the learning context. An example guide for assessing performance quality is Biggs and Collis' (1982) Structure of the Observed Learning Outcome (or SOLO) taxonomy, which includes the performance levels of "pre-structural", "uni-structural", "multi-structural", "relational" and "extended abstract" (Biggs & Collis, 1982, pp. 24-25), and can equally be adapted to context.

These two considerations in assessment, performance elements and quality of performance are central to 'how to interpret' and may be used in a variety of formats in a classroom. Assessment rubrics, however, have been increasingly adopted as an efficient way of making learning goals clearly visible. Rubrics, generally displayed as a grid, inform teachers and students "what elements of performance matter most, and how [those elements] to be judged will be distinguished in terms of relative quality" (Wiggins, 1998, p. 153), for which indicators of performance are used. Rubrics, therefore, demonstrate the 'what and how to assess' and the 'how to interpret'.

Guidance on quality rubric design recommends consistency of the elements of performance as well as consistency in the descriptions of increasing quality (for example, Andrade, 2000; Jonsson & Svingby, 2007; Tierney & Simon, 2004; Wenzlaff, Fager, & Coleman, 1999; Wiggins, 1998). Differences of opinion exist, however, on whether rubrics should be designed to support either holistic or analytical judgements. Holistic rubrics support an assessor to make, "an overall judgment about the quality of performance while in analytic scoring, the [assessor] assigns a score to each of the dimensions being assessed…" (Jonsson & Svingby, 2007, pp. 131-132). While some authors argue that whether a rubric is holistic or analytic is dependent on the learning goal (Jonsson & Svingby, 2007; Tierney & Simon, 2004; Wiggins, 1998), others do not. Sadler (2009) cautions against using an analytic model for assessment, suggesting that a holistic model is better suited to educational initiatives that present open problems with indefinite answers.

Rubrics are useful for ensuring learning goals are visible, however, there remain limitations to this method. Jonsson and Svingby (2007) argue that teachers still need to ensure that the content of a rubric and the indicators of performance are valid and the observation and judgements made with them are reliable. They conclude that rubrics are not inherently valid and require ongoing validation processes. Another confounding factor in the dimensions of 'how to assess' and 'how to interpret' is that the quest for enabling, reliable judgements risks compromising the validity or authenticity or alignment of a learning task with its primary purpose (Jonsson & Svingby, 2007, p. 141). This relates to the definitional function of assessment (Orrell, 2010; Rowntree, 1987) and teachers are encouraged to recognise the potential for an assessment to become the default curriculum. If rubrics are employed to ensure that learning goals and indicators of performance quality are clear, then guidance on the development of quality rubric construction is also required. Even though there are limitations to assessment rubrics, when used thoughtfully, the benefits may outweigh the limitations.

How to respond

The fifth dimension, 'how to respond', focuses on the reporting and response to assessment (Rowntree, 1987). This might involve engaging students in feedback-for-learning activities in a variety of forms and contexts, adjusting the planned curriculum to better suit student needs and communicating progress to the students, parents and other key stakeholders.

Formative assessment skills include those of interpreting and responding to assessment information and develop within teacher-student or student-student partnerships (Black et al., 2003; Black & Wiliam, 2010; Hattie, 2012; Hattie & Timperley, 2007; Sadler, 1989; Wilson & Murdoch, 2006). Arguably, formative assessment has a critical function in supporting the interpretation and response to assessment activities. The formative function of assessment occurs *during* the teaching and learning process, influencing pedagogical adjustments, differentiation of learning activities and assists in closing the gap between where students are and the learning goal (Earl, 2014; Hattie, 2012; Sadler, 1989; Wilson & Murdoch, 2006). Importantly, 'how to interpret' and 'how to respond' are central to the concept of assessment *as* learning (Earl, 2014), in which students engage in self- and peer-assessment practices and develop assessment interpretation and response skills (Black et al., 2003; Hattie, 2012).

Challenges in interpreting and responding

The first significant challenge in encouraging assessment response skills is the teacher-student partnership. For formative assessment, students need to be deliberately engaged in their own learning, appreciate what constitutes quality learning and actively employ ways to respond and improve (Black et al., 2003; Black & Wiliam, 2010; Hattie, 2012; Hattie & Timperley, 2007). Research to date has shown that this can be difficult to achieve, for example, James and colleagues (James et al., 2007, in Earl, 2014, p. 17) argue that students tend to acquire surface techniques for peer- and self- assessment rather than understanding the deeper principles of formative assessment. Butler's (1988) defining research illustrates how formative comments, if presented with or without grades, can have negative or positive effects respectively on student efforts. Hattie and Timperley (2007) provide a helpful formative assessment strategy, providing three guiding questions for feedback, 'where am I going?', 'how am I going?' and 'where to next?', that are supported with four levels of feedback, 'task', 'process', 'self-regulation' and 'praise' (Hattie & Timperley, 2007, pp. 88-102). This strategy, which aligns with Rowntree's (1987) 'what and how to assess', 'how to interpret' and 'how to respond', is suggested for use together with an acknowledgement of classroom factors that influence assessment and provides an additional framework to assist teachers to engage students in formative assessment whether teacher-, self-, or peer-driven.

A second challenge to interpreting and responding is that formative assessment, both *for* and *as* learning, conflicts with traditional conceptions of assessment *of* learning, which is primarily summative. Shifting from a summative assessment of learning conception and practices to a conception of assessment for and as learning involves a significant conceptual and cultural change for teachers (Earl, 2014; Hager & Butler, 1996) as well as for students and their parents.

A third challenge is that there is a risk that formative comments may be interpreted as personal criticism of students rather than advice and guidance regarding the task at hand. This can result in a negative impact on some students' sense of self-efficacy and future learning efforts (Hattie & Timperley, 2007, pp. 98-100). Torrance (2012) warns of this de-formative assessment and provides a persuasive argument to minimise this risk where possible.

The significant challenge of establishing teacher-student partnerships that enable formative assessment is one which must be actively met when embedding assessment throughout the planning, teaching and learning process. This may in turn imply conceptual change for teachers, students and parents. Finally, it certainly implies that teachers and students need to work together to identify learning goals and develop strategies that enable formative feedback. Each of these challenges in interpreting and responding to assessment activities have been identified as potential obstacles to be addressed during the research process.

Broader assessment challenges

Even when there is a coherent approach to assessment practice, there are broader challenges that need to be considered. These challenges are closely related to school contexts and assessment traditions and include:

- a potential need for change in teachers' conceptual understanding of what it means to assess with a resulting need for change in pedagogy,
- the challenge that many schools are bound to external assessment requirements that greatly impact the *why* and *what* of assessment, and
- the challenge that all assessment is subjective. Any judgement on student progress is imbued with the perspective and bias of the assessor and may also be influenced by decisions leading to the creation of the learning activity itself.

The current literature on assessment is in general agreement that while it is important to consider the assessment purpose, each purpose hinges critically upon one factor, the interaction between teachers and students (Black et al., 2003; Nuthall, 2004). This interaction, however, may require a significant change in pedagogy or even a change in overall conceptions of teaching and classroom

practice (Black et al., 2003). It is important that teachers question the effects that they have on students and the classroom environment and be prepared to change their own practices to adapt to the needs of learners in their classrooms (Hattie, 2012). This implies that a key challenge in implementing quality assessment practices, is not that teachers simply need to change their assessment practice, but that they may need to change their whole pattern of pedagogy and their ways of thinking that underpin their pedagogy (Black et al., 2003). It means that teachers need to acknowledge the interrelated nature of the written, taught and assessed elements of the curriculum, ensure that students have multiple opportunities to make their learning visible and encourage a classroom environment that is conducive to formative assessment partnerships.

The 'why' and 'what' of assessment also have inherent challenges, in that teachers do not always have control over the purpose of the assessment activity or the content on which students are assessed. Black and colleagues (2003) note that it is "evident that the context of national or local requirements for certification and accountability exert… a powerful – usually harmful – influence on assessment practice" (p. 13). The challenge in this context, is that teachers are often forced to accept an external assessment requirement that imposes its own interpretation of assessment need, without regard to contextual needs or appropriateness.

Subjectivity in assessment practice is present at all stages, from the 'why' of assessment, through to the 'what' and the 'how'. Hattie (2009) states that education is never neutral, that its core purpose is "intervention or behaviour change" (p. 254). Biesta (2007) highlights the dilemma that arises when educational effectiveness is being judged, that this judgement creates a conflict between what has been deemed "educationally desirable", a subjective judgement in itself, and the need for teachers to be sensitive to their own classroom context (p. 5). Sadler (2009) describes subjectivity of assessment at length in the context of grading student work with analytic rubrics. He observes some of the challenges that arise in this context:

- Even when assessors use analytic rubrics to assess, they simultaneously make holistic judgements as to the quality of the work, based on experience rather than stated qualities
- Sometimes the holistic and analytic judgements do not align, resulting in a conflict the assessor needs to solve
- As much as possible, criteria should be functionally uncorrelated, however, assessors may find overlap, often due to situational influences
- Sometimes unexpected criteria emerge during the assessment process, resulting in another conflict assessors need to solve

- Selection of certain criteria is a subjective judgement and involves an inherent decision to exclude other criteria
- Assessors may have different interpretations of criteria and how they should be applied (Sadler, 2009, pp. 164-168)

Although subjectivity is at the core of most of these challenges, Schuwirth and van der Vleuten (2004) argue that subjective measures can still be reliable and generate reproducible results (p. 809).

Within this research it is therefore acknowledged that teachers make decisions about what is educationally valuable and desirable, within a context where decisions may have already been made as to what is valuable and desirable, and this directly influences all levels of teaching, learning and assessment. Even though the challenges inherent to assessment cannot always be fully addressed, they are directly relevant to the research challenge and must still be acknowledged openly to mitigate any adverse effects.

Section two – summary

This second section of the literature review provides an overview of various considerations that contribute to an understanding of educational assessment. It has described a coherent approach (Rowntree, 1987) to assessment that focuses on assessment purposes and the acknowledgement that assessment is interrelated with the planned, taught and learned curriculums (Earl, 2014; Graves, 2008; Hattie & Timperley, 2007; Ridden & Heldsinger, 2014; Sharratt & Fullan, 2012; Wilson & Murdoch, 2006). This section also touches upon some challenges that are specific to educational assessment and that are summarised here.

Teachers need to be aware of the summative, formative, diagnostic and definitional purposes and functions of assessment and understand which purpose(s) their assessment regimes address to better describe and exemplify desired results and provide success criteria (Hattie, 2012; Rowntree, 1987). Assessment is an information-gathering process that ensures quality teaching and learning. Even though it is an inherently complex undertaking, assessment should support planning and instruction (Sharratt & Fullan, 2012, p. 94) and enhance and support the learning process itself (Earl, 2014, p. 50; Wilson & Murdoch, 2006, p. 4).

There is an interrelationship between assessment and the planning-teaching-learning process (Earl, 2014; Graves, 2008; Hattie & Timperley, 2007; Ridden & Heldsinger, 2014; Sharratt & Fullan, 2012; Wilson & Murdoch, 2006). This is particularly exemplified through the ‘backward planning’ curriculum method (Wiggins & McTighe, 2005).

Learning must be visible to be captured and must be captured from multiple different perspectives, giving students a variety of opportunities to demonstrate their learning (Earl, 2014; Hattie, 2009; Nuthall, 2004; Ridden & Heldsinger, 2014; Ritchhart et al., 2011). Teacher-student partnerships that enable interpretation of and responses to assessment activities must be actively constructed. Teachers and students need to work together to identify learning goals and develop strategies that enable feedback, including definitions of success criteria and teacher-, student- and peer-assessment that will assist students in addressing learning gaps (Black et al., 2003; Black & Wiliam, 2010; Hattie, 2012; Hattie & Timperley, 2007; Sadler, 1989, 2009).

This research is focused upon the development of a method to assess interdisciplinary teaching and learning that will strengthen resource provision in the domain of the assessed component of curriculum. This second section of the literature review, theoretical construction of assessment, provides a conceptual understanding of what constitutes quality assessment practice in a general classroom setting and assists in the critique to come of existing interdisciplinary assessment resources.

The third and final section of the literature review considers the fields of interdisciplinarity and educational assessment in combination. It considers the interrelationship of the planned, taught and assessed curriculums and how this relationship transfers to the interdisciplinary classroom context. The third section also reviews what types of assessment currently exist in the context of interdisciplinarity, to what extent assessment exists and what remains to be developed, with a view to supporting the development of a new resource.

Section three – interdisciplinary assessment

Sections one and two of the literature review consider interdisciplinarity and assessment separately. The terminology in each field have been defined for the purposes of this research and the sections have individually addressed elements relevant to the field. Section one describes processes for enabling interdisciplinary teaching and learning in the classroom and describes the purpose, benefits and challenges of interdisciplinarity. Section two describes the purposes and functions of assessment, how assessment must be acknowledged as embedded in the teaching and learning process and some of the challenges related to assessment.

Sections one and two also illuminated the notion of 'purpose', which is common to both interdisciplinary teaching and learning and educational assessment. As explained in section one, interdisciplinarity occurs when separate disciplines are consciously and deliberately integrated for a purpose and this purpose should be at the forefront of interdisciplinary planning, teaching and learning. Section two explained that purpose should be at the forefront of assessment planning and that assessment is a support mechanism for the planning, teaching and learning cycle.

This third section of the literature review therefore considers the intersection of these two fields in interdisciplinary assessment. The existing literature that illustrates some aspects of interdisciplinary assessment in practice is critiqued and ideas proposed regarding what is considered quality assessment practice in the interdisciplinary context. Importantly, for this study, this section discusses the extent to which the reviewed literature is helpful for the classroom context.

The literature review then concludes with an analysis of the literature from all three sections, guided by the following considerations.

- Is the literature relevant or adaptable to interdisciplinary assessment in the middle- and high-school classroom?
- Are the examples of interdisciplinary assessment useful for middle- and high-school practice? Do they help with each of Rowntree's (1987) five dimensions of assessment?
- If there are gaps when attempting to transfer the interdisciplinary assessment literature into practice, how can the existing literature covered in this review be used to guide the generation of a solution?
- Can the reviewed literature inspire and inform an assessment framework that is rigorous, accessible and enabling for teachers who wish to implement interdisciplinary teaching and learning in the middle- and high-school context?

Interdisciplinarity is complex, yet assessment can be reductionist. Knight (2001, in McCulloch, 2007) argues that assessment is reductionist when it, "assumes that complex achievements can be separated into component parts that can be reliably assessed" (p. 5) and this is particularly reflected when complex performances are reduced to a single grade (Harrison, Könings, Schuwirth, Wass, & van der Vleuten, 2015). Even when assessment is conducted for formative and diagnostic purposes, it is intentionally reduced to comments on particular qualities of component parts of a task in order to give feedback to students (Black & Wiliam, 1998, 2010). Others also note the risk in applying standardised, reductionist instruments to a complex situation (Field, Lee, & Field, 1994; Sadler, 2009).

While interdisciplinary teaching and learning aims to embrace complexity, it does so within a paradoxical dilemma because the very act of assessing interdisciplinary learning may reduce the opportunity for complexity. Assessment of interdisciplinary teaching and learning, therefore, requires teachers to be fluent in both holistic *and* analytic assessment practices (Jonsson & Svingby, 2007; Tierney & Simon, 2004; Wiggins, 1998). Analytic assessment practices enable teachers to separate learning tasks and experiences into their component parts, in order to communicate the characteristics of quality performance and provide feedback for learning. Holistic assessment, in contrast, enables teachers to appreciate tasks as a whole (Sadler, 2015) and cater for unpredicted and unpredictable learning elements that naturally emerge in an interdisciplinary context. In addition to holistic and analytic assessment practices, interdisciplinarity would also seem to require multiple opportunities for assessment. Given the complex nature of interdisciplinary teaching and learning, multiple and varied assessment opportunities (Earl, 2014; Nuthall, 2004; Nuthall & Alton-Lee, 1995; Ridden & Heldsinger, 2014) would provide a clearer picture of a student's interdisciplinary progress and achievement.

Existing interdisciplinary assessment models

A variety of interdisciplinary assessment ideas have been proposed in recent decades, ranging across middle-school, high-school and university. Table 2.3 displays these ideas and, while the table does not claim to be a complete overview, it provides examples of the prominent ideas for assessment of interdisciplinary learning from recent decades and is organised using Rowntree's (1987) five dimensions of assessment.

The authors identified in Table 2.3 support the idea that assessment is a key element in interdisciplinary teaching and learning programs and their views represent the consensus on quality assessment practices reported in the previous section (for example, Earl, 2014; Hattie, 2012; Rowntree, 1987). These views include that assessment should focus on the process of learning,

incorporate formative feedback and use a mix of assessment instruments and methodologies (for example, Field et al., 1994, in the interdisciplinary context). There is also consensus that assessment should be *locally designed or elaborated* to cater for particular classroom needs (for example, Boix Mansilla, 2010; Field & Stowe, 2002, in Chettiparamb, 2007; Fogarty & Pete, 2009; IBO, 2017a). This expectation of locally oriented assessment design, however, has given rise to an interesting challenge in the field of interdisciplinary assessment design, namely, that while multiple authors propose categories or criteria that could be used to design and assess interdisciplinary programs ('what to assess'), fewer authors provide detailed examples of how this might be achieved in practice, namely, examples of 'how to assess'. In addition to this paucity of examples of how to assess, even fewer resources address 'how to interpret' and 'how to respond'.

Table 2.3 therefore provides a critique of existing ideas related to interdisciplinary assessment, organised by author and publication date. It includes a brief explanation of the performance elements ('what to assess') and their abbreviated forms that conceptualise their domain, as proposed by researchers and practitioners. These performance elements are highlighted in colour to demonstrate the different notions of what should be assessed. The table then identifies whether examples of how to assess, interpret and respond are included, as well as the context of the research.

Not included in Table 2.3 are researchers and practitioners who have based their own performance elements on the original work presented in the table (for example, Pettitt & Muga, 2008, whose performance elements are based on those of Boix Mansilla et al., 2003, 2005, 2007), nor are domains bordering interdisciplinarity like multi- or trans-disciplinarity (for example, Association of American Colleges and Universities, 2009), due to these curriculum approaches differing from interdisciplinarity as described in section one. Some curriculums, whose authors claim they are 'integrated', are included if they meet the accepted definition of an interdisciplinary curriculum provided in section one[5], namely, that interdisciplinary teaching and learning occurs when disciplinary knowledge, concepts and skills are consciously integrated to solve a problem, create a solution, explain phenomena or generate further questions (Boix Mansilla & Gardner, 2003; Repko & Szostak, 2017).

[5] There is one exception to this, the resources of the SACE Board of South Australia (2011a, 2011b), which are included due to their immediate relevance to one of the volunteer schools in the research.

Table 2.3: Existing guidance for assessment of interdisciplinary performance

Researchers/ Practitioners	**Rowntree's (1987) dimensions of assessment**[6]				**Educational context**
	Performance elements: 'what to assess'[7]	**'What to assess' abbreviated**	**'How to assess'**	**'How to interpret/ respond'**	
Krovetz, Casterson, McKowen and Willis (1993)	• Articulate purpose of activity[8] • Analyse and practice what students know • Acknowledge what they do not know • Formulate questions that lead to further knowledge • Synthesise connections between knowledge and life • Evaluate what was learned and how it could be improved	• *Articulate purpose* • *Analyse and practice* • *Acknowledge unknowns* • *Formulate questions* • *Synthesise connections* • *Evaluate*	Student task shown		10th grade
Martin-Kniep, Feige and Soodak (1995)	• Disciplinary concepts are significant • Curriculum has cognitive and affective connections with students • Learning goals, activities and assessments are coherently integrated	• *Disciplinary significance* • *Relevance* • *Coherence*	Student tasks described		High school, USA
Teachers from Rutland Northeast Supervisory District, quoted in Clarke and Agne (1997, pp. 109-110)	• The work is infused with individual spirit • The work has an impact on others through its communication • The work employs multiple sources and media that are integrated • The work results from invention with some risk • The work reflects a process by which the student has changed	• *Uniqueness* • *Communication* • *Integration* • *Challenge/innovation* • *Student Growth*	Examples of teaching ideas		High school, USA

[6] "Why assess" is not considered in this table. The purpose for assessment is often flexible, as described in section two of the literature review

[7] Red= disciplinary grounding, Green= integration of disciplines; Blue= academic processing skills; Orange= Holistic advancement or interdisciplinary purpose

[8] In isolation, some performance elements may appear disciplinary. Note that each of these elements is proposed by the author(s) in the context of interdisciplinarity

Table 2.3: continued

Researchers/ Practitioners	Rowntree's (1987) dimensions of assessment				Educational context
	Performance elements: 'what to assess'[9]	'What to assess' abbreviated	'How to assess'	'How to interpret/ respond'	
Boix Mansilla, Miller and Gardner (2000)	• Emphasis on how knowledge from multiple disciplines can build towards interdisciplinarity • Identification of specific concepts and modes of thinking from multiple disciplines • Disciplines are purposefully intertwined; concepts and modes of thinking in one discipline enrich understanding in another	• *Knowledge use* • *Careful treatment of each discipline* • *Disciplinary interaction*	Detailed student reflections		High school, USA
Wolfe and Haynes (2003)	• Primary sources included, range of disciplinary perspectives included • Problem is defined, assertions supported, meta-analysis and reflection evident • Identifies disciplinary perspectives and how disciplines contribute to the study, including terminology and diverse disciplinary sources • Create common ground, new holistic understanding, application of new holistic understanding	• *Disciplinary sources* • *Critical argumentation* • *Multidisciplinary perspectives* • *Interdisciplinary integration*	Writing tasks described	'Quality' in ID writing tasks described	University
Boix Mansilla and Gardner (2003); Boix Mansilla (2005)	• Work is grounded in the disciplines • Integration of disciplinary perspectives • Advancement of understanding and inquiry	• *Disciplinary depth* • *Integration* • *Advancement*	Student questions described		University

[9] Red= disciplinary grounding, Green= integration of disciplines; Blue= academic processing skills; Orange= Holistic advancement or interdisciplinary purpose

Table 2.3: continued

Researchers/ Practitioners	Rowntree's (1987) dimensions of assessment				Educational context
	Performance elements: 'what to assess'[10]	'What to assess' abbreviated	'How to assess'	'How to interpret/ respond'	
Drake (2007)	• Knowledge taken from multiple disciplinary standards • Skills taken from multiple disciplinary standards, skills cut across disciplines • Reflective, attitudinal domain	• *Know* • *Do* • *Be*	Examples of teaching ideas		K-12
Fogarty and Pete (2009)	• Subject matter, content, target disciplines • Process skills of organisation, problem solving, decision making, creative ideation • Enduring subject and content learning • Unexpected results examined for value	• *Knowledge* • *Skills* • *Learnings* • *Serendipities*	Examples of teaching ideas		High school
SACE Board of South Australia (2011a, 2011b)	• Development and application of knowledge, concepts and skills • Investigation into and analysis of concepts ideas and skills • Collaboration with others, communication, discussion and justification of ideas • Reflection on and evaluation of own and peers' learning • Explanation of connections between program focus and capabilities	• *Application* • *Investigation & Analysis* • *Communication & Collaboration* • *Evaluation & Reflection* • *Understanding*	Teaching ideas	Examples of assessed student work	Year 11-12, Australia

[10] Red= disciplinary grounding, Green= integration of disciplines; Blue= academic processing skills; Orange= Holistic advancement or interdisciplinary purpose

Table 2.3: continued

Researchers/ Practitioners	Rowntree's (1987) dimensions of assessment				Educational context
	Performance elements: 'what to assess'[11]	'What to assess' abbreviated	'How to assess'	'How to interpret/ respond'	
Boix Mansilla (2012b)	• Purpose calls for an interdisciplinary approach • Learning is grounded in the disciplines and draws upon data, concepts, methods, applications, *et al.* • Integration enables more comprehensive explanation, contextualisation, solution, model • Understanding is measured against purpose, disciplinary evidence, integration; understanding is provisional	• *Purpose* • *Disciplinary insights* • *Leveraging Integrations* • *Critical stance*	Examples of teaching contexts		University
Huutoniemi (2012)	• Prioritising and mastering multiple disciplinary standards • Emphasising integration and synergy • Redefining knowledge, reassessing governance of knowledge production	• *Mastery of disciplines* • *Integration & synergy* • *Critiquing disciplinarity*	Some teaching contexts discussed		University
Lattuca, Knight and Bergom (2013)	• Awareness of extra-disciplinary perspectives; ability to connect multiple disciplinary ideas • Recognition of distinct ways of knowing • Self-assessment, critical reflection abilities	• *Interdisciplinary Skills* • *Recognizing Disciplinary Perspectives* • *Reflective Behaviour*	Questionnaire measuring ID competence described		University

[11] Red= disciplinary grounding, Green= integration of disciplines; Blue= academic processing skills; Orange= Holistic advancement or interdisciplinary purpose

Table 2.3: continued

Researchers/ Practitioners	Rowntree's (1987) dimensions of assessment				Educational context
	Performance elements: 'what to assess'[12]	'What to assess' abbreviated	'How to assess'	'How to interpret/ respond'	
Vasquez, Sneider and Comer (2013)	• Disciplines need to be integrated • Interdisciplinary endeavour must be relevant and have authentic purpose • Twenty-first century skills – collaboration, critical thinking, problem solving, creativity and communication – are developed • Students should be appropriately challenged to ensure engagement • Problem- and project-based approaches should be included	• *Integration* • *Relevance* • *21C skills* • *Challenge* • *Variety of approach*	Examples of interdisciplinary STEM teaching ideas		Grades 3-8
IBO (2014a, 2016a, 2017a)	Assessment criteria – disciplinary grounding, synthesising, communicating, reflecting – build upon Boix Mansilla's criteria in the previous iteration of the IBO's interdisciplinary guide – purpose, disciplinary grounding, integration, thoughtfulness (Boix Mansilla, 2010) – and are further influenced by IBMYP skills criteria across the other eight middle years subject groups (2017c).	• *Disciplinary grounding* • *Synthesising* • *Communicating* • *Reflecting*	Teaching unit examples	Assessment criteria with descriptors of quality and examples of assessed student work provided	Grades 6-10

[12] Red= disciplinary grounding, Green= integration of disciplines; Blue= academic processing skills; Orange= Holistic advancement or interdisciplinary purpose

Table 2.3: continued

Researchers/ Practitioners	Rowntree's (1987) dimensions of assessment				Educational context
	Performance elements: 'what to assess'[13]	'What to assess' abbreviated	'How to assess'	'How to interpret/ respond'	
Drake and Reid (2017)	• Students are assessed against disciplinary objectives and corresponding standards • Cross-curricular skills, e.g. literacy, as well as Communication and Inquiry, are assessed in more than one subject at once	• *Disciplinary standards* • *Cross-curriculum expectations*	Student questions described		Middle school
Newell (2007), Tress et al. (2006), Szostak (2009), Boix Mansilla, Duraisingh, Wolfe and Haynes (2009), all summarised in Repko and Szostak (2017)	Repko and Szostak (2017) triangulate among four others' assessment methods and highlight seven main categories for consideration, arguing that these should be used as per the needs of the project at hand. • Newell (2007, in Repko & Szostak, 2017) focuses on utility of the understanding and processes (comparison, self-reflection, communication) used to get there • Tress et al. (2006, in Repko & Szostak, 2017) also focus on utility of understanding generated, but from an explicit viewpoint of how useful the new knowledge is to others • Szostak (2009, in Repko & Szostak, 2017) asks whether there is an improved insight or explanation generated • Boix Mansilla, Duraisingh, Wolfe and Haynes (2009, in Repko & Szostak, 2017) propose focusing on the criteria of *purposefulness*, *disciplinary grounding*, *integration* and *critical awareness*	• *Usefulness* • *Purposefulness* • *Critical awareness* • *Process* • *Comparison* • *Self-reflection* • *Communication* • *Disciplinary grounding* • *Integration*	Examples of teaching contexts	Boix Mansilla et al. (2009) provide a detailed description of assessment of one student's work against the nominated performance elements (purposefulness, disciplinary grounding, integration and critical awareness)	University

[13] Red= disciplinary grounding, Green= integration of disciplines; Blue= academic processing skills; Orange= Holistic advancement or interdisciplinary purpose

Two key functions are achieved by aligning the existing literature on interdisciplinary assessment with Rowntree's (1987) dimensions of assessment in Table 2.3. The first function of the table is that it provides a basis to determine whether the research premise holds, namely, that while interdisciplinary teaching and learning is promoted as a useful pedagogy, there are few resources available to help enable this pedagogy in the classroom, particularly assessment resources in the domains of 'how to interpret' and 'how to respond'. The third column of Table 2.3 indicates the range of resources currently provided, that are largely in the domain of 'how to assess'. This provision of resources, or lack thereof, is further analysed later in this chapter in Table 2.4.

The second function of this table is that it identifies and analyses existing ideas for interdisciplinary assessment of planning, teaching and learning in a middle- or high-school classroom setting and indicates the usefulness of these ideas in the development of an interdisciplinary assessment resource. Table 2.3 shows how the performance elements, the 'what to assess', differ according to author while still implying commonalities. These common notions of what constitutes quality in interdisciplinarity are indicated by colour. These notions are also further analysed in Table 2.4 for use in constructing the first indicators of interdisciplinary quality as part of the first phase of research.

Strengths of existing models

The strengths of the reviewed literature are clearly centred in the conceptual commonalities identified in Table 2.3. There are four themes that identify interdisciplinary quality that emerge from an analysis of the conceptual development of interdisciplinary performance elements. These themes have been identified by colour in the table. They are *disciplinary grounding, integration, interdisciplinary skills* and *purpose*. Three of these themes are consistent with the accepted definition of interdisciplinarity, namely, that *disciplines* must be consciously and deliberately *integrated* to address a *purpose* (Boix Mansilla & Gardner, 2003; Repko & Szostak, 2017).

The first theme, disciplinary grounding, reflects the requirement that disciplinary components should be assessed in interdisciplinary education (Boix Mansilla, 2005, 2012b; Boix Mansilla et al., 2009; Boix Mansilla & Gardner, 2003; Boix Mansilla et al., 2000; Drake, 2007; Drake & Reid, 2017; Fogarty & Pete, 2009; Huutoniemi, 2012; IBO, 2017a; Lattuca et al., 2013; Martin-Kniep et al., 1995; Repko & Szostak, 2017; SACE Board of South Australia, 2011a, 2011b; Wolfe & Haynes, 2003).

The second theme, integration of disciplines, reflects the requirement that the act of integration should be assessed. This ensures that the deliberate integration of separate disciplines is a key consideration in interdisciplinary learning (Boix Mansilla, 2005, 2012b; Boix Mansilla et al., 2009; Boix Mansilla & Gardner, 2003; Boix Mansilla et al., 2000; Clarke & Agne, 1997; Huutoniemi, 2012;

IBO, 2017a; Lattuca et al., 2013; Martin-Kniep et al., 1995; Repko & Szostak, 2017; Vasquez et al., 2013; Wolfe & Haynes, 2003).

The third theme, academic processing skills, identifies requirements to address a range of academic processing skills relevant to an interdisciplinary curriculum. These include inquiry, communication, analysis, reflection, evaluation and general process skills that help leverage disciplinary knowledge into new understandings or purposes (Clarke & Agne, 1997; Drake, 2007; Drake & Reid, 2017; Fogarty & Pete, 2009; IBO, 2017a; Krovetz et al., 1993; Lattuca et al., 2013; Repko & Szostak, 2017; SACE Board of South Australia, 2011a, 2011b; Vasquez et al., 2013; Wolfe & Haynes, 2003).

The fourth theme, interdisciplinary purpose, identifies that interdisciplinarity has its own unique purposes. A continuous thread observed throughout the literature review has been the notion of the distinctive purpose for interdisciplinarity and the need to have this purpose in mind when planning assessment. Boix Mansilla (2012b) explains the necessity of interdisciplinary purpose, indicating that as a *productive epistemology*, interdisciplinarity can "shed light on how humans can make increasing and better sense of the world, themselves, and others through the integration of available disciplinary insights" (pp. 294-295). The purpose of interdisciplinary inquiry is, therefore, the advancement of understanding and this purpose can be achieved by building upon prior knowledge and enabling insights from a broad range of knowledge systems (Boix Mansilla, 2012b).

This theme of interdisciplinary purpose is significant in that the purpose of interdisciplinarity, advancement of understanding, is only briefly alluded to in the interdisciplinary assessment literature, even though it is referred to frequently in the interdisciplinary teaching literature. The first three themes, disciplinary grounding, integration and interdisciplinary process skills, are addressed (Boix Mansilla, 2012b; Boix Mansilla & Gardner, 2003; Drake & Reid, 2017; Fogarty & Pete, 2009; Huutoniemi, 2012; IBO, 2017a; Lattuca et al., 2013), and less commonly, exemplified (IBO, 2014a; Krovetz et al., 1993; Martin-Kniep et al., 1995). Interdisciplinary purpose, or advancement of understanding, however, is not included in these depictions. Boix Mansilla (2012b) and Klein (2002a) acknowledge this omission in the literature, accompanied with Stowe and Eder's (2002) observation that traditional forms of assessment, those which need empirical or logical evidence, are too simplistic to make sense of interdisciplinary advancement. Reasons proposed for this omission include that interdisciplinarity is too diverse, complex and unpredictable to be adapted to conventional assessment practices (Boix Mansilla, 2012b; Klein, 2002a; Stowe & Eder, 2002).

An inference is that interdisciplinary purpose may not be assessable through empirical, logical or deductive means but maybe through holistic or inductive means. This recalls Sadler's (2009) ideas that privilege holistic assessment over analytical assessment. On reflection, however, rather than

choosing one over the other, the very nature of interdisciplinary teaching and learning suggests that both could be useful. That is, the assessment of disciplinary grounding, integration, interdisciplinary skills and a student's overall advancement may need an appropriate combination of analytical and holistic assessment methods.

Limitations of existing models

Table 2.3 also highlights the paucity of examples of 'how to interpret', examples of de-integrated assessment, examples of assessment that is not aligned with the 'why' or 'what to assess' and examples of rubrics that do not reflect quality assessment practice as described in section two of this literature review. Only three of the 16 resources provide examples of both assessment rubrics (whether grid-based or free-form) and assessment of student work (Boix Mansilla et al., 2009; IBO, 2014a, 2016a, 2017a; SACE Board of South Australia, 2011a, 2011b). Of these three, one set of resources is from an educational organisation (IBO) whose resources are restricted to schools delivering their programs and one is from a local (SACE), integrated curriculum that was not intentionally interdisciplinary (teachers could also deliver this curriculum in a multi- or transdisciplinary way). These two examples of 'how to interpret/respond' are either inaccessible to a majority of teachers or they still need modification to ensure interdisciplinarity. The third resource (Boix Mansilla et al., 2009) provides a detailed description of assessment of one student's work against nominated performance elements but the student work itself is not provided for reference.

Four of the resources in Table 2.3 (Clarke & Agne, 1997; Drake, 2007; Drake & Reid, 2017; Fogarty & Pete, 2009) provide example assessment rubrics. These rubrics, however, represent de-integrated assessment where disciplinary elements within a learning outcome are extracted for assessment. This seems to be common in practice as schools are obliged to use local subject-based standards and reporting requirements and therefore prioritise disciplinary assessment practices that meet these needs; Kim and Stogdill (2018) provide a clear example of this. There are other examples of assessment rubrics (Clarke & Agne, 1997; Drake & Reid, 2017; Fogarty & Pete, 2009; IBO, 2017a; Krovetz et al., 1993; Martin-Kniep et al., 1995; SACE Board of South Australia, 2011b; Vasquez et al., 2013) but these rubrics do not address the interdisciplinary advancement that has been argued to be a key purpose of interdisciplinarity (Boix Mansilla, 2005, 2012b; Boix Mansilla et al., 2009; Boix Mansilla & Gardner, 2003; Huutoniemi, 2012; Wolfe & Haynes, 2003). Even though some authors speak of the importance of interdisciplinary purpose (Fogarty & Pete, 2009; IBO, 2017a; Vasquez et al., 2013), they do not include it in their assessment guidance.

Further limitations of the assessment guidance presented in Table 2.3 relate to the utility of the assessment rubrics, which may be too brief or too generalised to be immediately useful (Boix

Mansilla et al., 2009; Boix Mansilla & Gardner, 2003; Fogarty & Pete, 2009; Huutoniemi, 2012; IBO, 2017a; Martin-Kniep et al., 1995; Repko & Szostak, 2017). For example, in the International Baccalaureate's rubric for the interdisciplinary skill of "disciplinary grounding", the top-level descriptor reads, "The student demonstrates extensive necessary disciplinary grounding" (IBO, 2017a, p. 53). While such a statement has the potential to broadly encompass a range of classroom contexts, it requires significant modification to be useful for practical assessment. Repko and Szostak's (2017) review and discussion of various interdisciplinary performance elements is informative. Their ideas still require significant effort and interpretation on the part of classroom teachers, however, to transfer these ideas into practice. Other resources in Table 2.3 have similar limitations because they were designed for specific or restricted contexts and are, therefore, difficult to transfer to other contexts (Boix Mansilla et al., 2000; SACE Board of South Australia, 2011a, 2011b; Wolfe & Haynes, 2003). For example, the conceptual or contextual leap of transferring ideas from a university to a middle-school context is a challenge.

Contextual considerations

The assessment of interdisciplinary purpose also needs to be considered in the context of its implementation in the classroom. The epistemological reasoning behind interdisciplinary purpose is the further advancement of understanding over and above what could be achieved in a disciplinary classroom. However, this interdisciplinary purpose cannot be assessed in isolation from the teaching and learning context. That is, interdisciplinarity is dependent upon effective planning, teaching and learning in order for its purpose to be enabled. In Table 2.1, Vasquez, Sneider and Comer (2013), Repko, Szostak and Buchberger (2014) and the International Baccalaureate (IBO, 2017a) explain that the purpose of disciplinary integration needs to guide an interdisciplinary endeavour. Identification of purpose is an important factor to be embedded within other planning, teaching and learning considerations, including assessment of the achievement of the purpose, to provide direction to the learning experience.

Boix Mansilla (2010, 2012b), the International Baccalaureate (IBO, 2017a), Nikitina (2006) and Repko and colleagues (Repko & Szostak, 2017; Repko et al., 2014) all argue that there is a need to both identify and embed interdisciplinary purpose to guide classroom planning and teaching practices. Interdisciplinarity needs to be driven by its purpose while also addressing the needs of the classroom context. In this research, it is important, therefore, that the situation of interdisciplinary approaches in a range of classroom environments is acknowledged and accommodated as an integral part of any assessment resource development. The 'why' and 'what' and 'how's (Rowntree, 1987) of interdisciplinary assessment each need to be in alignment.

Each of the strengths and limitations relating to resource breadth, depth, alignment, availability and transferability provide support for the research premise and indicate that further research would be useful. An overview of the strengths and limitations of the reviewed literature as presented above, with indications of which elements of the interdisciplinary curriculum and assessment cycle each author currently addresses, is provided in Table 2.4.

Table 2.4: Analysis of existing guidance for interdisciplinary practice in middle and secondary school

	Krovetz et al., 1993	Martin-Kniep et al., 1995	Clarke and Agne, 1997	Boix Mansilla, Miller and Gardner, 2000	Wolfe and Haynes, 2003	Boix Mansilla and Gardner, 2003; Boix	Drake, 2007	Boix Mansilla, Duraisingh, Wolfe and Haynes, 2009[14]	Fogarty and Pete, 2009	SACE Board of SA, 2011a, 2011b	Boix Mansilla, 2012b	Huutoniemi, 2012	Lattuca, Knight and Bergom, 2013	Vasquez, Sneider and Comer, 2013	IBO, 2014a, 2016a, 2017a	Drake and Reid, 2017	Repko and Szostak, 2017
Pedagogical guidance for the Planning-Teaching-Learning cycle, incl. 'why assess'	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓
Performance indicators, 'what to assess'	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Examples of assessment tasks, 'how to assess'	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓
Assessment rubrics, 'how to interpret'	×	×	✓	×	✓	×	✓	✓	✓	✓	×	×	×	✓	✓	×	×
Examples of 'how to interpret' applied to student work	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	✓	×	×
'How to assess, interpret, respond' aligned with 'why and what to assess'	×	×	×	✓	✓	✓	×	✓	×	×	✓	✓	✓	×	×	×	✓
Critique – is it useful for the school classroom? (see *Note* for codes)	5	4, 5	1, 2, 5	4	4, 6	4	1, 3	4, 8	1, 2, 3	2, 5, 7	4	3, 4	6	2, 4	2, 3	1, 2	4

Note. Critique reasons are: 1 – Assessment is de-integrated; 2 – Assessment does not address the interdisciplinary purpose; 3 – Rubrics are simple (one-line performance descriptors) or not self-explanatory (too general); 4 – Performance indicators too broad for practical transfer; 5 – Assessment is not drawn from the literature, or it pre-dates the seminal literature; 6 – Self-assessment survey, 7 – Local curriculum that is integrated but not interdisciplinary, 8 – Assessed student work not actually provided to exemplify 'how to interpret'

[14] a) Incorporated into the Repko and Szostak (2017) summary in Table 2.3.

Building on what is known

In the context of designing an interdisciplinary endeavour, the interdisciplinary purpose, contextual considerations and teaching and learning strategies integrate with a need for assessment. Teachers need a robust assessment structure that supports multiple assessment judgements and guides their planning decisions.

The guidance derived from Table 2.1 (planning processes for interdisciplinary teaching and learning) and Table 2.3 (existing guidance for interdisciplinary assessment) already builds upon, reflects and extends high quality research and practice. These tables, however, also identify limitations. There are propositions regarding what constitutes quality in an interdisciplinary endeavour (see particularly Boix Mansilla, 2012b; Boix Mansilla & Gardner, 2003; Fogarty & Pete, 2009; Repko & Szostak, 2017), that provide clarity on 'what to assess' and to some extent on 'how to assess' (Rowntree, 1987). There are clear ideas on how to design an interdisciplinary course of study (see particularly IBO, 2014a, 2016a; IBO, 2017a; Repko et al., 2014), providing clarity on 'why assess' (Rowntree, 1987). None of these propositions, however, align each component of the planning-teaching-learning model with best assessment practice or make it easily accessible for middle- and high-school classroom practice. A comprehensive model for interdisciplinary planning, teaching, learning and assessment is not openly available for teachers of middle and high school.

Importantly, much of the literature reviewed *does not intend* to provide a comprehensive interdisciplinary planning, teaching and learning cycle that is supported by a robust assessment framework. As demonstrated by Wolfe and Haynes (2003), their "…Interdisciplinary Writing Assessment Profiles are not intended as a substitute for academic evaluation, one-on-one feedback to individual writers, or grading" (p. 128). The research presented in Tables 2.3 and 2.4 demonstrates that most authors address interdisciplinary planning, teaching, learning or assessment from specific perspectives and provide rigorous insight into limited aspects of interdisciplinary endeavours.

It is this very limitation, however, that creates a gap in resource provision. If teachers in schools wish to facilitate interdisciplinary teaching and learning in their classrooms, there is no single place where they can access guidance on how to do so. Teachers in schools are faced with the task of gaining insight into interdisciplinary teaching and learning and the processes to accomplish it from diverse and sometimes narrow perspectives. Indeed, the most helpful guidance in terms of classroom accessibility has been written from an international curriculum organisation whose guidance and professional education services are generally restricted to member schools (IBO, 2014a, 2016a, 2017a) and from a university perspective (Boix Mansilla et al., 2009; Repko & Szostak, 2017; Repko

et al., 2014). While the insights from the reviewed literature are useful and transferable, transferring these insights to the middle and secondary classroom imposes an onerous task on individual teachers.

The intent of this research is to attempt to mitigate these limitations. To do so suggests the need to design an interdisciplinary planning, teaching and learning framework that supports robust assessment practices. The development of this framework needs to be strongly influenced by the conceptual frameworks that have been reviewed in this chapter, bringing together what has been identified as quality practice in interdisciplinary planning, teaching and learning (section one of the literature review), quality practice in assessment (section two of the literature review), and build upon and improve the current models of interdisciplinary assessment (reviewed in section three). Such a framework could help close the resource gap and provide support for teachers throughout an interdisciplinary curriculum cycle. That is, interdisciplinary planning, teaching and learning could be supported by a resource that aligns each dimension (Rowntree, 1987) of interdisciplinary assessment with the interdisciplinary planned and taught curriculum.

Chapter Two: Summary

Chapter Two provides a review of the literature on interdisciplinarity, educational assessment and interdisciplinary assessment. The key ideas that arise from this literature review are as follows.

- There is strong support for a clear purpose to drive interdisciplinary approaches in the classroom. This purpose is sometimes represented as theoretical, methodological, instrumental or critical interdisciplinarity (Klein, 2012) and has been demonstrated through various examples (Boix Mansilla, 2005; Boix Mansilla & Gardner, 2003; Klein, 2012; Nissani, 1997; Repko & Szostak, 2017; Repko et al., 2014). Without purpose, interdisciplinary approaches lack direction and academic rigour.
- The literature on pedagogical approaches to interdisciplinarity is useful but highly dependent on context and whether teachers can transfer others' pedagogies to their own classroom.
- Educational assessment needs to be coherently embedded in the ongoing planning, teaching and learning process and learning must be made visible to enable a multi-dimensional picture of students' progress and achievements.
- There is a paucity of supporting evidence for the effectiveness of interdisciplinary teaching and learning. This is perhaps driven by the difficulty in applying existing, often disciplinary, assessment practices to novel, complex and diverse outcomes.
- There are clear propositions for what constitutes quality in an interdisciplinary endeavour.

- There are explicit ideas on how to design an interdisciplinary course of study.
- None of the planning models (Table 2.1) or assessment propositions (Table 2.3), however, provide a complete conceptualisation of interdisciplinary planning, teaching, learning and assessment guidance that is easily accessible for middle- and high-school classroom practice.

These ideas presented in the literature review lead directly to the purpose of this research.

Research aims and questions

The existing limitations in the interdisciplinary, assessment and interdisciplinary assessment literature have been identified in the three literature review sections. Interdisciplinary theory and general guidance for interdisciplinary teaching and learning is abundant. There is, however, a lack of comprehensive, practical resources that synthesise and disseminate best practice in interdisciplinary teaching and learning for teachers engaging with an interdisciplinary approach.

It is proposed that it would be useful, therefore, to have a tool or a framework that draws upon quality literature in the fields of interdisciplinarity and interdisciplinary assessment and that is supported by clear and rigorous assessment practice. This could contribute to a form of practical guidance for the interdisciplinary planning, teaching and learning cycle.

The central question for the research study is, therefore,

How can interdisciplinary planning, teaching and learning be enhanced through assessment design?

To address this question, the research draws upon the reviewed literature to develop an interdisciplinary assessment resource that is theoretically *rigorous* and defensible. The research process also seeks to ensure that the interdisciplinary assessment resource is *accessible* and *enabling* for classroom teachers, who may be in a range of classroom contexts. Teacher voice, therefore, is a critical element in the design and development process as well as teacher input from a variety of contexts. This addresses a current limitation in resource provision that indicates existing resources are somewhat inaccessible or not necessarily transferable from one school context to another.

This research attempts to develop a resource that demonstrates the complexity of interdisciplinary study and provides clear guidance on why, what and how to assess outcomes, as well as how to interpret and respond to these outcomes (Rowntree, 1987). The resource aims to incorporate assessment considerations into the planning, teaching and learning cycle so that each of these elements are mutually supportive. It also aims to comprehensively incorporate best practice from the reviewed literature and give sufficient practical guidance to teachers, while remaining flexible

enough to allow for local contexts and the inherent complexity of interdisciplinarity. To do all of this, the research implements a robust methodology that supports the development of such a framework and enables each of these elements to be intertwined throughout the development process.

The literature review therefore pauses here so that the research methodology can be explained. Further analysis of the reviewed literature and transfer of this literature into research practice is critical to the development of the proposed interdisciplinary resource and is embedded within the research method. This further development and analysis of the literature review continues in Chapter Four.

Chapter 3 – Methodology

Chapter Three, Methodology, describes how this research is situated in a broader theoretical context, the choice of Educational Design Research as the research methodology that was best suited to the needs of the research challenge, and the specific adaptation of the methodology to this research. The chapter also provides a detailed description of how the research-specific Educational Design Research process was enacted with volunteer schools and participants. Chapter Three specifically addresses the need for research designs to be transparent and replicable (Cobb & Gravemeijer, 2008) so that future researchers may customise the design to their own context.

Inducting the methodology

Crotty (1998) describes the research process as having four domains that each inform the other: ontology and epistemology, theoretical perspective, methodology and methods (p.3). He explains, however, that it is more useful to describe the process from the smaller details, the methods, toward the overarching epistemology, reasoning that research begins with an issue, problem or question and that researchers "[plan] research in terms of that issue or problem or question" (Crotty, 1998, p. 13). This reverse-organisation forms the introduction of the chapter, however, the main body of the chapter follows a more traditional form, beginning with the paradigms of reality and knowledge within which the research sits, the ontology and epistemology, through to the finer details.

This research was driven by the needs of the research question rather than by the overarching research paradigm (Punch, 2009, pp. 19-20), that is, the research aimed to discover whether interdisciplinary teaching and learning could be enhanced through assessment design. The research process involved an investigation into whether the development and application of an assessment resource enabled existing interdisciplinary research to be transferred into classroom practice, and whether this evidence-based resource assisted teachers with planning, teaching and assessment in an interdisciplinary context.

The centrality of teachers' practices in this research in the context of this problem provoked the decision to incorporate teachers' participation and voice within the research process (Baumgartner et al., 2003; Vanderlinde & van Braak, 2009). These teachers had diverse starting points in regard to interdisciplinary teaching and assessment, including those who were already teaching as well as those planning to teach in an interdisciplinary context. The notion of working in collaboration with practicing professionals involved meeting face-to-face or online, administering questionnaire(s), collaboratively designing an assessment tool and conducting interview(s) to review and further

develop the tool. This range of selected research methods led, therefore, to a mixed-methods approach.

A mixed-methods approach needs an organising methodology. The research would involve active intervention with teachers, but not to the extent that it necessarily impacted upon or changed a teacher's curriculum in the classroom. The elements of the intervention would require a trial and review process to identify whether the newly-identified elements of the tool were helpful for the teachers and to enable the unfolding (Punch, 2009, p. 30) production of an increasingly better intervention. This idea of trial-redevelop-trial-redevelop naturally lent itself to a design cycle and the selection of the *Educational Design Research* methodology (McKenney & Reeves, 2014; Plomp, 2007; Reimann, 2011), which provided a framework of multiple design cycles within an overarching design structure.

A theoretical framework provides context to a methodology (Crotty, 1998) however, Educational Design Research is a methodology that brings its own theoretical framework. Plomp (2007) and Reimann (2011) explain that educational research is often removed from everyday teaching practice and this has led to a perception of diminished relevance of educational research to the classroom. The goal of Educational Design Research is to bridge this gap between research and practice by developing solutions for problems in the context of the problems themselves and subsequently communicating the solutions and enabling practices back to the academic literature, thus informing and advancing theory and practice (McKenney & Reeves, 2014; Plomp, 2007; Reimann, 2011).

The overarching epistemology in which this research resides is constructivism, as defined by Guba and Lincoln (2013, pp. 39-41) and Crotty (1998, p. 58). Research in education involves working within a constructed context, the education system itself. This research acknowledged the multiple, subjective viewpoints of the researcher and teachers involved and sought to construct meaning related to the current representation of interdisciplinary teaching and learning in the classroom within this relativist ontology. New ideas regarding how classroom-based interdisciplinarity might be represented were to be inductively generated or negotiated. These overarching paradigms of reality and knowledge frame the research and are explained in further detail below.

Ontology and epistemology

Guba and Lincoln (2013) define constructivism as having a relativist ontology, a transactional-subjective epistemology and a hermeneutic methodology, as well as having an axiological element that defines the value of the research. These are the lenses through which this research has been viewed and subsequently grounded and are explored further here.

In a constructed context, such as education, the nature of the context is relative to those who interpret it. Participants engage with abstract ideas and interpretations are highly dependent on their own experiences, ideas and biases that are brought to the situation. Despite the potential perceived chaos from multiple varied perspectives, however, it must be emphasised that without the involvement of the mind there could be no meaning created at all (Crotty, 1998, pp. 8-9). This is the relativist ontological standpoint: it is understood that there are multiple ways of interpreting and constructing meaning from what is found.

The relativist ontology is closely tied to the subjective, constructivist epistemology. The transactions between the researcher, the reviewed literature and the teacher participants are highly dependent on the context in which the research is situated and the people involved. Therefore, any knowledge that comes from these transactions has not been discovered, but *created* (Guba & Lincoln, 2013, p. 40).

The inquiry into the realm of interdisciplinary teaching, learning and assessment involved extended dialogue with practicing teachers, as well as with the reviewed literature. In this context, a positivist model is not appropriate since the inquiry focuses on the 'mental life', as well as the practical life, of the research participants (Pring, 2015, p. 45). The perspectives that all research participants brought to this research have influenced the constructions made, resulting in this relativist, subjective standpoint that even now will continue to be subject to ongoing change. "What I know is a construction and subject to continual reconstruction" (Guba, 2013, p. 29).

This research is therefore intentionally and unapologetically subjective and relativist and this standpoint applies to both the researcher and the volunteer teacher participants. Even though the subjectivity and relativity are acknowledged, however, this should not be seen to undermine the credibility or the interpretations of the findings. While the researcher and teachers were all influenced by their experiences, ideas and biases however, the research was also informed by the existing academic research on interdisciplinarity. This grounding in research evidence added a small degree of objectivity for the researcher and teacher participants and provided a potential shift towards a broader truth that ensured that the research could be used in future validation studies (Plomp, 2007).

Crotty (1998) makes a crucial distinction between two epistemologies that are very closely related and often conflated, namely, *social constructionism* and *constructivism*. Social constructionism emphasises the influence of the surrounding culture, whereas constructivism emphasises each person's unique experience and perspective (Crotty, 1998, p. 58). In this research, the individual experience of the research participants was pivotal in collecting data. It was acknowledged that the

participants, all of whom were teachers practicing in schools, would have been, and indeed were, influenced by their surrounding cultures, particularly that of the school and educational environment. It is the individual meaning that they created themselves, however, that they contributed to the research. It is critical, therefore, that the potential grounding in either epistemology is acknowledged, as this research could have been grounded in either. Ultimately, even though the research was conducted in a social environment, the focus was on the teachers' and researcher's unique experiences and perspectives. The research was therefore grounded in *constructivism*.

Theoretical Framework

The theoretical framework provides a context for the research process and it is here that assumptions are stated about the contextual reality in which the research will be carried out (Crotty, 1998, p. 7). The main assumption brought to this research is that there is a gap between educational research and classroom practice that needs to be addressed. Vanderlinde and van Braak (2009) found that teachers want research that has practical relevance for the classroom, yet this is generally not made available. Research is often published in journals that are inaccessible to teacher practitioners and teachers rarely recognise the relevance of the findings to their classroom needs and conditions. Pring (2015) gives the high-profile example of the University of Chicago's School of Education that began by purposely conducting classroom-based research, but eventually disconnected its theoretical pursuits from the practice of teaching (pp.21-22). Even though this latter example is decades old, it is an issue that continues as one of the key criticisms today (Vanderlinde & van Braak, 2009). Pring (2015) discusses these criticisms at length, but summarises that educational research is

1. too small-scale and fragmented;
2. non-cumulative;
3. ideologically driven;
4. methodologically soft
5. inaccessible (Pring, 2015, p. 202)

The theoretical framework that structures this research is designed to address these criticisms and contributes to the axiological element of its constructivist nature. It attempts to bridge the gap between the constructed dualism of theory and practice and reintegrate the two in the context of the classroom where both theory and practice belong. Specifically, and with respective reference to the criticisms above:

1. While the scale of this research could be considered small, working with 14 teachers in just 4 schools, it incorporates the work of previous researchers and builds on a large body of existing research;
2. This research intentionally grounds itself in the existing literature around interdisciplinary teaching and learning, enabling a cumulative effect to expand the body of knowledge further;
3. While there is rarely a situation where a researcher can be completely disinterested, keeping in mind particularly the relativist, subjective stance here, this research involves a search for a 'best truth' that can be found within the research parameters;
4. Educational Design Research methodology, as explained later in this chapter, is a methodology that aims to bring structure and rigour to qualitative methods, in both the conduct and reporting of the research;
5. This research has been conducted by a teacher-researcher, in partnership with teachers (Bang & Vossoughi, 2016), with the goal of making the outcomes easily accessible for all teachers. The demographic most likely to use the research outcome was representative of those recruited for the research partnerships (McKenney & Reeves, 2012). In addition, as part of Educational Design Research methodology, the research goals included the development of a practical tool for use in planning, teaching and assessment contexts, as well as a post-thesis contribution to the body of research literature on interdisciplinary teaching and learning, thus contributing to bridging the gap between educational research and practice (Plomp, 2007; Reimann, 2011). These research goals are focused on ensuring the research is accessible.

These are the considerations grounding the theoretical framework for this research. The complexity of the research environment, however, cannot be underestimated. The school environment is a complex system and the research is situated in this complex environment. The inherent social features of the educational system produce complexity, that is, the teachers or "social agents" within the system interact with each other, they can make thoughtful changes to the environment and predict and react to these changes (Mason, 2008; Miller & Page, 2007). Even though this research did not use the ideas within complexity theory as a driver, the consequences of an intervention are unpredictable in a school's complex environment (Mason, 2008). This research is attempting to close a gap where the end points, namely, theoretical and research literature and classroom contexts, are constantly changing. It is into this unpredictable, non-linear context that the research was launched.

Methodological design

Educational Design Research, also known as Design-based Research that is specific to the field of education (McKenney & Reeves, 2014), involves the design, development and evaluation of interventions that aim to close the gap that often appears between educational research and educational practice. Educational Design Research aims to transfer research into practice by experimenting with interventions in context (Anderson & Shattuck, 2012; Plomp, 2007; Reimann, 2011) and uses classroom practice to inform the research. Key characteristics of Educational Design Research include:

- the two-fold purpose of a) developing a research-based solution to a complex educational problem and b) contributing to the advancement of knowledge in the field (McKenney & Reeves, 2014; Plomp, 2007; Reimann, 2011),
- an iterative design cycle that brings the research methods into a systematised process, with the iterations organised in a series of phases (McKenney & van den Akker, 2005; Plomp, 2007; Reeves, 2006). Plomp (2007) summarises these into three main phases of *preliminary research*, the *development* or *prototyping* phase and the *assessment* phase (p. 15).

Importantly, Plomp (2007) emphasises distinguishing whether the research is a development study, to develop a research-based solution for a complex problem, or a validation study, to validate theories about educational interventions (p. 16). This research fits clearly into the category of *development study*.

Educational Design Research is often compared to Action Research, however, there are some key differences. In Action Research the researcher is usually the teacher in the classroom where the research is enacted; in Educational Design Research a researcher who is not in the classroom works in partnership with teachers to conduct research (Anderson & Shattuck, 2012). In addition, while Action Research aims to solve a local problem, Educational Design Research aims to advance theory about teaching and learning (Anderson & Shattuck, 2012; Baumgartner et al., 2003) so that local solutions, while not necessarily generalisable, can still be informative to a broader context.

The development of an interdisciplinary planning, teaching, learning and assessment tool was considered a complex educational problem needing an *intervention*. The proposed interdisciplinary framework was intended to be the basis of an intervention in current teaching practices to provide guidance and support to teachers and students, as well as offering new ideas on interdisciplinary assessment. The other, broader goal of the research was to *advance theoretical understanding* of interdisciplinary teaching and learning through critical analysis of both the existing literature and the

outcomes of the intervention. These two goals, of advancing both theory and pedagogical practices, demonstrate the first key characteristic of Educational Design Research (McKenney & Reeves, 2013; Plomp, 2007).

The second key characteristic, the iterative design cycle of analysis, design and development, implementation and review is the defining image of Educational Design Research (Plomp, 2007). While there are multiple visual representations that include these ideas (Amiel & Reeves, 2008, p. 34; Ejersbo et al., 2008, p. 150; Middleton, Gorard, Taylor, & Bannan-Ritland, 2008, p. 32; Plomp, 2007, p. 17; Wademan, 2005, p. 228), McKenney's (2001) design process (Figure 3.1) was the most helpful in guiding this research towards its own methodological structure. This process illustrates the *needs and context analysis* (or, *preliminary*) phase, the *design, development and formative evaluation* (or, *prototyping*) phase and *semi-summative evaluation* (or, *assessment*) phase, which can be interpreted as an overarching design cycle. It then incorporates multiple sub-cycles within these phases to show the iterative nature of the methodology.

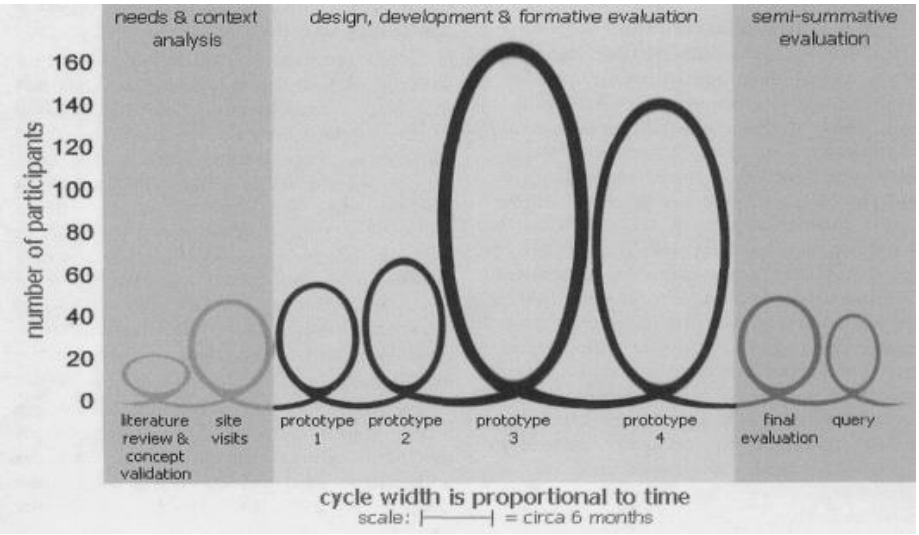

Figure 3.1: McKenney's (2001) design process

McKenney's (2001) design study process was adapted to the needs of this research. To design and develop an interdisciplinary planning, teaching, learning and assessment framework, two key characteristics of the process were important:

1. information collected from the reviewed literature and volunteer teachers' feedback needed to be transferred directly into an ongoing prototype
2. transfer of this information needed to occur throughout the research process.

Adopting this approach was important to enable the interdisciplinary framework to evolve and incrementally improve and close the gap between theory and effective practice.

Further to the two key characteristics, other important characteristics of Educational Design Research that influenced this research include:

- being situated in a real educational context, involving collaboration between researcher(s) and practitioner(s),
- using mixed methods for data collection,
- the evolution of design principles (which differentiates it from action research) and
- having a practical impact on practice (Anderson & Shattuck, 2012; McKenney & Reeves, 2012; Plomp, 2007; Reimann, 2011).

These characteristics were evident in the research context, the research process, or were identified as goals for post-research publications, particularly the characteristics related to the dissemination of design principles and interdisciplinary classroom practice.

Adapted research process

Figure 3.2 illustrates the Educational Design Research process that was adapted from McKenney's (2001) design study process to this research. The Educational Design Research process contains the requisite (Plomp, 2007) three phases of research that contain five iterative cycles and one evaluative cycle.

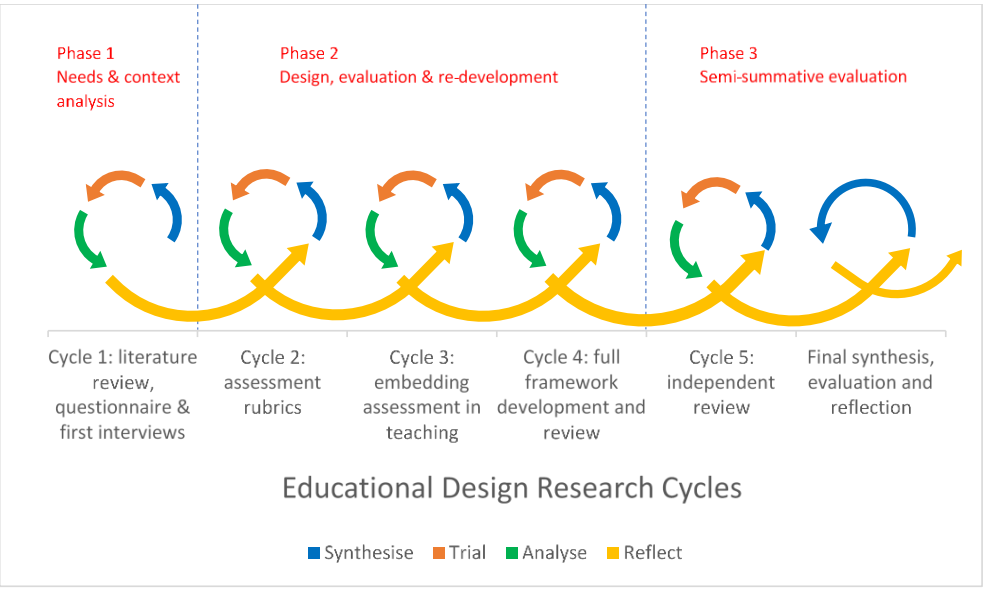

Figure 3.2: Educational Design Research process, as adapted to this research

Phase 1, the *needs and context analysis*, involved investigation into and analysis of the existing literature on interdisciplinary assessment, as well as site visits, questionnaires and early meetings with volunteer teachers to identify and confirm the need and context for the research. One purpose

of the early meetings with volunteer teachers involved presenting findings from the literature analysis to determine whether this could contribute to an initial assessment tool prototype.

Phase 2, the *design, evaluation and re-development* phase, involved three cycles of development. The first cycle of this phase, Cycle 2, developed the initial prototype assessment tool further to include draft rubrics for interdisciplinary assessment, followed by further interviews with volunteer teachers and reviews of the prototype tool.

The second cycle of this phase, Cycle 3, developed a broader teaching and learning framework that addressed all stages of the teaching and learning process. This framework detailed the early planning stages of a unit or task through to finalising and reflecting on the learning journey. This development was again followed by further interviews with teachers and reviews of the prototype framework.

The third cycle of this phase, Cycle 4, incorporated feedback into a revised design, which was reviewed by the schools participating in the ongoing trial.

Phase 3, the *semi-summative evaluation* began with the incorporation of feedback from the final interviews into the development of a penultimate prototype. This prototype was reviewed by an additional participating school – schools are described in detail later in this chapter – to gauge the potential effectiveness of the tool at the point of first contact.

The final, evaluative cycle was completed by the researcher. The outcomes of this cycle are presented through the reflections and decisions in the outcome and discussion chapters (Chapters Six and Seven) in this thesis.

The three phases provide a single, overarching cycle of design. Each of the five cycles within the phase-structure followed a design cycle of *Synthesise, Trial, Analyse, Reflect*, as shown in Figure 3.3.

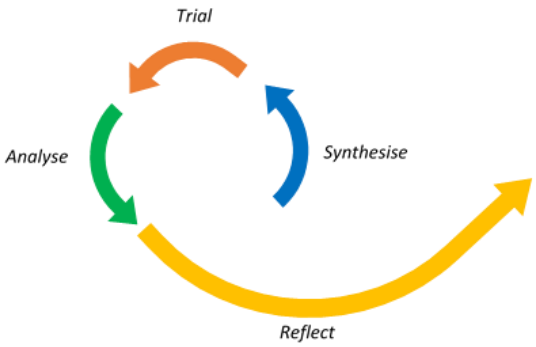

Figure 3.3: Iterative design cycle used in this research

Figure 3.3 is a visual representation of Plomp's (2007, pp. 35-37) guidelines for design research, that each cycle should begin with research or evaluation questions, which lead into an appropriate

design, which is tested and then formatively evaluated in order to feed the next cycle. This last stage of the design cycle, *Reflect*, straddles two cycles, completing one cycle and prompting the next *Synthesise* stage. Each individual design cycle was tailored to the needs of the individual phase.

Phase 1 – needs and context analysis

The first phase of research included the literature review, analysis and concept validation (Figure 3.4). This is a distinctive feature within Educational Design Research, that the literature review is not only a precursor to, but also an integral part of, the research.

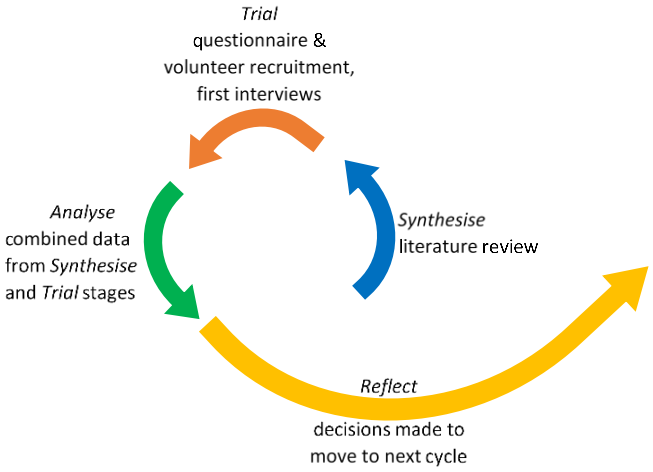

Figure 3.4: Design cycle, Phase 1 – needs and context analysis

Synthesise: The literature review illuminated ideas and propositions for interdisciplinary teaching, learning and assessment. These ideas and propositions were synthesised and used as part of the research proposal and the thesis literature review, as well as informing the content of the survey questionnaire.

Trial: A survey questionnaire (Appendix A) was developed that asked teachers about their own interdisciplinary planning, implementation and assessment processes and elicited satisfaction levels and opinions on whether further support for these processes should be provided. The questionnaire also asked whether teachers would be willing to participate in a trial of a new tool that aimed to provide such support. Follow-up interviews were held with volunteer teachers to confirm findings from the questionnaire and propose the transfer of ideas from the reviewed and analysed literature into classroom practice.

Analyse: Questionnaire and interview responses were analysed to gain an overall understanding of levels of satisfaction with current processes, particularly existing interdisciplinary assessment processes. This was done specifically to gauge whether teachers agreed that a new tool might be helpful and whether the research was justified. The findings that arose from the analysis of the

literature was presented to the volunteer teachers, their responses were analysed, and the results were developed into a format that became the first assessment framework prototype.

Reflect: The researcher reflected on the completed design cycle to ensure that the research was justified through both the reviewed literature and the reported experiences and attitudes of teachers in the interdisciplinary teaching space. Findings from Phase 1 were identified in order to support the subsequent *Synthesise* stage of Phase 2.

Phase 2 – design, evaluation and re-development

The second phase of the research involved three development cycles to design and refine an interdisciplinary assessment framework. An academic base, developed from the analysed literature, and interdisciplinary assessment rubrics were developed first, followed by the insertion of this academic base and assessment rubrics into a broader framework that provided guidance for planning, teaching and learning in an interdisciplinary context. Each of the three development cycles in Phase 2 followed the same design cycle (Figure 3.5).

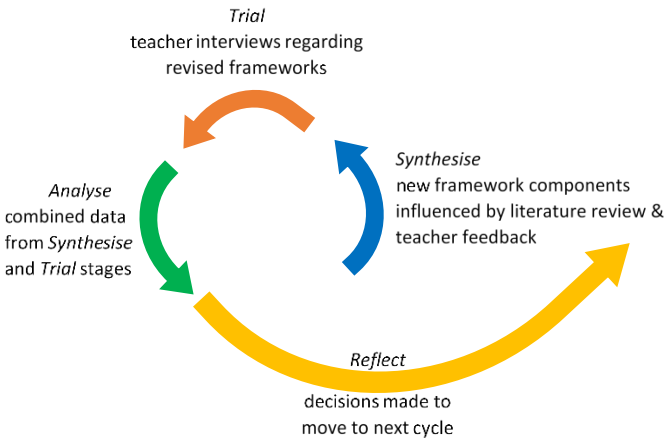

Figure 3.5: Design cycle, Phase 2 – design, evaluation and redevelopment

Synthesise: A framework prototype was developed and refined based on data and analysis from the previous design cycle, including findings from the literature analysis and feedback from volunteer teachers.

Trial: The new or revised prototype was distributed to participating teachers for their own review or for use in the classroom. Teachers were subsequently interviewed in order to generate feedback on the prototype. The interview protocol is described further below and shown in Appendix B.

Analyse: Data collected from teachers was reviewed as per the procedure detailed in the 'interview analysis', later in this chapter. This procedure triangulated findings with the analysed literature and linked the research process back to the research question.

Reflect: The researcher reflected on the completed design cycle, ensuring that the planned changes for the next prototype were justified and that the guiding questions for ongoing framework development were being addressed. Did the framework identify indicators of quality interdisciplinary learning (*rigorous*)? Was it *accessible* for teachers? Was the prototype fit for purpose (*enabling*)? Were there any other improvements needed?

Phase 3 – semi-summative evaluation

The third phase of the research involved two development cycles to finalise and evaluate the interdisciplinary assessment framework. Cycle 5 involved consultation with a teacher who was not involved with the previous development cycles to gauge the immediate accessibility of the framework. The final cycle involved the development of a final framework and an evaluation by the researcher, as presented in Chapters Six and Seven. The Phase 3 design cycle is shown in Figure 3.6.

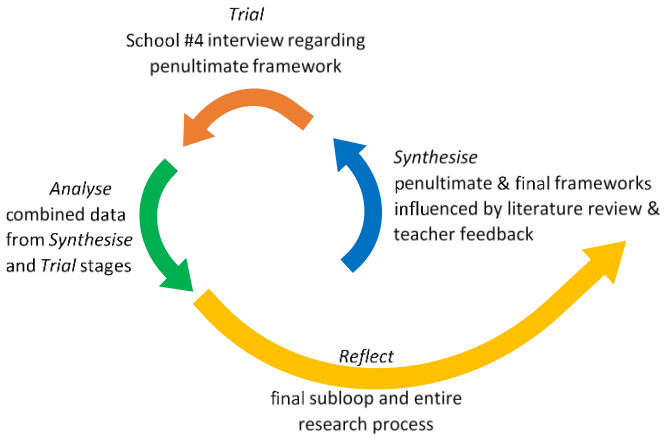

Figure 3.6: Design cycle, Phase 3 – semi-summative evaluation

Synthesise: Based on data and analysis from the previous cycles, the prototype was further developed and refined into a penultimate version to be used with a school that had not been involved in the development cycles (Cycle 5).

Trial: The penultimate prototype was introduced to the new school in Cycle 5. This was done to gauge the level of satisfaction with the assessment framework at first read-through stage. As most schools would encounter the framework in this fashion, it was important to gain feedback from this perspective as part of the final evaluation process. The *Trial* stage was not relevant for the *Final synthesis, evaluation and reflection* cycle.

Analyse: In Cycle 5, feedback from the new school was analysed as per the procedure in the *Interview Analysis* section (later in this chapter). This procedure directly cross-checked findings with

the analysed literature and linked the research process back to the research question. The *Trial* stage was not relevant for the *Final synthesis, evaluation and reflection* cycle.

Reflect: In Cycle 5, the researcher reflected on the completed design cycle and considered what the final school's evaluative feedback implied for the final version of the framework. The guiding questions for ongoing framework development, as above in *Phase 2 Reflect*, were considered.

Synthesise: In the *Final synthesis, evaluation and reflection* cycle, the researcher developed a final interdisciplinary framework that was based on all data and analysis from each of the five full cycles of research. This is the final framework that is presented in this thesis in Chapter Six.

Reflect: In the *Final synthesis, evaluation and reflection* cycle, the researcher reflected on the entire process, as presented in the discussion chapter (Chapter Seven) of this thesis.

Research methods

Educational Design Research is the methodology that assisted in organising the mixed methods used to analyse and refine the drafts of the interdisciplinary resource in this research (Baumgartner et al., 2003). To address the research question, data needed to be collected, analysed and synthesised from two sources: from the current academic literature on interdisciplinary teaching and learning and from teacher practitioners. Two key data collection methods, a *literature review and analysis* and *conversations with volunteer teachers*, enabled the researcher to collect and analyse information, and this subsequently fed the development of the interdisciplinary tool.

Literature review and analysis

The literature review was largely conducted during Phase 1 of the research, however, ongoing monitoring, analysis and incorporation of developments from the academic literature was conducted throughout the research. Data from the reviewed literature provided an overview of current thinking on the assessment of interdisciplinary learning. This data was collated, reviewed and analysed for two main purposes:

1. To confirm the purpose of the research, that an interdisciplinary assessment framework for the middle- and high-school classroom, based on best practice, is currently absent from but recommended by the reviewed literature
2. To identify any interdisciplinary assessment themes in the reviewed literature that show key performance indicators of quality interdisciplinary learning. These indicators guided conversations with teacher practitioners in both the questionnaire and interview contexts and guided the content of the interdisciplinary assessment tool or framework prototypes.

The first phase of this research, confirming the purpose, required a comprehensive review of the existing literature on interdisciplinary teaching and learning, assessment and interdisciplinary assessment, as presented in Chapter Two. The findings from the literature review needed immediate management and classification (Creswell, 2013) to confirm the original premise of the research, namely, while there is ample literature addressing the design and implementation of interdisciplinary learning experiences, there is a noticeable scarcity of guidance for practical assessment in the classroom.

The reviewed literature was classified into two categories, namely, interdisciplinary teaching and learning guidance and interdisciplinary assessment guidance. There were multiple sub-categories for interdisciplinary assessment guidance, which were organised according to Rowntree's five dimensions of assessment. While there is some overlap in the literature classifications, this was an effective method of organisation and analysis. An overview of this analysis of data is presented in Table 2.4 in the Literature Review chapter. Representing the relevant literature in this way demonstrated a clear need to develop existing ideas within the interdisciplinary assessment category further.

Once the purpose of the research had been confirmed, demonstrating that the interdisciplinary assessment literature needed translation to the classroom context, the next step was to extract ideas from the reviewed literature on quality interdisciplinary assessment to identify any themes or common performance elements (Creswell, 2013).

An important finding from the literature review was that many researchers emphasised the need to consider the main intent or purpose of an interdisciplinary exercise when planning assessment. That is, if the teacher had defined the intended purpose for the interdisciplinary learning then this was what should be assessed (Boix Mansilla, 2012b; Fogarty & Pete, 2009; Huutoniemi, 2012; Lattuca et al., 2013; Repko & Szostak, 2017). There were a range of purposes and performance elements proposed and even though they differed in terminology, there was much agreement among authors. An overview of this data is shown in Table 2.3 in the Literature Review chapter. The purposes and performance elements lent themselves to collation into four interdisciplinary performance themes: depth of disciplinary knowledge, integration, interdisciplinary skills and advancement of ideas. This collation of data has been discussed in the Literature Review chapter and is further analysed in Chapter Four.

These interdisciplinary themes guided the first prototype of the assessment framework tool and were a useful basis for devising questionnaire items and early interview conversation items. The

intention in the early interviews was to gauge whether the interdisciplinary themes collated from the reviewed literature would potentially transfer to classroom-based assessment.

Conversations with teachers – questionnaire

The input from practicing teachers of interdisciplinarity was critical in ensuring that the developed resource was accessible for classroom teachers and was enabling of interdisciplinarity in the classroom. Teacher voice was a critical element in the research design. The contribution from teachers would differentiate the framework from existing resources by ensuring its accessibility for teachers and its immediate usefulness in a classroom context. Teacher input was collected through a questionnaire and interviews.

First contact with teachers involved the distribution of an online questionnaire. The purposes for distributing a questionnaire to schools (Mertler, 2009, p. 117) included:

- The need to confirm that teachers understood the idea of interdisciplinarity as defined within the research project itself and to gauge teacher satisfaction with current support, both in-school and external, for their interdisciplinary teaching practice. The data from these questions particularly would contribute to the Phase 1 needs and context analysis, providing further support or refutation of the premise of the research.
- The need to recruit teachers for the in-depth trial of the interdisciplinary teaching, learning and assessment framework

The questionnaire (Appendix A) asked questions about the teachers' school context, to generate a database of curriculum type, year levels and subjects taught; questions on the interdisciplinary program in their school and the professional development support available; questions on interdisciplinary planning and assessment and to what extent teachers were satisfied with their current processes. The final question asked whether teachers were willing to volunteer for a trial of a new assessment tool for interdisciplinary teaching and learning. If the answer was positive, then teachers provided a name and email address for the researcher to contact; if the answer was negative, then teachers' questionnaire responses remained anonymous.

Apart from this final request, the questionnaire options were closed-response (Mertler, 2009), where participants chose their answers from options that included multiple-choice and Likert scales. There was the occasional option to provide additional comments if responses did not fit any of the categories provided. This enabled quantitative analysis of the data and adequately addressed the two purposes of the questionnaire, listed above. Any further qualitative data needed for this research was designated for collection through the interview sessions with teachers.

Recruitment of teachers was specifically designed to address part of the *accessibility* challenge in the proposed assessment framework. The Phase 1 literature review had indicated that transferability of existing interdisciplinary resources was a challenge. While the examples of practice from the university context are transferable *in principle* to the school context, the task-specific assessment examples are not. In addition, examples from the school context are highly task- and context-specific and not easily transferable to other schools. It was hoped that teachers from a variety of school contexts would volunteer for the research to increase the diversity of feedback and subsequently enable increased accessibility of the framework.

Conversations with teachers – interviews

The trial of the interdisciplinary assessment framework involved teachers reviewing or implementing progressive versions of the assessment framework tool and reflecting on this experience to provide feedback to the researcher. The feedback data was collected through interviews and discussions and this feedback was then applied to the subsequent iteration of the framework tool to enable further development and improvement.

Data collection through the interview conversations was grounded in the cyclical design of the research (see Figures 3.2 through 3.6). This gave it both a cyclical and a sequential nature in that each time data was collected it was applied to the current framework prototype, which was then redistributed to teachers for further review or implementation.

Interviews were audio-recorded and subsequently transcribed by the researcher. Transcriptions were forwarded to the teachers for confirmation of content and so that teachers had the opportunity to add to, modify or retract their comments if they wished.

Since specific feedback was being sought, the proposed interviews were *semi-structured*. This style utilised framing questions with the interviewees, as shown in Figure 3.7 below, but also contained open-ended questions that gave interviewees the opportunity to report their opinions and experiences in-depth (Punch, 2009; Silverman, 2006).

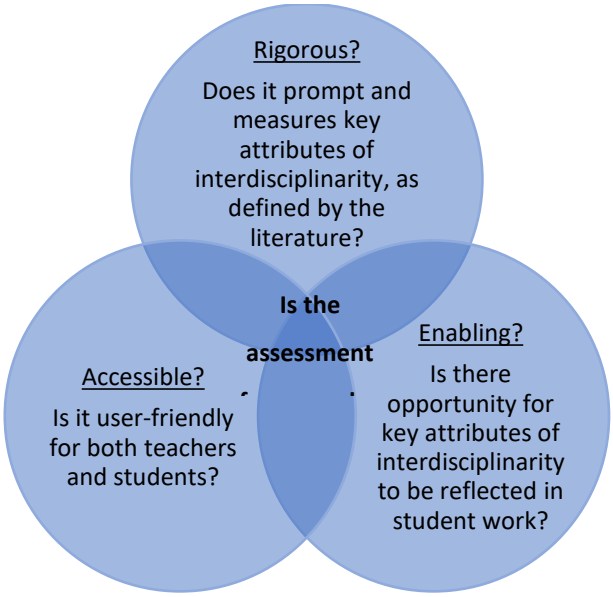

Figure 3.7: Framing questions for interviews

The researcher added or omitted questions at the time of the interview as appropriate while keeping within the intent of the framing questions (Lodico, Spaulding, & Voegtle, 2010). More-detailed prompts for the framing questions used by the researcher in interviews are listed in Appendix B.

The framing questions shown in Figure 3.7 were designed to not only prompt data collection in the interviews, but also to ensure that the data collected directly addressed the research goal. The research goal had emerged from the Phase 1 literature review and was to develop an interdisciplinary assessment resource that was *rigorous* according to scholarship as well as *accessible* and *enabling* for classroom teachers. These three elements, that the framework be rigorous, accessible and enabling, were in philosophical alignment with the criteria for high quality Educational Design Research interventions – that interventions have content validity, construct validity and be practical (Nieveen, 1999) – and were therefore chosen to guide the interviews and subsequent analysis.

Phase 1 interviews focused on the idea of academic rigour; when assessment tool and broader framework prototypes had been developed, all three question categories were used.

Data collected from the interviews included teachers' own framework modifications or notes made during the teaching and assessment process and included occasional student work samples that teachers brought along to exemplify the discussion point. Any student work collected was anonymised.

Research sites and participants

The questionnaire, interviews and discussions required collaboration with teacher-practitioners who already use, or who were planning to imminently use, interdisciplinary teaching and learning in their classrooms. This is because the research did not seek to change teacher-practitioner methods. It simply sought to interrogate the conceptual interdisciplinary literature and to determine whether there was a way to integrate those ideas into a practical tool that would be useful for teachers to plan, implement and assess their interdisciplinary curriculum. Teachers with some experience or a current need to implement interdisciplinarity in the classroom were, therefore, best placed to comment on whether the proposed tool, or components therein, would be useful in their practice. The research thus lent itself to *purposeful sampling* (Creswell & Plano Clark, 2007; Lodico et al., 2010) from the target group who would benefit from the research (McKenney & Reeves, 2012).

Interviews and discussions with teachers were likely to be a rich source of information and, in line with qualitative research practices (Creswell & Plano Clark, 2007), it was planned to keep the number of collaborating schools and teachers to a manageable size. The aim was to recruit three to five middle- or high-schools, with multiple teachers per school, to gain sufficient data. Fewer than this would have resulted in feedback that was too narrow, while a greater number would have generated too much data for a doctoral research initiative. The iterative nature of Educational Design Research implied that even a small number of schools and teachers would generate a relatively large volume of data. The opportunity to broaden this scope is an option for future projects.

Due to the relatively small sample of schools required and the need to meet in person with collaborating schools, initial recruitment occurred within the South Australian school community. As mentioned above, however, collaborating teachers needed to be using or planning to use interdisciplinary teaching and learning in the classroom, so this restricted recruitment to schools who advertised an interdisciplinary component to their curriculum. This information was gleaned from school websites and local media publications. Schools that offer the International Baccalaureate (IB) Middle Years Programme (MYP) were prominent candidates for recruitment as the MYP requires interdisciplinary teaching in every year of the programme (Australian years 6-10). In addition to this cohort, teachers in non-IB schools and from a range of sectors (government, independent, Catholic Education) were approached. Teachers' own experience or inexperience with interdisciplinary teaching and learning was not a recruitment factor, as both perspectives had the potential to generate useful feedback. Participation in the project was on a voluntary basis.

Questionnaire participation

To complete the initial validation of the research concept, as part of Phase 1, a questionnaire was sent to schools that were already engaged in interdisciplinary teaching and learning. The questionnaire had two purposes. The first purpose was to confirm the definition of interdisciplinarity and to gauge teacher satisfaction with current support for their own interdisciplinary teaching practice, whether in-school, external or both. This data contributed to the Phase 1 needs and context analysis and is presented in Chapter Five.

The second purpose of the questionnaire was to seek volunteers to participate in an in-depth trial of an interdisciplinary teaching, learning and assessment tool. After collection of the questionnaire responses, first interview meetings were organised and held with teachers who had volunteered to participate.

The recruitment pool included twenty-seven South Australian schools that use an interdisciplinary approach in their curriculum that were identified through public sources such as their own school website, local media and the International Baccalaureate Organization's *Find an IB World School* web tool. First contact with these schools was through the Principal or Head of School, in accordance with the Flinders University ethics conditions. Permission was granted by seven school principals to distribute information on the research project and the questionnaire link to their teaching staff, via an internal contact person.

From these seven schools, a total of 33 questionnaire responses were received. Demographic data that identified year level(s) and subject(s) taught was collected in case the number of volunteers greatly exceeded the research needs and the researcher had to select volunteers. The data was not needed for this purpose, as ultimately, only four schools volunteered to be part of the qualitative research and all of these schools were used. Regardless, the demographic data showed that the questionnaire responses came from a variety of teachers who taught across years 6-10 and in each of the Australian Curriculum Learning Areas (ACARA, 2017a) (see Table 3.1).

Table 3.1: Year levels and subject areas taught by responding teachers

Characteristic	Categories	Teachers, N=33
Year level(s) taught	Year 6	9
	Year 7	11
	Year 8	16
	Year 9	13
	Year 10	19
Subject area(s) taught	The arts	7
	English	10
	Health and physical education	4
	Humanities and social sciences	9
	Language acquisition/second languages	2
	Mathematics	5
	Sciences	12
	Technology and design	2
	Work studies	0
	Other	9

Note. "Other" included religious education 5, ICT 1, intensive ESL 1, and interdisciplinary progams 2. Teachers were asked to choose all options that applied, so the category totals are greater than the 33 teachers who responded.

In addition to the call for volunteers in the questionnaire, an information flyer was made available during an International Baccalaureate Middle Years Programme Interdisciplinary Teaching and Learning workshop in Adelaide in January 2016. Two participants volunteered through this activity.

Some volunteer teachers were also accepted as volunteers through indirect means, with no recruitment effort from the researcher. Some of the teachers who had volunteered via the questionnaire relayed information about the research project to other teachers in their schools. These other teachers indicated their willingness to participate in the project and attended interviews with their colleague(s).

A detailed description of the teacher and school cohort is provided below. An overview of volunteer teachers, with pseudonyms applied, is shown in Table 3.2. Names beginning with the same letter belong to the same school group.

Volunteer teacher cohort

Over the course of the research project, 18 teachers volunteered. Four withdrew before the first interviews began, leaving 14 teachers who participated in the in-school trials. These included teachers who had volunteered via the questionnaire or flyer (direct recruitment) and teachers who

had volunteered through talking with an existing volunteer teacher in their school (indirect recruitment).

Some teachers who had volunteered subsequently found that they could no longer participate and withdrew either before the research began (four teachers) or during the project (three teachers). Teachers who withdrew during the project are still counted in the final number of volunteers as each of them left for reasons external to the research (existing school workload or moved schools) and did not request that their contributions, if any, be withdrawn.

Some teachers who entered the project part-way through, notably two teachers in School B, were both indirectly recruited. This was an important aspect of the findings to note, as it reflects a common reality of the school system. Teachers are often employed temporarily on a contractual basis and so are required to use the prevailing school curriculum. If this curriculum includes interdisciplinary teaching and learning, this would further support the argument that a planning, teaching and learning resource would be useful for teachers who need to implement interdisciplinary approaches at short notice.

It is interesting to note that the three teachers who indicated in their questionnaire responses that they were “highly satisfied” with planning and assessment processes in their school did not participate in the trial. One of these teachers did volunteer but withdrew before the research began.

All of the volunteer teachers had classes in the year 6-10 range at the time of the interviews. Some of the teachers also taught classes outside this range (primary or senior high school). While this extended experience would have influenced the teachers’ contributions, these year levels were not a focus of the research. An exception to this is included in the description of School A below.

Table 3.2: Teachers who volunteered to participate in the research, with pseudonyms applied

Teacher	Volunteered via questionnaire	Volunteered via own school contact	Volunteered via workshop flyer	Withdrew before research began	Withdrew part-way through research
Jamie	✓				
Jordan	✓				✓
Jean	✓			✓	
Jesse		✓			✓
Jo	✓			✓	
Morgan	✓				
Mel	✓				
Martin	✓				
Max	✓				
Marie			✓		
Matt		✓			
Murray		✓			✓
Rohan	✓				
Riley	✓				
Robin		✓			
Regan	✓			✓	
Reece	✓			✓	
Dale			✓		
Totals	12	4	2	4	3
		18 volunteers		4 full withdrawals; 3 partial withdrawals	

Email contact was made with the volunteers to set up a first meeting. In the first meeting, each teacher was asked to read and sign a consent form to indicate that they understood the nature of the research and that they consented to being recorded during interviews. All volunteer teachers were assured that their identities would remain confidential in relation to the research, both during data collection and in future public dissemination of the findings.

Volunteer schools

The volunteer teachers came from four schools in metropolitan Adelaide, South Australia, which have been coded as Schools A, B, C and D. A brief description of these schools follows, with an overview in Table 3.3. Some school descriptions are limited to maintain confidentiality of the identity of the schools and teachers.

School A is a government-funded school, or state school, that adheres to the Australian Curriculum (ACARA, 2017a) in the compulsory years of schooling and the South Australian Certificate of Education (SACE) in years 11 and 12. School A has used an interdisciplinary approach to guide their

curriculum for 10-15 years and has a strong curriculum review cycle to ensure the curriculum is meeting the needs of teachers and students. The school is proud of their interdisciplinary program, teachers are committed to its success and it is promoted as a distinctive element of the school. The school's interdisciplinary program includes combined classes of year 10 and 11, so reflections from the teachers in this school included data that may have been generated from year 11, as well as from middle-years classes.

School B is an independent school that adheres to the Australian Curriculum (ACARA, 2017a) and the International Baccalaureate Middle Years Programme (IBMYP) in years 6-10 and offers students the choice of SACE or the IB Diploma Programme (IBDP) in years 11 and 12. Even though the school has offered the IBMYP for many years, incorporation of an interdisciplinary approach to teaching and learning has been fragmented. With the recent introduction of compulsory interdisciplinary units in the IBMYP, one unit per year, per year level (IBO, 2017a), the school has been making a concerted effort to meet the requirement. None of the volunteer teachers from School B, however, were involved in the units that the school had identified as its formal IBMYP interdisciplinary units during the period of data collection. This had some advantages during the research process, including the flexibility to trial draft assessment criteria on student work without the need to adhere to IBMYP interdisciplinary criteria as well.

School C is an independent school that adheres to the Australian Curriculum (ACARA, 2017a) and the IBMYP in years 6-10 and offers students the choice of SACE or the IBDP in years 11 and 12. The school has offered the IBMYP for many years and identifies some strong interdisciplinary units within its curriculum. The teachers in the school are confident that their existing interdisciplinary units have transferred well to the new, compulsory IBMYP requirements. All the volunteer teachers from School C were directly involved in a major interdisciplinary unit that integrated four disciplines during the period of data collection. This situation had one disadvantage in that teachers did not have the flexibility to trial the draft assessment criteria with student work. There were some significant advantages, however, in that the teachers were very experienced with interdisciplinary planning, teaching and assessment, they were immersed in an interdisciplinary unit at the time of the research and could therefore analyse the draft interdisciplinary framework more easily and give feedback towards improvement.

School D is an independent school that adheres to the Australian Curriculum (ACARA, 2017a) and the IBMYP in years 6-10 and offers the SACE in years 11 and 12. While the school was only recently authorised to offer the IBMYP, the school board had employed highly experienced IBMYP teachers to lead other teachers in this new curriculum, including the design and implementation of

interdisciplinary units as per the requirements of the IBMYP. The volunteer teacher from this school was one of the highly experienced lead teachers.

Schools A, B and C were involved at various stages of the framework design and redesign process, however, the volunteer teacher from School D was used as a once-only critic of the final draft version. This was done to provide an extra, quality-focused review at the end of the research process, from someone who had not had input into the iterative design process and who had an immediate need for an interdisciplinary teaching, learning and assessment tool to support ongoing planning.

Table 3.3: Overview of schools involved in the research process

Variable	School A	School B	School C	School D
Curriculum in compulsory school years				
Aust. curriculum	✓	✓	✓	✓
IBMYP		✓	✓	✓
Year 11/12 curriculum				
SACE	✓	✓	✓	✓
IBDP		✓	✓	
School authority[a]				
Government	✓			
Non-government		✓	✓	✓
School experience with interdisciplinarity				
Low level		✓		✓
High level	✓		✓	
Overall teacher experience with interdisciplinarity				
Low level		✓		✓[b]
High level	✓		✓	

[a]For the purposes of this description, "non-government" includes the Catholic Education and Independent sectors. [b]Low level of experience school-wide, however, the teacher interviewed was highly experienced with interdisciplinary teaching and learning

Interviews – Complete timeline

The process for collecting data through sharing the draft frameworks with volunteer teachers and engaging in subsequent guided interviews has been explained earlier in this chapter. It is useful, however, to show the timeline for actual data collection here, in the context of the schools themselves.

The intended schedule for interviews included conducting three interviews per teacher, either individually or as a group if requested. This was planned with the understanding that the schedule

would be highly dependent upon and adaptable to volunteer teachers' availability. The aims of the interviews were:

- Interview 1 – introduction to the research project overall, including introduction to the idea of a tool that was *rigorous*, *accessible* and *enabling*; conversation on the context of the volunteer teacher and their school and the teacher's expectations of participation in the research
- Interview 2 – introduction of the current draft version of the framework and a discussion of how the teacher could trial the draft in their own planning or classroom context
- Interview 3 – feedback on the draft version of the framework used, to improve and further develop a subsequent version
- Interview X – this interview was for School D only and was planned as a once-only critique of the final draft framework

Schools A, B and C all followed different timelines, due to the dependence on teachers' availability for both reviewing a prototype and providing feedback. All interviews were held at the teachers' schools, in an office or empty classroom, depending on the time of day and room availability.

The teachers at School A were the first to enter the process and followed the planned three-interview format. The first teacher from this school was interested in continuing the collaboration until the final draft and so this teacher continued for three further meetings, incorporating aims from Interviews 2 and 3 in each of these extra meetings. The second teacher completed Interviews 1 and 2 but then withdrew due to concerns around school workload. Another teacher participated in a single interview but did not continue due to school workload.

Most teachers from School B participated in a one-to-one Interview 1, however, two of the teachers did Interview 1 together. After this introductory interview, however, one teacher suggested that the teachers from School B could make good use of a set professional development time that included two meetings after school per term, to continue the interview conversations. All teachers from School B agreed with this as it was a highly effective use of their time. This meant that Interviews 2 and 3 were spread out across five meetings that included all School B teachers as a group. While this was a more fragmented method of collecting data, it was much more convenient for the teachers involved and a clear advantage was that they had more time to talk through the draft frameworks, gain a better understanding of interdisciplinary planning and assessment and trial the assessment criteria with their own student work. Two teachers entered the School B group part-way through the research: one of these teachers continued through to the final meeting; one participated in two meetings and then withdrew due to moving schools.

By the time School C was available to meet in person, the draft frameworks had progressed significantly. Because of this, it was feasible to combine Interviews 1 and 2 into one meeting session. Two teachers participated in this session together and a third teacher completed Interview 1-2 as a one-on-one session. Interview 3 was held as a group session with teachers from School C all present.

The interview with School D was held as planned, as a once-only one-to-one session. Figures 3.8 and 3.9 provide an overview of the interview times. The figures do not include the full research timeline that included an analysis of the literature leading up to the first interviews, as this analysis was completed over the 20 months leading up to the first interview in October 2015, nor the timeline for the final synthesis and reflection cycle that was completed over the 18 months after the final interview was complete.

Figure 3.8 shows that the interdisciplinary assessment resource was trialled in schools over a period of fourteen months from the Trial stage of Cycle 1 to the Trial stage of Cycle 5. There was a slower lead-in period with the early meetings and drafts, followed by a more intense period of design and re-design between May and November 2016.

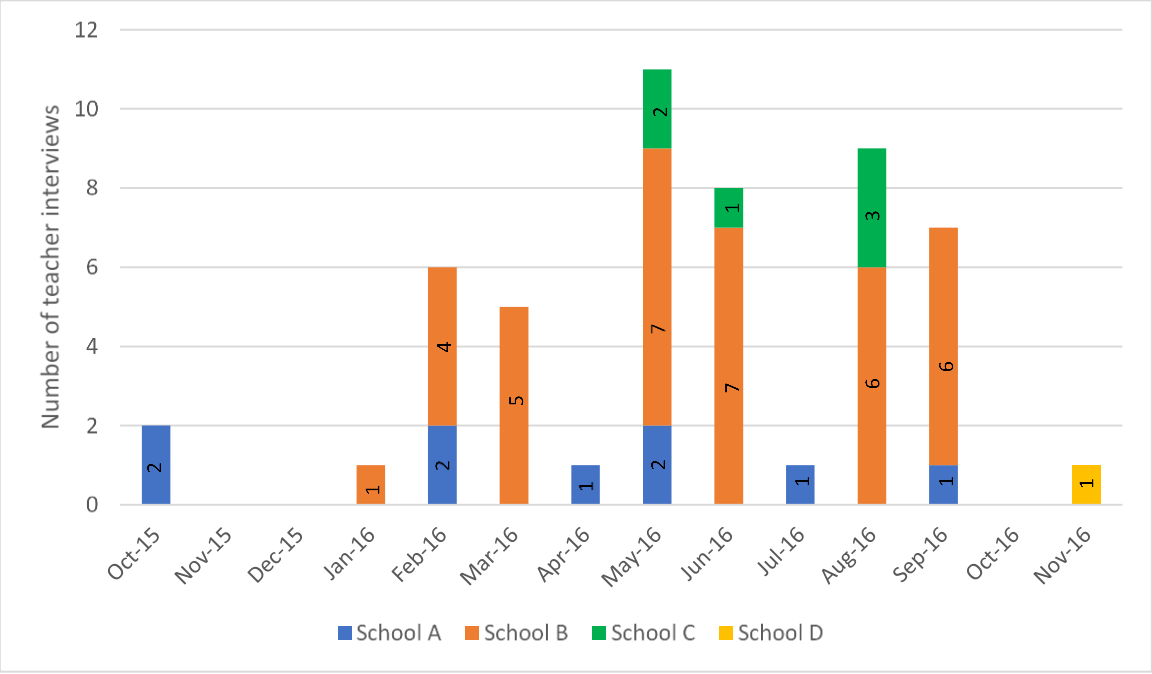

Figure 3.8: Timeline of interviews conducted with teachers

Figure 3.9 shows that teachers from Schools A and B were involved through all development stages. Teachers from School C participated in the questionnaire, but then entered the interview stage later, when the framework had progressed to the second cycle of development (Cycle 3). Even though

School C entered the project at a later stage, data relevant to the needs and context analysis was still collected at their combined Interview 1&2 meetings. The teacher from School D entered in Phase 3, providing the independent critique.

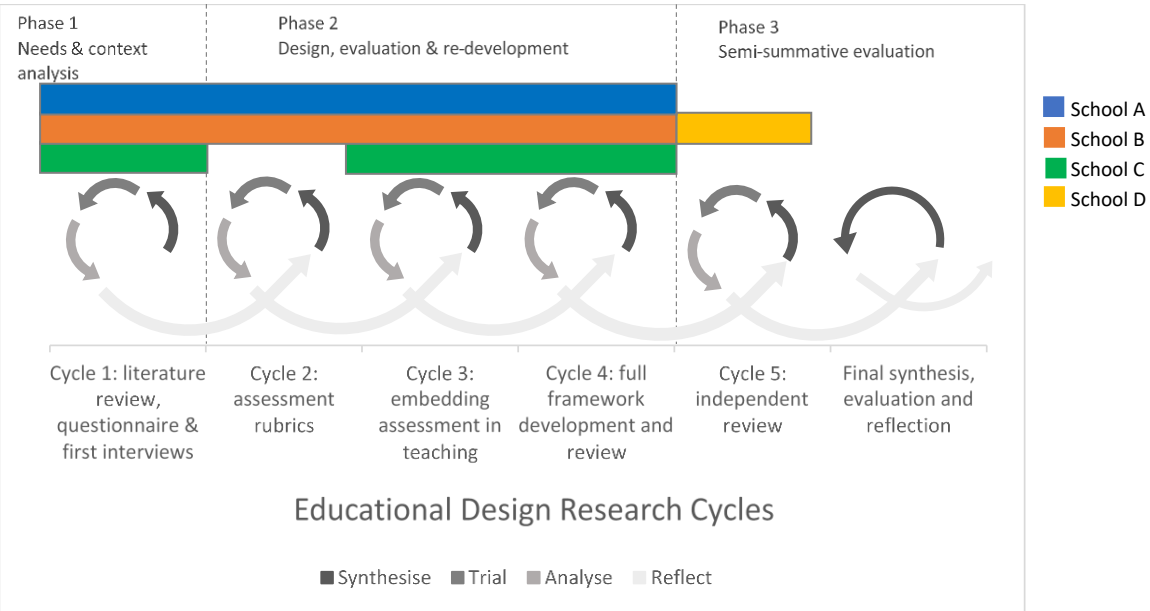

Figure 3.9: Timeline of interviews conducted according to research cycles

Interview analysis

The first step in analysing the interview data was through purposeful transcription by the researcher. Richards (2005) explains that the act of conducting the interview is distracting, since the researcher is usually concentrating on asking the questions as well as ensuring the interview context is conducive to eliciting responses. Researchers are attentive to the interviewee and the interviewee's needs rather than attempting to analyse answers on the spot. This first step of interview transcription by the researcher was therefore a key stage in revising and reflecting upon the interview content, where the researcher gained more detailed knowledge of the content of the interviews.

The interviews were transcribed with a denaturalised approach that, while still transcribing as verbatim as possible, did not intend to depict accents or involuntary vocalisations (Oliver, Serovich, & Mason, 2005, p. 1277). A denaturalised transcription method was appropriate for the interview data as the intended focus was on the substance of the interview rather than conversation style.

Transcription of the interviews was followed by close reading and questioning of the transcripts. This involved reading through the texts, noticing interesting elements, questioning why they were interesting and how these elements were relevant to the research (Richards, 2005). In the context of this research, close reading and questioning sought explicit and implicit feedback on the prototype framework being used and examples of how it could, or could not, be applied to teaching practice. This process sought to identify feedback on the rigour, accessibility and usefulness of the framework (Figure 3.7).

The questioning of the transcripts led naturally to an open coding process (Richards, 2005; Silverman, 2006). This coding style retained the original data but categorised the data into a system that facilitated its application to addressing the research question and informed the next design cycle of assessment framework development.

Data from the interview transcripts was coded as shown in Tables 3.4 and 3.5 and was assigned 'framework' or 'context' themes. The framework themes – rigorous, enabling and accessible – came directly from the research question and were further aligned with the interview framing questions (Figure 3.7) and the criteria for high quality Educational Design Research interventions – content validity, construct validity and practicality (Nieveen, 1999). A fourth theme, 'additional feedback' was created to capture any data that was relevant feedback but did not fit under the other three themes.

Table 3.4: Framework themes for interview analysis

Framework Theme	**Description**
Rigorous (content validity)	Feedback is directed to how the draft assessment framework aligns with quality interdisciplinary learning, as presented in the analysed literature
Accessible (construct validity)	Feedback indicates the extent to which the draft assessment framework is relevant to a school classroom setting, including the perceived conceptual change for teachers and students new to interdisciplinary practice
Enabling (practical)	Feedback is directed to how the draft assessment framework integrates rigour and accessibility to provide teachers with a means to implement interdisciplinary approaches
Additional feedback	Feedback is explicitly directed to the draft assessment framework to generate an improvement or highlight a challenge but does not align with one of the three themes above.

As the data collection progressed, there were further elements in the transcripts that emerged as interesting (Richards, 2005). These elements were identified as contextual enablers and barriers.

Some were directly relevant to interdisciplinary approaches to curriculum and others were relevant to curriculum change in general. While these emergent enablers and barriers were not a primary focus of the research as they were not directly relevant to the development of an assessment framework, they were coded as 'context' themes (Table 3.5), since they illuminated the relevance of the research context and the potential impact of school context on the introduction of an interdisciplinary curriculum. The themes themselves emerged from participants' comments on enablers and barriers to interdisciplinary curriculum.

Table 3.5: Context themes for interview analysis

Context Theme	Description
Conceptual understanding	Transcript records comments on the nature of interdisciplinary teaching and learning and the implications of implementing this in the classroom. Largely used during the needs and context analysis to gain an insight into teachers' understanding of interdisciplinarity.
Context	Transcript records comments that highlight school organisational or professional practices that influenced (or could potentially influence) the implementation of interdisciplinary approaches to curriculum.
Change	Transcript records comments on how a teacher's conceptual understanding of interdisciplinarity or classroom practice has changed or how students' understanding or achievement changed. This included change that was not directly attributable to the research.
Causation	Transcript records comments on how change was directly attributable to the research process. Comments on causation were co-coded with the 'Change' theme if appropriate.
Challenges	Transcript records comments on the challenges to implementation of an interdisciplinary approach. This theme included any perceived or potential challenges. Conceptual and contextual challenges were co-coded as needed.

The interviews were intended to be open and honest in nature as there was no intent or need for the researcher or teacher-interviewees to speak in coded language, euphemism or give hints toward meaning. It must be considered, however, that there were occasions where teachers may have felt uncomfortable giving negative feedback, whether about the feedback tool, the research process or about their own school's practices. Comments given on these occasions were also coded according to the themes in Tables 3.4 and 3.5, rather than attempting to perform a more in-depth discourse analysis by breaking down the language structure to attempt to discover any further or hidden

meaning (Johnstone, 2008, p. 4). This was in keeping with the intent of the interviews to be simply a method of gaining direct access to teachers' experiences and opinions (Silverman, 2006).

Quality and credibility

This research fits clearly into Plomp's (2007, p. 16) definition of an Educational Design Research *development study* and this has implications for determining the quality and credibility of the research. In contrast with a validation study, the research cannot be subjected to questions of empirical validation or causality as the intervention has not yet been tested, only developed to testing stage (Plomp, 2007; Reimann, 2011). Equally, attempts at falsification are not relevant in theory generation, as they are in theory validation (Punch, pp.25-26). For a development study, the researcher can only get data on the *expected* practicality or effectiveness of the intervention (Nieveen, 1999).

There are various indications of quality in the methodological literature. Nieveen (1999, in Plomp, 2007) proposes four criteria to assess quality of Educational Design Research, indicating that these will be observable at different stages of the research:

- relevance or 'content validity', that there is a need for the research;
- consistency or 'construct validity', that the intervention is logically designed;
- practicality, that the intervention is expected to be usable in the proposed settings; and,
- effectiveness, that the intervention is expected to result in the desired outcomes (pp. 29-30)

Each of these criteria for quality are addressed within the Educational Design Research process. Relevance is addressed during the initial needs and context analysis phase; and consistency, practicality and effectiveness during the second and third design/redesign and evaluation phases. Strict adherence to these processes and principles of Educational Design Research is a key method of ensuring quality. Plomp (2007) reiterates that the cyclical nature of Educational Design Research and its repetition of practice over multiple cycles of research contributes to quality outcomes. When the researcher concludes that the intervention is not yet good enough, it must be refined or re-designed; when the conclusion is that the outcomes are close enough to the intended goals, the re-design and refinement can cease and the evaluation stage can begin (Plomp, 2007, p. 33).

Systematic reviews of Educational Design Research are recommended to ensure credibility (Cobb & Gravemeijer, 2008; Pring, 2015). Pring (2015) also points to four indicators of credibility: (1) clear formation of the research question; (2) systematic review of the existing research literature relevant to the question; (3) critical appraisal of this literature; and (4) opening the research methods and findings to critical appraisal (Pring, 2015, p. 169). This final point is particularly justified based on the

Popperian argument that knowledge grows through criticism that encourages error elimination and that research that stands up to critique has stronger credibility and validity (Popper, 1963). Pring's (2015) first three indicators here are addressed in the first phase of the Educational Design Research process, the needs and context analysis. The final indicator is addressed in two ways. Firstly, the product of the research, the interdisciplinary framework, is subjected to criticism throughout the research process from the volunteer teachers involved. Popper (1963, p. vii) argued that by identifying and critiquing the limitations and challenges within the framework, "we become better acquainted with our problem, and able to propose more mature solutions". Secondly, wider criticism of the research can be encouraged post-thesis through a variety of research dissemination pathways.

McKenney and Reeves (2014) indicate various forms of post-research impact as indicators of quality, stating that research using Educational Design Research methodology should be assessed on three elements: impact on practice, contribution to theory and improvement in design or research methodology (p. 137). Each of these elements can be tested post-thesis through publication and the logical next step, a *validation study* (Plomp, 2007).

Clear communication and transparency with regard to each of these quality indicators contribute to research that is credible and trustworthy.

Limitations

While all efforts have been made by the researcher to ensure the research is credible according to the indicators described immediately above, there are limitations to how it can be interpreted and used. Guba and Lincoln (2013) speak of the true-false dualism and how there can be different possible paradigms nesting between true and false, created by choice of epistemologies and methodologies. As researchers, the context and perspectives that have influenced the research need to be clearly explained, so that readers can appreciate the context in which the findings are 'true'.

Truth is a concept that needs to be considered carefully in both constructivist research and Educational Design Research and Crotty (1998) is emphatic that there is no one true or valid interpretation (p. 47). In specific educational contexts there are more variables present than can be controlled and it cannot therefore be claimed that any truth or transferability of principles arises (McKenney & Reeves, 2014; Plomp, 2007). With Educational Design Research particularly, it is accepted that any intervention is integrated into a specific context and, while the outcomes will be helpful, they will not be generalisable (Van den Akker et.al., 2006, in Plomp, 2007).

It is important to be reminded, however, that despite being bound to the original context, findings and interpretations can certainly provide useful, informative and illuminating insights for other practitioners (Crotty, 1998, p. 48; McKenney & Reeves, 2014, p. 138) and make educational theory and research transferable to the classroom and vice versa (Walker, 2011). As Black and colleagues (2003) note in their own research, often findings that are from an authentic classroom practice environment are more useful to schools than those findings that result from artificially controlled situations (pp. 119-120).

This research aimed to develop a practical tool for teachers in the middle and senior years of compulsory schooling, specifically, years 6 to 10. The drafts of the tool were trialled in metropolitan schools within the Australian education system. The research is credible in the context that is was conducted. Feedback and opinions from the volunteer teachers are representative of their truths at the time they were provided. Having said this, it must be noted that other teachers in the same educational context or even the same schools would likely have brought different interpretations and ideas to the research. Equally, the researcher acknowledges the sampling bias of the research in that the teachers who volunteered were enthusiastic supporters of interdisciplinary teaching and learning.

This research does not claim generalisability; however, it does claim that the outcomes will be *helpful* to those accessing it. The research presents an interdisciplinary planning, teaching, learning and assessment framework, developed, trialled and re-developed in an authentic professional educational environment. It is the outcomes of this development that those who access the research might find helpful and it is in this spirit that the research is communicated.

Ethics considerations

To recruit and collaborate with teachers on this research, it was necessary to gain ethics approval from the Flinders University Social and Behavioural Research Ethics Committee, as well as from the Department for Education and Child Development (DECD) and Catholic Education South Australia (CESA). Key ethical considerations within the research included ensuring that teachers were approached with full and prior permission of their principal and that teachers participated voluntarily and felt no coercion at any stage.

Potential schools were identified through a generalised internet search. Principals of schools identified as International Baccalaureate Middle Years Programme schools and schools that self-identified as offering an interdisciplinary curriculum were approached via email to gain permission to distribute the online questionnaire to staff. Research information and the questionnaire link were to

be distributed to teachers by a school staff member nominated by the principal, so that the researcher would not gain unnecessary access to teacher email addresses.

If teachers followed the online questionnaire link, the first question confirmed their consent to participate in the questionnaire. The final question asked whether the teachers would be interested in participating in the trial of the interdisciplinary assessment framework. It was only at this point that, if volunteering to participate in the trial, teachers would provide an email address to the researcher. If teachers did not volunteer to participate further, their questionnaire responses remained anonymous and no contact information was exchanged.

Upon meeting with volunteer teachers for the first time, the researcher explained the parameters of the research, confirmed that participants were willing to be audio recorded during interviews and asked the teachers to sign a consent form (Appendix C). The researcher also confirmed that participation in the research would be confidential, that teachers were at liberty to add to, modify or retract their contributions and that they could withdraw their participation at any stage.

Meetings with volunteer teachers were held at their schools, at their convenience. These meetings were audio recorded and transcribed by the researcher. Participants were provided with transcripts of the meetings and reminded that they were at liberty to add to, modify or retract any of their comments as they wished. At the point of transcription, all comments were de-identified and both teachers and their schools were assigned pseudonyms.

While students were not directly involved in the research, on occasion, student work was used to illustrate or exemplify an element of interdisciplinary learning or assessment by a teacher. Any such work collected by the researcher was de-identified.

Throughout the research process, volunteer teachers were kept informed of the research goals and ongoing progression of the assessment framework being trialled. This ranged from provision of an information sheet (Appendix D) at the earliest stage, through to revised versions of the framework for discussion and overall research summaries.

Chapter Three: Summary

Chapter Three described the methodology, the adapted research process and the methodological choices within this process that would contribute to the development of an educational intervention. The chapter provided a snapshot of the volunteer teachers who gave their time to provide feedback to the developing interdisciplinary resource. Chapter Three also considered the limitations, delimitations, quality control and ethical considerations applicable to the research.

Cobb and Gravemeijer (2008) reinforce the requirement that Educational Design Research should be replicable. Chapter Three begins the descriptive process that will enable replicability; Chapters Four and Five continue this effort. Chapter Four describes the products – the framework prototypes – generated in each research cycle. Chapter Five describes the data collected in each research cycle based on the working prototype, along with the reasoning that contributed to the evolution of each subsequent prototype.

Chapter 4 – Prototype Synthesis

Chapter Four continues to address the need for research designs to be transparent and replicable (Cobb & Gravemeijer, 2008) so that future researchers may customise the design to their own contexts. This chapter shows the outcomes of the research as enacted through the Educational Design Research process.

The Educational Design Research process has a cyclical design and there are two cycle types in the process. The first is an overarching cycle of 'phases'. Phase 1 is the needs and context analysis, Phase 2 is the design, evaluation and redevelopment and Phase 3 is the semi-summative evaluation. This research used one overarching cycle, moving through Phase 1, Phase 2 and Phase 3 once only. Within this overarching cycle there is the second cycle type, which is a series of design cycles of *Synthesise – Trial – Analyse – Reflect*. This research used five full design cycles, moving through Cycles 1-5 (Figure 4.1). The last stage of each design cycle, *Reflect*, straddled two cycles, completing one cycle and prompting the next *Synthesise* stage. The final cycle in Phase 3 contains only *Synthesise* and *Reflect* components as this was a final evaluation point completed by the researcher and presented in Chapters Six and Seven.

When the overarching Phase cycle and the multiple design cycles were put into practice in this research, even more layers became apparent. The two cycles became even more complex as these cycles were immersed in the interdisciplinary literature and the research context. This is also shown in Figure 4.1, with the pink and blue highlights under the two cycles.

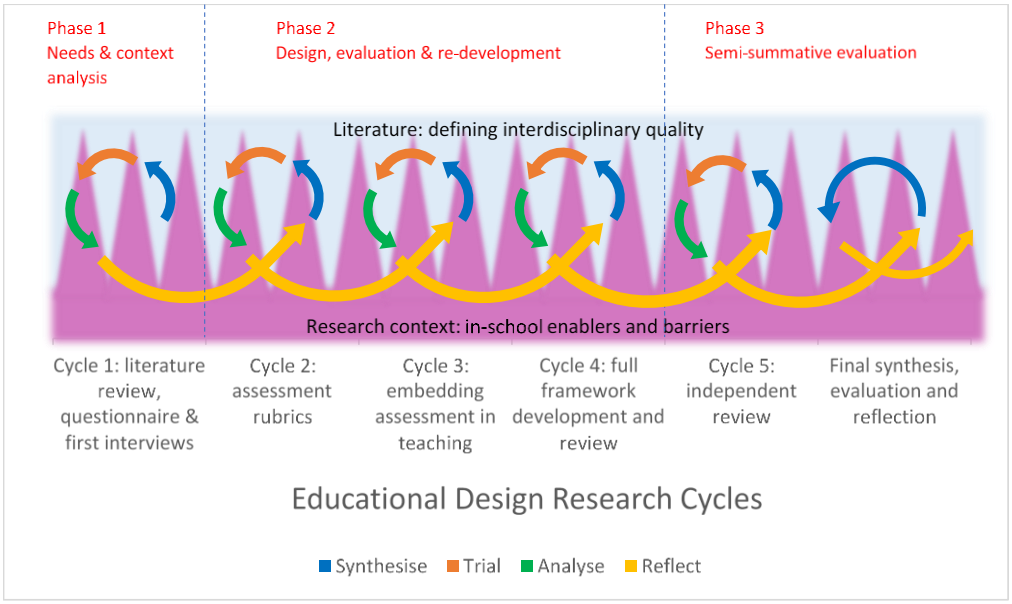

Figure 4.1: Educational Design Research cycle, immersed in the literature and research context

Chapters Four through Seven aim to disaggregate this complexity and present the research outcomes and findings more clearly. Chapter Four, presents the research outcomes – the framework prototypes – across the study, from Cycle 1 through to the end of Cycle 5. The data that emerged through analysis of these prototypes in each school context are presented in Chapter Five, along with the reasoning that contributed to the development of each subsequent prototype. That is, Chapter Four elaborates on 'what we created' and Chapter Five describes 'what we found' and 'how we used what we found', in order to facilitate replicability. The synthesis of the final prototype is presented in Chapter Six and the final evaluation and reflections are presented in Chapter Seven as part of the research discussion. This organisational style for the research outcomes and findings in this thesis is reflective of the style shown by McKenney (2001), whose design study process was adapted for this research.

Overview of Synthesise stages

This chapter demonstrates the evolution of the interdisciplinary assessment framework by presenting the products generated in each *Synthesise* stage of the design cycles. The *Synthesise* stages began with an extended analysis of the literature review in Cycle 1 that was used as part of the first meetings with schools. It was intended that an ongoing, explicit referral to the reviewed and analysed literature would ensure the intervention was academically rigorous and had content validity (Nieveen, 1999), and this literature ultimately became the "core" of the framework.

The subsequent development and redesign of the framework drafts was led by the researcher, based on the literature review and analysis in Cycle 1 and then based on both this literature review and analysis as well as analysis of the feedback from teachers in Cycles 2-5. These *Synthesise* stages are shown in Figure 4.2. The framework core and the four framework prototypes that developed from this core are shown in the rest of this chapter. The final version of the framework, including discussion of decisions related to its development and design, is presented in Chapter Six.

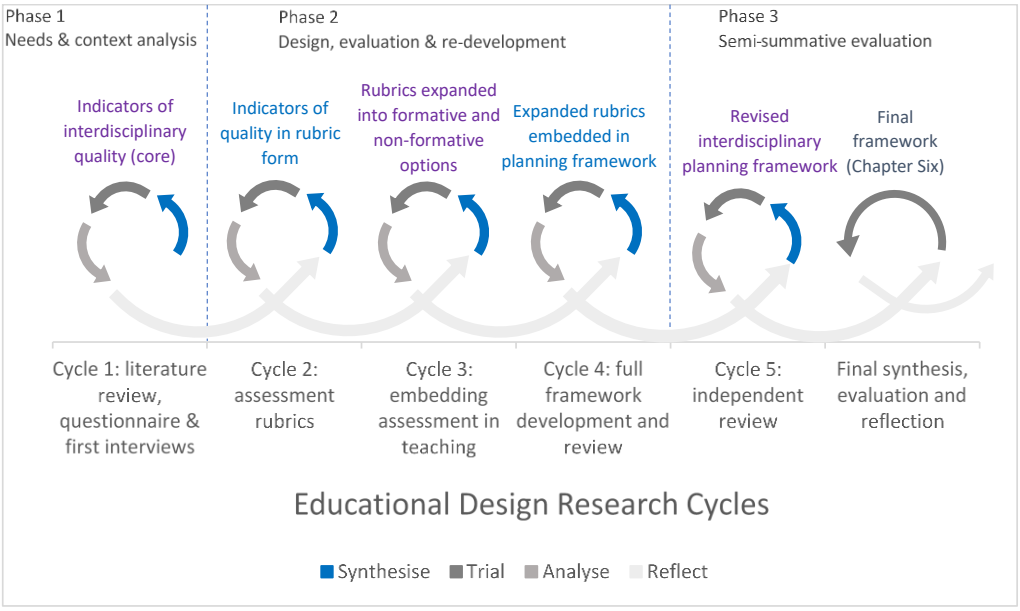

Figure 4.2: Interdisciplinary planning and assessment framework drafts presented in this chapter, an overview

Cycle 1: Literature review and analysis

Phase 1, Cycle 1 of the research involved a literature review, questionnaire and first interviews with teachers, as shown in Figure 4.3. These methods were used to validate the premise that specific guidance for interdisciplinary assessment was needed in the middle- and high-school context. The Synthesise stage of the design cycle focused on an analysis of the literature reviewed in Chapter Two.

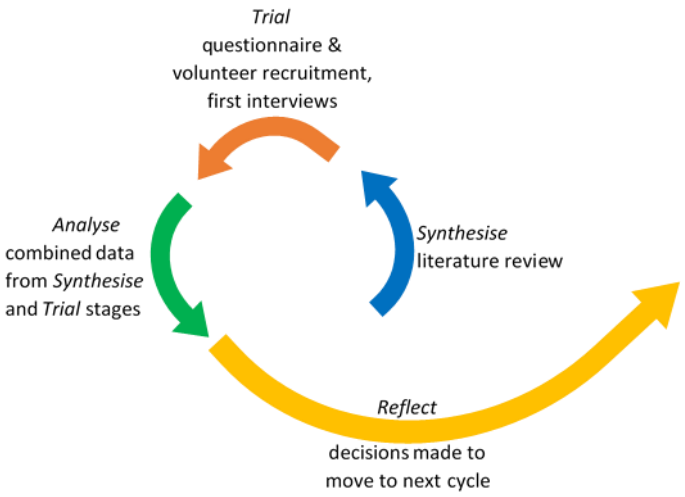

Figure 4.3: Phase 1, Cycle 1 design cycle

The literature review was conducted first, for two reasons. The first reason was to investigate the perception that there was little practical guidance for teachers who wish to implement interdisciplinary teaching and learning in their school or individual classroom. This perception was supported in the Literature Review chapter, which argued that while there was some practical guidance in the existing literature, none of it gave teachers a complete tool, from planning through to completion of a course of work, that was aligned with what was considered good practice (Table 2.4). Despite the absence of a complete tool, the second reason for reviewing the literature at the very beginning was to collate the existing guidance towards quality interdisciplinary classroom approaches so that this could potentially be used to synthesise a complete tool. It was intended to take this literature analysis to the first interview meetings with teachers to generate discussion on whether the reviewed and analysed literature, in principle, was transferable to a school classroom context.

The strengths and limitations highlighted in the literature review provided positive grounding to begin the generation of an interdisciplinary assessment tool and were used to guide the first prototype of the interdisciplinary framework core. Clear indicators or themes for interdisciplinary quality that emerged from the literature review included 1) the importance of disciplinary grounding

as a base for interdisciplinary exploration, 2) the need to deliberately and clearly integrate disciplinary components, 3) the need for academic processing skills in order to manage disciplinary integration and 4) the identification of an advancement of knowledge or understanding, or a product or a solution, that could not have occurred through single disciplinary means. These indicators of quality are drawn from Table 2.3 and collated according to the emergent themes, as shown in Table 4.1. The indicators of quality in Table 4.1 are also referred to as the *analysed literature* in the remainder of this thesis.

Table 4.1: Indicators of interdisciplinary quality, according to the reviewed literature (Table 2.3)

Interdisciplinary Quality Indicators	As stated in the literature	Researchers/ Practitioners[15]
Disciplinary grounding	• *Disciplinary concepts are significant*	• Martin-Kniep, Feige and Soodak (1995)
	• *Work is grounded in the disciplines*	• Boix Mansilla and Gardner (2003); Wolfe and Haynes (2003); Boix Mansilla (2005, 2012b); Boix Mansilla, Duraisingh, Wolfe and Haynes (2009); IBO (2017a); Repko and Szostak (Repko & Szostak, 2017)
	• *Subject matter, content, target disciplines, enduring subject and content learning*	• Boix Mansilla, Miller and Gardner (2000); Drake (2007); Fogarty and Pete (2009); SACE Board of SA (2011a, 2011b); Drake and Reid (2017)
	• *Recognition of distinct ways of knowing*	• Lattuca, Knight and Bergom (2013)
	• *Mastering and critiquing disciplinarity*	• Huutoniemi (2012)
Integration of disciplinary components	• *Synthesising*	• IBO (2017a)
	• *Integration of disciplinary perspectives enables a more comprehensive explanation, contextualisation, solution, model*	• Clarke and Agne (1997); Boix Mansilla, Miller and Gardner (2000); Boix Mansilla and Gardner (2003); Wolfe and Haynes (2003); Boix Mansilla (2005, 2012b); Boix Mansilla, Duraisingh, Wolfe and Haynes (2009); Huutoniemi (2012); Lattuca, Knight and Bergom (2013); Vasquez, Sneider and Comer (2013)
Academic processing skills	• *Articulate, analyse, acknowledge, formulate, synthesise, evaluate*	• Krovetz, Casterson, McKowen and Willis (1993); SACE Board of South Australia (2011a, 2011b)
	• *Communication, challenge to invent*	• Clarke and Agne (1997)
	• *Organisation, problem solving, decision making, creative ideation, critical argumentation, communicating, reflecting*	• Wolfe and Haynes (2003); Drake (2007); Fogarty and Pete (2009); Lattuca, Knight and Bergom (2013) Vasquez, Sneider and Comer (2013); Drake and Reid (2017); IBO (2017a); Repko and Szostak (2017)
Advancement (of knowledge, understanding, skills, or of a product or solution)	• *Student growth*	• Clarke and Agne (1997)
	• *Advancement of understanding and inquiry*	• Boix Mansilla and Gardner (2003); Boix Mansilla (2005)
	• *Serendipities, unexpected results examined for value, improved insight or explanation; usefulness of this new insight*	• Fogarty and Pete (2009); Szostak (2009), Newell (2007), Tress et al. (2006), all cited in Repko and Szostak (2017)
	• *Critical stance, measured against purpose, disciplinary evidence & integration; understanding is provisional*	• Wolfe and Haynes (Wolfe & Haynes, 2003); Boix Mansilla (2012b); Boix Mansilla, Duraisingh, Wolfe and Haynes (2009); Lattuca, Knight and Bergom (2013); Vasquez, Sneider and Comer (2013)

[15] This is the final, thesis version of Table 4.1. At the time of first interviews, literature from 2016 and 2017 was not included.

The indicators of interdisciplinary quality were explained and exemplified to different extents within the reviewed literature. The first, disciplinary grounding, was the most straightforward and reflective of current disciplinary practice; the next two, integration and academic processing skills, were described for assessment as far as they could be visualised. Each of these three components had examples of student work or assessment rubrics, though rarely had both. The fourth component, advancement, had some secondary descriptions or analyses of student advancement (Boix Mansilla et al., 2009; Boix Mansilla & Gardner, 2003) however, there were no examples of assessed student work that exemplified this component for a middle school classroom context.

Synthesise framework core

Despite the sporadic nature of corresponding examples of assessment, these four quality-indicator groupings were justified and cross-validated sufficiently in the reviewed literature to indicate that they were important enablers of a complete judgement of interdisciplinary quality. These four indicators were therefore used as the first draft of the interdisciplinary assessment framework core. This first draft of the core was simplified for use in the first interview meetings with volunteer teachers, as shown in Table 4.2. The development of this table completed the Synthesise stage of the first cycle of research.

Table 4.2: Framework core – simplified version of the indicators of interdisciplinary quality

Key purpose and outcome	Purpose in the literature	Researchers/Practitioners
Depth of knowledge	Disciplinary grounding Content knowledge Significance	Boix Mansilla and Gardner (2003); Fogarty and Pete (2009); Martin-Kniep, Feige and Soodak (1995)
Integration	Synthesising Integration Coherence	IBO (2014)[16]; Boix Mansilla and Gardner (2003); Martin-Kniep, Feige and Soodak (1995)
Advancement of ideas	Advancement of understanding Serendipity	Boix Mansilla and Gardner (2003); Fogarty and Pete (2009)
Interdisciplinary skills	Process skills Communication (between disciplines and of ID endeavour) Reflection (critical awareness)	Fogarty and Pete (2009); Clarke and Agne (1996); Tress et al. (2007); IBO (2014)[5], Boix Mansilla et al. (2009);

[16] Referred to in the rest of the thesis as "IBO (2017a)". This simplified first draft of the core of the tool was used in Phase 1 meetings in 2015/16: the current version of the IBO document, was updated with minor changes in 2017.

Cycle 2: Assessment rubrics

Phase 2 of the research involved three distinct cycles of development, Cycles 2, 3 and 4, that used the Educational Design Research cycle of *Synthesise-Trial-Analyse-Reflect* (Figure 4.2). This was the phase of research where the interdisciplinary planning tool or framework was to be developed, trialled, critiqued, reflected upon and then redeveloped to generate an ever-improving framework (Figure 4.4).

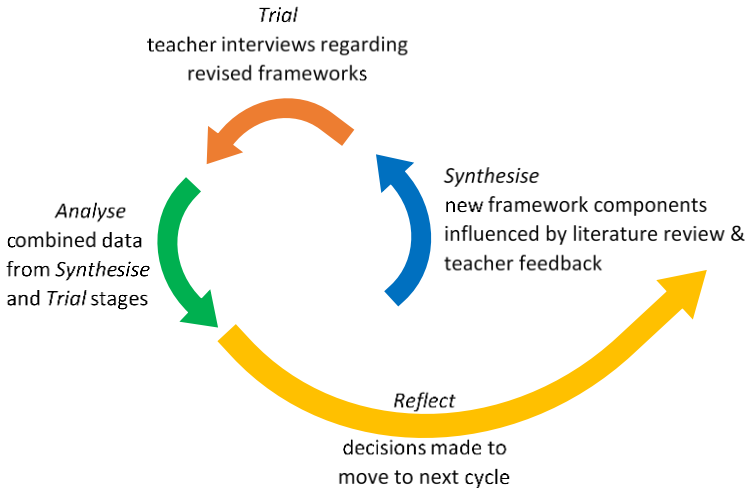

Figure 4.4: Phase 2 design cycles for framework development, used in Cycles 2, 3 and 4

The second design cycle, Cycle 2, involved taking the findings from Phase 1 and transforming these into the beginnings of a classroom tool to be used by teachers. The data gathered from the literature review, the questionnaire and first interview meetings were combined to synthesise a first prototype for interdisciplinary assessment.

The data from the literature review and analysis, questionnaire and first interview meetings in Phase 1 are presented in Chapter Five but are summarised here to provide context to the Cycle 2 synthesis:

- The literature review had identified a scarcity of examples of quality assessment practice. There were very few examples of assessment rubrics and, where there were examples, they were not aligned with the interdisciplinary planning, teaching and learning literature.
- The literature review analysis identified quality indicators for interdisciplinary planning teaching and learning that could be used in a classroom context. These indicators were disciplinary grounding, integration of the disciplinary components, academic processing skills and students' advancement of understanding that is greater than what would be expected in a disciplinary context. During the first interview meetings, it was identified that the integration of disciplinary components is an academic processing skill and it was suggested that these be combined into the same category, resulting in three indicators of quality rather

than four (Table 4.3). The third indicator was abbreviated to 'Advancement of understanding', with the intent to keep the extended meaning.

- The questionnaire confirmed that teachers were seeking improvement in their interdisciplinary planning and assessment practices.
- The first interview meetings confirmed the literature review findings, with teachers agreeing that the quality indicators would indeed assist with quality classroom practice.

Table 4.3: Revised indicators of interdisciplinary quality

First draft of indicators (Tables 4.1 and 4.2)		Revised indicators
Disciplinary grounding/Depth of knowledge	→	Disciplinary grounding
Integration of disciplinary components	↘	Integration and process skills
Interdisciplinary and academic processing skills	↗	
Advancement of knowledge, understanding, skills, ideas, or of a product or solution	→	Advancement of understanding

Given these findings, it was proposed that the first step in developing an interdisciplinary planning, teaching and learning tool be the development of some assessment rubrics that were *directly* aligned with the quality indicators from the analysed literature. These assessment rubrics were to be developed through the lens of quality assessment and rubric-development practice, as identified in *Section two* of the literature review.

Synthesise assessment rubrics

The first step in designing the assessment rubrics was to collate the main ideas from the analysed literature, the quality indicators, as well as from the questionnaire and first interviews. These were developed directly into assessment rubrics that described quality in interdisciplinary practice, positioned against some notional achievement levels. This collation and development of the rubrics was completed by the researcher, with the intention to trial the rubrics with the volunteer teachers in the Trial stage of Cycle 2. This first assessment rubric design is shown in Figure 4.5.

The key element that helped generate this first design was that the assessment rubrics should directly align with the indicators of quality as described in the analysed literature (Table 4.1): disciplinary grounding, integration and academic processing skills and a synergistic advancement.

Disciplinary objectives

Students show achievement of the disciplinary objectives as defined by their local curriculum (Australian Curriculum, MYP, SACE, school-based disciplinary assessment)

Level	Description
X	
X	
X	
X	

Level	Description
X	
X	
X	
X	

Level	Description
X	
X	
X	
X	

Integration and process skills

Students show the ability to blend relevant disciplinary knowledge, concepts and skills in innovative ways to address the situation presented.

Description Students blend relevant disciplinary knowledge/concepts/skills in innovative ways. They show:	**Level** (A, B, C, D)	**When assessed?** (start, mid, end, throughout?)
• how disciplines intertwine and support each other		
• an ability to communicate between disciplines to generate mutual understanding of the situation presented and enable a solution/product		
• an ability to reflect upon and analyse the disciplinary combination		
• creativity in combining the disciplines		

A=exceptional, B=above expectations, C=achieved to minimum standard, D=progressing towards minimum

Advancement of understanding

Students show an advancement of knowledge that could not have been achieved through an isolated discipline

Description Students demonstrate an advancement of knowledge/concepts/skills that could not have been achieved through an isolated discipline. They show:	**Level** (A, B, C, D)	**When assessed?** (start, mid, end, throughout?)
• a quantitative or qualitative advancement of knowledge/concepts/skills from an integrated context. Advancement may be reflected in innovation, creativity and/or perceptive analysis.		
• elements of synergy: advancements that arise from skilful integration of disciplines		
• elements of serendipity: unexpected advancements that arise from skilful integration of disciplines		
• the ability to reflect upon and evaluate their own advancement of knowledge/concepts/skills from an integrated context		

A=exceptional, B=above expectations, C=achieved to minimum standard, D=progressing towards minimum

Figure 4.5: Cycle 2, first interdisciplinary assessment rubric draft

Cycle 3: Embedding assessment in teaching

Within Phase 2, the next cycle of development involved utilising the feedback, decisions and reflections from Cycle 2 to improve and extend the first draft of the assessment rubrics. The Synthesis stage of Cycle 3 (Figure 4.4), therefore, uses cumulative data gathered from Cycle 2, as well as from the literature review and analysis, the questionnaire and first interview meetings in Cycle 1.

The findings from Cycle 2 of the assessment tool development are presented in Chapter Five, however, are summarised here to give context to the Cycle 3 Synthesis. Findings indicated that the next draft should continue to include the three indicators of interdisciplinary quality from the analysed literature. Suggested additions or improvements included that there should be clarifications regarding the term "advancement", an expansion of the assessment rubrics to contain greater detail and practical guidance on when to assess and who carries out the assessment. These suggestions were addressed in the development of the next draft of the assessment tool, as presented in Table 4.4 and Figures 4.6 and 4.7.

The first step taken was to address the practical questions of 'when' assessment occurs and 'who' conducts the assessment. To answer these, it was necessary to refer to classroom assessment literature for guidance (reviewed in Chapter Two), since the answers would be highly dependent on the assessment purpose. That is, whether the intention is for assessment *of*, *for*, or *as* learning (for example, Earl, 2014) and whether the assessment will ultimately define (Rowntree, 1987) the interdisciplinary curriculum being implemented.

The definitional importance of assessment was a broader curriculum issue in the context of this research, rather than a practical one. With the act of creation of an assessment tool comes an underlying assumption that teachers wish to assess. Teachers, therefore, need to be aware that by committing to an assessment process they are influencing their curriculum (Rowntree, 1987). It was noted at this stage that while the definitional importance of assessment needs to form the part of the conceptual understanding of and background to an assessment tool, it is not directly involved in its practical creation.

This left the question of whether the proposed assessment would be *for*, *of*, or *as* learning (Earl, 2014), namely, formative, summative or self-/peer-assessment respectively. These assessment types cleaved neatly into two practical categories at this stage, assessment that requires grades and assessment that does not. Formative, self- and peer-assessment processes are heavily oriented towards feedback that helps improve learning (for example, Black et al., 2003; Black & Wiliam, 2010;

Earl, 2006; Hattie, 2012; Hattie & Timperley, 2007) and are not dependent on a final grade, or necessarily any grade at all, whereas the purpose of summative assessment is to provide a final judgement on learning (Earl, 2006; Wilson & Murdoch, 2006). Despite this, it was acknowledged that both these forms of assessment are often used to support each other over a course of learning. To develop the assessment tool further at this stage, it was therefore decided to create two options for assessment: a formative option (that would also be used for self- and peer-assessment) and a summative option.

The remainder of the suggestions from Cycle 2 related to content or explanatory depth in the assessment tool and would fit within both assessment options. Maintaining the three indicators of quality and including more explanatory detail within the rubrics themselves, particularly greater clarity with the intention of "advancement", would therefore be inserted in both.

Synthesise assessment for the classroom

These two assessment options, a formative and a summative, were identified and explained briefly in Table 4.4 below. This table was used in the Cycle 3 interviews to guide conversations around the new draft assessment tool. It summarised both new assessment rubric options and showed teachers that firstly, the indicators of quality had been maintained and secondly, there were slightly different considerations for planning, teaching and learning, depending on whether teachers and students required a final grade. In this table, "D" indicates a discipline, "I&PS" indicates *Integration and Process Skills* and "Synergy" was used as a synonym for *Advancement*. Text in red indicated the difference between the two options.

Table 4.4: Two-way assessment option

Grades not required	**Grades required**
1. Elements for assessment (disciplinary + interdisciplinary skills) identified e.g.: D1 + D2 + (D3) + I&PS + Synergy English + Science + I&PS + Synergy	1. Elements for assessment (disciplinary + interdisciplinary skills) identified e.g.: D1 + D2 + (D3) + I&PS + Synergy Math + Lang2 + Design + I&PS + Synergy
2. Teachers monitor elements to: • Inform task design • Enable task • Provide formative feedback • Review for future use	2. Teachers use elements to: • Inform task design • Enable task • Provide formative feedback • Develop into task-specific assessment rubrics • Review for future use
Elements identified (D, I&PS, Synergy) are explained in the rubrics but not elaborated as a grading rubric.	Elements identified and shown as full rubrics for summative assessment

The expanded rubrics for the two assessment options are shown in Figures 4.6 and 4.7. Figure 4.6 shows the first assessment option, for situations where a grade is deemed unnecessary. The draft rubrics for this assessment option build directly upon the first draft assessment rubrics created in Cycle 2. The rubrics further expanded and developed the descriptions of the understandings and skills that students could develop in an interdisciplinary endeavour, attempting to make these elements clearer and identify what they might look like in the classroom. In the right-hand column, teachers are prompted to identify when the assessment(s) might take place, with the option to identify multiple occasions.

Figure 4.7 shows the rubrics for the second assessment option, for situations where a grade is deemed necessary. This option builds on the first assessment option, Figure 4.6, as this was the most recently improved version, rather than directly from the Cycle 2 rubric draft. In Figure 4.7, the descriptions of understandings and skills that students will develop in an interdisciplinary endeavour have been summarised at the beginning of the rubrics. How well students display these understandings or skills is then elaborated in an ascending scale. In addition to prompting teachers to identify when the assessment(s) might take place, there is also a column where teachers may insert a level or grading system that matches that of their school.

To synthesise the rubrics, it was necessary to refer to the literature on effective assessment practice. The taxonomies of Biggs (Biggs & Collis, 1982) and Bloom (Krathwohl, 2002) provided guiding frameworks to describe learning and its subsequent assessment. Bloom's revised taxonomy provided a common language and structure to identify learning goals according to the cognitive domain (Krathwohl, 2002). Biggs' SOLO taxonomy provided a structure to articulate levels of cognitive attainment in the context of increased abstraction and complexity of learning and standards of performance within rubrics (Biggs & Collis, 1982).

Literature on interdisciplinary assessment, specifically that describing indicators of interdisciplinary quality as presented in Table 4.1, was used to generate the performance attributes in the assessment rubrics. The same literature helped to elaborate and explain what was meant by each indicator of quality and these elaborations became the descriptions of understandings and skills that students might develop.

The performance attributes were then combined with principles for quality rubric construction to develop the draft assessment rubrics. Important principles taken from the reviewed assessment literature (Chapter Two) at this stage included ensuring consistency of the performance attributes, which in the context of this research translated to consistency in the indicators of interdisciplinary quality and consistency in the increasing complexity of the performance descriptors for summative assessment (Andrade, 2000; Biggs & Collis, 1982; Tierney & Simon, 2004; Wiggins, 1998). It was also important to heed the cautions regarding rubric design, including questions of validity and reliability (Jonsson & Svingby, 2007; Wenzlaff et al., 1999) and the limitations of rubrics themselves (Kohn, 2006; Popham, 1997).

In Cycle 3, the performance attributes (the elaborated indicators of interdisciplinary quality) were checked against the increasing levels of the cognitive domain according to Bloom's revised taxonomy (Krathwohl, 2002). Each performance level gives students the opportunity to display increasing abilities in complexity and abstraction (Biggs & Collis, 1982). In this draft, the performance levels were summarised as number, letter, one-word description, or face grades, to indicate that teachers would insert their own school's grading convention in these boxes.

The draft assessment rubrics synthesised in Cycle 3 are shown here in Figures 4.6 and 4.7.

Grades not required

Disciplinary objectives

Students show achievement of the disciplinary objectives as defined by their local curriculum (Australian Curriculum, MYP, SACE, school-based disciplinary assessment)

Level	Description
X	
X	
X	
X	

Level	Description
X	
X	
X	
X	

Level	Description
X	
X	
X	
X	

Integration and process skills

Students show the ability to blend relevant disciplinary knowledge, concepts and skills in innovative ways to address the situation presented.

Description Students blend relevant disciplinary knowledge/concepts/skills in innovative ways. They show:	**When assessed?** (start, mid, end, throughout?)
• understanding of the interplay between disciplines - how disciplines integrate in order to support/contradict each other (do they interlock, intertwine, blend, build upon?)	
• an ability to communicate between disciplines to generate mutual understanding of the situation presented and enable a solution/product (including the use of an interdisciplinary vocabulary)	
• an ability to reflect upon and analyse the disciplinary combination (particularly if disciplines are contradictory in any sense): how do the disciplines illuminate the issue/problem/challenge?	
• creativity in choosing and combining the disciplines	

Synergy

Students show an advancement of knowledge, understanding, skills or attitudes that could not have been achieved through a single discipline

Description Students demonstrate an advancement of knowledge/concepts/skills/attitudes that could not have been achieved through a single discipline. They show:	**When assessed?** (start, mid, end, throughout?)
• a quantitative or qualitative advancement of knowledge/concepts/skills/attitudes in an integrated context. Advancement may be reflected in innovation, creativity and/or perceptive analysis.	
• elements of synergy or serendipity: deliberate or unexpected advancements that arise from skilful integration of disciplines	
• the ability to reflect upon and evaluate their own advancement of knowledge/concepts/skills from an integrated context	

Figure 4.6: Cycle 3 interdisciplinary assessment rubric draft – no grades

Grades required

Disciplinary objectives

Students show achievement of the disciplinary objectives as defined by their local curriculum (Australian Curriculum, MYP, SACE, school-based disciplinary assessment)

Level	Description
X	
X	
X	
X	

Level	Description
X	
X	
X	
X	

Level	Description
X	
X	
X	
X	

Integration and process skills

Students show the ability to blend relevant disciplinary knowledge, concepts and skills in innovative ways to address the situation presented. They show:

- understanding of the interplay between disciplines - how disciplines integrate in order to support/contradict each other – do they interlock, intertwine, blend, build upon?
- an ability to communicate between disciplines to generate mutual understanding of the situation presented and enable a solution/product (including the use of an interdisciplinary vocabulary)
- an ability to reflect upon and analyse the disciplinary combination (particularly if disciplines are contradictory in any sense): how do the disciplines illuminate the issue/problem/challenge?
- creativity in choosing and combining the disciplines

Description **The student shows:**	**Level, grade, etc** (align with disciplinary style)	**When assessed?** (start, mid, end, throughout?)
Limited understanding of the interplay between disciplines **Limited** ability to communicate between disciplines **Limited** reflection on and analysis of the disciplinary combination and how it illuminates the issue/problem/challenge **Shows limited** creativity in choosing and combining disciplines	1-2 D Beginning ☹	
Some understanding of the interplay between disciplines. **Some** ability to communicate between disciplines **Some** reflection on and analysis of the disciplinary combination and how it illuminates the issue/problem/challenge **With support, shows** creativity in choosing and combining disciplines	3-4 C Improving 😐	
Good understanding of the interplay between disciplines. **Requisite** ability to communicate between disciplines **Adequate** reflection on and analysis of the disciplinary combination and how it illuminates the issue/problem/challenge **With little support, shows** creativity in choosing and combining disciplines	5-6 B Meeting ☺	
Thorough, detailed understanding of the interplay between disciplines. **Sophisticated** ability to communicate between disciplines **Deep** reflection on and **thorough** analysis of the disciplinary combination and how it illuminates the issue/problem/challenge **Shows** creativity in choosing and combining disciplines	7-8 A Exceeding ☺☺	Mid Mid, end Throughout Start

Figure 4.7: Cycle 3 interdisciplinary assessment rubric draft – with grades (1 of 2)

Synergy

Students show an advancement of knowledge, understanding, skills or attitudes that could not have been achieved through a single discipline. They show:

- a quantitative or qualitative advancement of knowledge/concepts/skills/attitudes (KCSA) in an integrated context. Advancement may be reflected in innovation, creativity and/or perceptive analysis
- elements of synergy or serendipity: deliberate or unexpected advancements that arise from skilful integration of disciplines
- the ability to reflect upon and evaluate their own advancement of knowledge/concepts/skills/attitudes (KCSA) from an integrated context

Description The student shows:	**Level, grade, etc** (align with disciplinary style)	**When assessed?** (start, mid, end, throughout?)
Limited or no advancement of KCSA in an integrated context **Limited or no** elements of synergy or serendipity **Limited** ability to reflect upon their own advancement of KCSA	1-2 D Beginning ☹	
Supported advancement of KCSA in an integrated context **Limited** elements of synergy or serendipity, due to support **Some** ability to reflect upon their own advancement of KCSA	3-4 C Improving 😐	
Some advancement of KCSA in an integrated context **Some** elements of synergy or serendipity **Requisite** ability to reflect upon their own advancement of KCSA	5-6 B Meeting ☺	
Clear advancement of KCSA in an integrated context **Clear** elements of synergy or serendipity **Sophisticated** ability to reflect upon their own advancement of KCSA	7-8 A Exceeding ☺☺	Throughout End Throughout

Figure 4.7: continued (2 of 2)

Cycle 4: Full framework development

Within Phase 2 (Figure 4.2), the final cycle of development involved taking the cumulative feedback, decisions and reflections from earlier cycles and using these to both improve the draft assessment rubrics themselves and embed them within a planning, teaching and learning cycle. Cycle 4 (Figure 4.4) therefore used cumulative data gathered from Phase 2 Cycles 2 and 3, as well as from the literature review and analysis, questionnaire and first interview meetings in Phase 1.

Findings from Cycle 3 of the assessment tool development are presented in Chapter Five but summarised here to give context to the Cycle 4 Synthesise stage. The findings continued to indicate that the next draft should include the three indicators of quality from the analysed literature. Further suggestions from teachers indicated that there should be:

- Further elaboration of the indicator 'synergy', not only within the assessment tool itself but in a format that gives broader guidance and supports teachers in using the tool
- Increased clarity and elaboration of the practicalities of assessing interdisciplinary learning, including guidance on how many descriptors to use in any one assessment, at what stage of learning and by whom should the descriptors be used, what the levels of quality look like and ensuring that the assessment system is easily compatible with existing school systems
- Consideration of timetabling restrictions and lesson time allocated to individual subjects

It was decided that to incorporate the suggestions above, the assessment tool would be embedded within an interdisciplinary pedagogical cycle to show what assessment might look like and how it would support each element of planning, teaching, learning and reflection. The framework could then be made adaptable to school-specific curriculums at the end of the research period.

These suggestions and decisions were addressed and incorporated into the development of the next draft of the assessment tool. This was the first time the tool appeared as assessment embedded within a full interdisciplinary planning, teaching and learning cycle. This draft is presented in Figure 4.8.

Synthesise full framework

The first step in creating a draft of a full interdisciplinary planning, teaching, learning and assessment framework was to return to the reviewed literature for guidance. Fortunately, as seen in the literature review chapter, there is already significant guidance on what planning, teaching and learning in an interdisciplinary context in schools might look like. Therefore, to create a new framework that was supported by the new assessment tool it was necessary to organise the published guidance into a format that would be useful for teachers.

The organisation of this guidance was driven by two key questions:

- What are the stages for planning and implementing an interdisciplinary endeavour, and,
- How can it be ensured that the interdisciplinary indicators of quality are present in all of these stages?

The first question here has been answered in the literature review via Vasquez, Sneider and Comer (2013), Repko, Szostak and Buchberger (2014) and the International Baccalaureate (IBO, 2017a), who all provide guidance in planning a sequence of interdisciplinary learning (presented in Table 2.1). The commonalities across their ideas include that:

- Planning starts with the overall intention, therefore the guiding purpose, research problem and/or intended outcomes of an interdisciplinary endeavour must be identified at the very beginning. This was interpreted as 'informing' the task design.
- When the overall intention has been identified, the smaller details that support the achievement of this intention can be identified. Identification of which disciplines will contribute and to what extent, what disciplinary objectives or standards will be met, how disciplines might be integrated, and what academic processing skills students might need are all necessary. This was interpreted as 'informing' and 'enabling' the task.
- When the smaller details that support the intended outcomes have been identified, the actual teaching and learning experiences can be identified and planned. This notion was also interpreted as 'enabling' the task.
- The teaching and learning experiences are formatively assessed to guide improvement and summatively assessed where needed. This was summarised as 'formative feedback' and 'summative assessment' and represented by the assessment rubrics developed in Cycles 2 and 3.
- When the overall intention has been achieved, reflection on the planning, teaching and learning process is needed to understand how the interdisciplinary approach has enhanced understanding and to guide planning for the next time the interdisciplinary endeavour is planned (the IB also encourages reflection before and during the unit of study). This was summarised as 'reflection'.

It was therefore decided to transfer these commonalities into a cyclical planning, teaching and learning framework that would enable teachers to access guidance from the reviewed literature in the one framework. The first draft of this is shown in Figure 4.8. Note that within this first draft, the assessment rubrics had not yet been updated, they were simply transferred from Cycle 3 with the

intent to elaborate them further as soon as possible. The subsequently updated rubrics are shown in Figure 4.9.

The first page of the draft framework shows the overall model for interdisciplinary planning, teaching and learning. This was designed with the reviewed and analysed literature in mind (see Tables 2.3 and 4.1) and placed the three indicators of interdisciplinary quality at the centre of the model. The purple circles, 'interdisciplinary (ID) literature' and 'task-specific rubrics' were identified as external influences on the model but not included in detail in the framework.

The second page elaborates the indicators of interdisciplinary quality further and was taken from the 'no grades' version of the assessment rubrics draft (Figure 4.6) from Cycle 3. It was decided that this portion of the earlier draft would, at this point, give a reasonable explanation of the indicators of quality. The rest of the framework, page by page, was inspired by the guidance shown in Table 2.1 and elaborates what was meant by 'Inform task design', 'Enable task', 'Formative feedback', 'Generic rubrics' and 'Reflection for future tasks'.

Guidance for 'inform task design' was derived from the reviewed literature (particularly that shown in Figure 2.2) and, as such, is cited within the framework. Guidance for 'Enable task', 'Formative feedback' and 'Reflection for future tasks' was inspired by the reviewed literature but newly exemplified in the framework. Giving examples of what these elements might look like in a classroom or asking relevant guiding questions, rather than citing directly from the literature, was intended to make the framework more immediately accessible for teachers. For example, the 'Formative feedback' page exemplifies the need to bridge the gap between where the students are and where they are headed (Black et al., 2003; Black & Wiliam, 2010; Hattie, 2012; Hattie & Timperley, 2007; Sadler, 1989; Wilson & Murdoch, 2006). It was therefore designed with three columns: one indicating the previous step (scaffolding), one indicating the goal (targeted descriptors) and the formative column identifying the type of feedback that might help students bridge the gap.

The 'Generic rubrics' guide the summative assessment and at this stage, were taken directly from the 'with grades' version of the assessment rubrics draft (Figure 4.7) from Cycle 3, with plans to update once the broader framework was in place.

Each of these elements of the draft framework are shown in Figures 4.8 and 4.9.

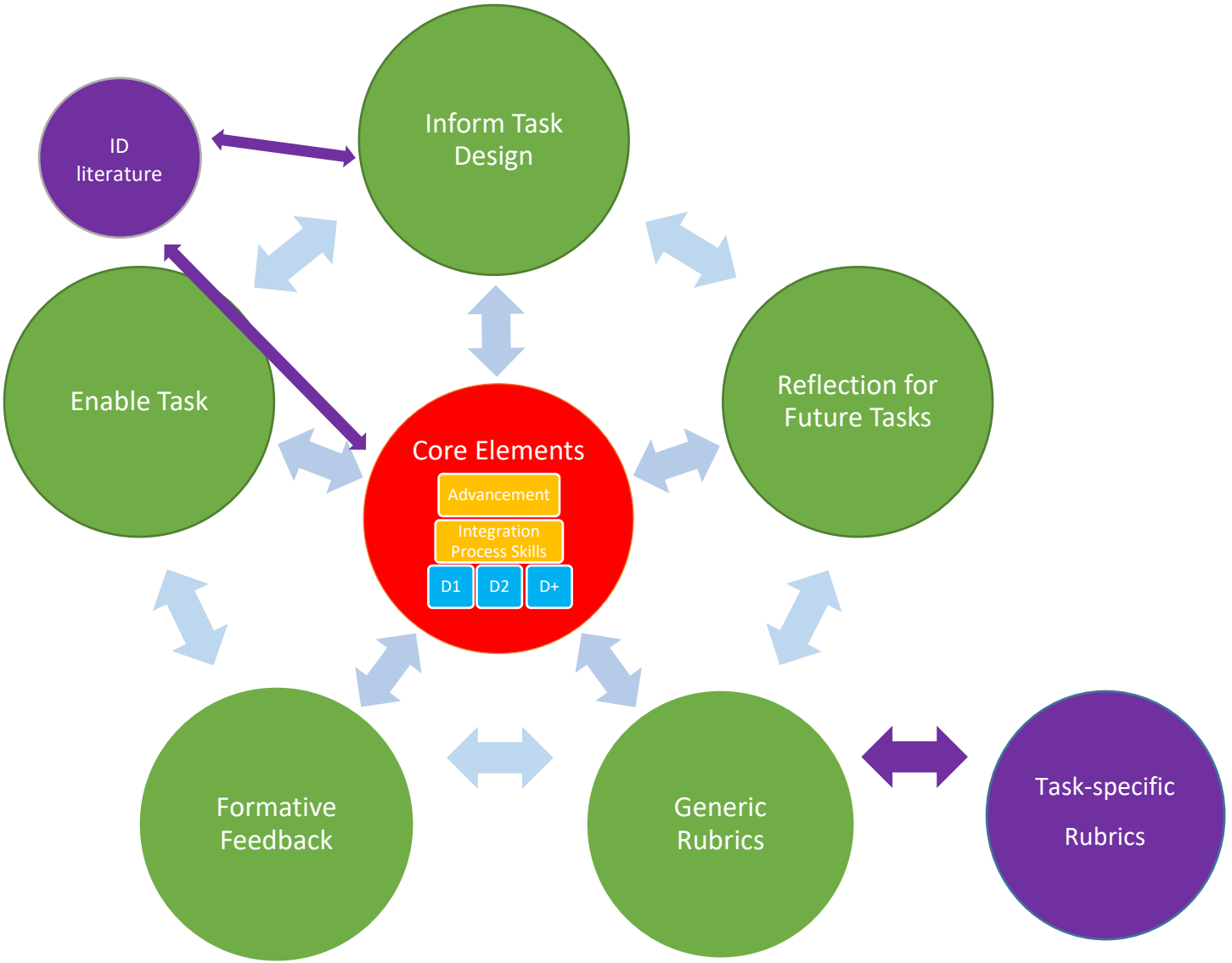

Figure 4.8: Cycle 4, first full draft of interdisciplinary planning, teaching and learning framework (1 of 7)

Core Elements

Disciplinary objectives

Students show achievement of the disciplinary objectives as defined by their local curriculum (Australian Curriculum, MYP, SACE, school-based disciplinary assessment)

Level	Description
X	
X	
X	
X	

Level	Description
X	
X	
X	
X	

Level	Description
X	
X	
X	
X	

Integration and process skills

Students show the ability to blend relevant disciplinary knowledge, concepts and skills in innovative ways to address the situation presented.

Description Students blend relevant disciplinary knowledge/concepts/skills in innovative ways. They show:	**When assessed?** (start, mid, end, throughout?)
• understanding of the interplay between disciplines - how disciplines integrate in order to support/contradict each other (do they interlock, intertwine, blend, build upon?)	
• an ability to communicate between disciplines to generate mutual understanding of the situation presented and enable a solution/product (including the use of an interdisciplinary vocabulary)	
• an ability to reflect upon and analyse the disciplinary combination (particularly if disciplines are contradictory in any sense): how do the disciplines illuminate the issue/problem/challenge?	
• creativity in choosing and combining the disciplines	

Advancement

Students show an advancement of knowledge, understanding, skills or attitudes that could not have been achieved through a single discipline

Description Students demonstrate an advancement of knowledge/concepts/skills/attitudes that could not have been achieved through a single discipline. They show:	**When assessed?** (start, mid, end, throughout?)
• a quantitative or qualitative advancement of knowledge/concepts/skills/attitudes in an integrated context. Advancement may be reflected in innovation, creativity and/or perceptive analysis.	
• elements of synergy or serendipity: deliberate or unexpected advancements that arise from skilful integration of disciplines	
• the ability to reflect upon and evaluate their own advancement of knowledge/concepts/skills from an integrated context	

*This page is directly from the previous draft assessment rubrics

Figure 4.8: continued (2 of 7)

Inform Task Design

How do the core elements influence task design? Disciplinary objectives – integration and process skills – advancement

What is the purpose for interdisciplinarity?

Purpose of the interdisciplinary effort	**Questions for Planning**
Task/Outcome-focused • Will it be an aesthetic or literary synthesis: a symbolic work that can help viewers make sense of complex ideas? (IBO, 2014) • Will it be personal expression: a song/performance or similar that expresses a concept? (IBO, 2014)	What is the purpose of this interdisciplinary unit/task? (Choose one from the column at left) **Core elements** With the purpose in mind: • What disciplinary objectives will be met? What existing disciplinary assessment will this involve? • What integration and process skills* do students need? • What advancement* might happen? *Check the core elements/rubrics for tips
Skill-focused • Will it involve cross-over tooling: use of a skill or concept in multiple disciplines to understand a new issue? (IBO, 2014)	
Knowledge- or Concept-focused • Will it be a complex explanation: combining expertise from multiple disciplines to develop a more complete/complex understanding? (IBO, 2014; Nikitina, 2006) • Will it be a contextualisation: embedding ideas from one discipline into another disciplinary context or into a larger philosophical framework? (IBO, 2014; Nikitina, 2006)	
Problem-focused • Will it be a practical solution: multiple disciplines combine to address a problem and create a product, find a solution, develop an intervention? (IBO, 2014; Nikitina, 2006)	

Figure 4.8: continued (3 of 7)

Enable Task

How do the core elements enable the task?

Core Elements	Questioning	Scaffolding
Disciplinary Objectives	• What do we need to know from the disciplines? • How will we learn this?	• What are the disciplinary objectives? • Where do they come from? • How will the objectives be assessed? And when? • Could we design the task-specific rubric together? • How can the disciplinary objectives be taught/learned? • What activities will the students need to come to grips with these building blocks?
Integration and Process Skills	• How are we going to combine the disciplinary knowledge, concepts, skills or attitudes?	• What are the integration skills needed for this task? • How will students combine disciplines? • What skills do students need to think about disciplinary combination? • How can students act upon their integrative thinking? • How can students show their integrative thinking? • How and when will these skills be assessed?
Advancement	• What are we going to produce? • How will we show our learning?	• What do we imagine will be the outcome of this task? A product, solution, explanation? • How will the outcome show the disciplines? • How will the outcome show the integration? • Within the above, is the task open enough to allow synergy or serendipity to happen? • How will students recognise the advancement? (By using multiple disciplines, do you think you have a better understanding?) • How will students talk about the advancement?

Figure 4.8: continued (4 of 7)

Formative Feedback

How do the core elements enable formative feedback?

Core Elements	Scaffolding	Targeted descriptors	Feedback
Disciplinary Objectives	• What are the disciplinary objectives? • Where do they come from? • How will the objectives be assessed? And when? • Could we design the task-specific rubric together? • How can the disciplinary objectives be taught/learned? • What activities will the students need in order to come to grips with these building blocks?	**Sophisticated** performance of the objectives in each discipline	• How can the student improve the disciplinary building blocks – knowledge, concepts, skills or attitudes – required?
Integration and Process Skills	• What are the integration skills needed for this task? • How will students combine disciplines? • What skills do students need to think about disciplinary combination? • How can students act upon their integrative thinking? • How can students show their integrative thinking? • How and when will these skills be assessed?	**Thorough, detailed** understanding of the interplay between disciplines. **Sophisticated** ability to communicate between disciplines **Deep** reflection on and **thorough** analysis of the disciplinary combination and how it illuminates the issue/problem/challenge **Shows** creativity in choosing and combining disciplines	• How can the student improve their demonstration of disciplinary interplay? • How can the student improve their communication between disciplines? • How can the student improve their analysis of the disciplinary combination? • Does the student need to experiment with other disciplinary combinations, ratios or integration methods?
Advancement	• What do we imagine will be the outcome of this task? A product, solution, explanation? • How will the outcome show the disciplines? • How will the outcome show the integration? • Within the above, is the task open enough to allow synergy or serendipity to happen? • How will students recognise the advancement? (By using multiple disciplines, do you think you have a better understanding?) • How will students talk about the advancement?	**Clear** advancement of KCSA in an integrated context **Clear** elements of synergy or serendipity **Sophisticated** ability to reflect upon their own advancement of KCSA	• How can the advancement – over and above the disciplinary standard – of knowledge, concepts, skills or attitudes be made clearer? Will it be part of the outcome or reflection? • Have there been elements of synergy or serendipity? How can the students highlight these? • Can students recognise and reflect upon their advancement? How can the student improve their reflection on the task?

Figure 4.8: continued (5 of 7)

Generic Rubrics

First trials were completed with the rubrics from Cycle 3 (*Figure 4.7: Cycle 3 interdisciplinary assessment rubric draft – with grades*)

See Figure 4.9 for the revised generic rubrics for Cycle 4.

Figure 4.8: continued (6 of 7)

Reflection for Future Tasks

How do the core elements enable reflection for future tasks?

Core Elements	Reflection on performance	Reflection leading forward
Disciplinary Objectives	• Were the disciplinary objectives fit for purpose? Do we need to modify/add to/swap them? • Were the objectives assessable? Do we need to modify disciplinary assessment? • Do we need to change the timing of assessment? • Could there be other ways for students to develop knowledge/concepts/skills/ attitudes to address the disciplinary objectives?	Where will we go next time? Will the interdisciplinary effort be: • Task/outcome focused? • Skill focused? • Knowledge- or concept-focused? • Problem focused? With the above purpose in mind (see reflections from column at left): • What disciplinary objectives will be met? What existing disciplinary assessment will this involve? • What integration and process skills will students need? • What advancement might happen?
Integration and Process Skills	• Did students understand the need to integrate disciplines? How can this be improved? • Were the integration skills fit for purpose? Did students need more skills, more practice, or both? • Were the disciplinary combinations effective? How can we further enable this step? • Were students able to show their integrative thinking? How can this be enabled further? • Do we need to change the timing of assessment of integration and process skills?	
Advancement	• What were the various outcomes of this interdisciplinary endeavour? As predicted? Were there any unpredicted outcomes? • How did the outcomes show the disciplines? How did the outcomes show the integration? Were they shown appropriately to the task or does this need modifying? • Was the task open enough to allow synergy? Serendipity? Unpredictability? Could it be modified to do so? • Did students recognise the advancement? Do we need to enable this further? • Were students able to talk about the advancement? Do we need to enable this further?	

Figure 4.8: continued (7 of 7)

The *Generic rubrics* section of the full draft framework was updated eight weeks after the development of the surrounding framework draft. Feedback on the first draft of the assessment rubric, as elaborated in Cycle 3 had been positive in terms of content and adherence to the indicators of quality, however, teachers had suggested that the descriptors could be further elaborated to better describe what achievement of a particular level looked like. This suggested that a full expansion and explanation of indicators within the assessment rubrics was warranted. At this stage, the title for the third indicator was reverted to 'Advancement' so that discussions would continue to interrogate this more-problematic indicator.

The update and expansion of the rubrics were influenced again by the interdisciplinary literature on indicators of quality (see Table 4.1) and by the assessment taxonomies (Biggs & Collis, 1982; Krathwohl, 2002). These influences helped explain and elaborate further what was meant by the indicators of quality, ensured that each level of the cognitive domain was being addressed and that the rubric descriptors increased in complexity and abstraction. The rubrics were then checked according to the principles of quality rubric design (Andrade, 2000; Jonsson & Svingby, 2007; Popham, 1997; Tierney & Simon, 2004; Wenzlaff et al., 1999; Wiggins, 1998) to ensure overall consistency of performance attributes and consistency in the complexity of the performance descriptors.

The updated and expanded assessment rubrics are shown in Figure 4.9. These were then integrated into the full draft framework, as the 'Generic rubrics' section.

Generic Interdisciplinary Rubrics

Disciplinary objectives

Students show achievement of the disciplinary objectives as defined by their local curriculum (Australian Curriculum, IBMYP or DP, SACE, school-based disciplinary assessment)

Level	Description
X	
X	
X	
X	

Level	Description
X	
X	
X	
X	

Level	Description
X	
X	
X	
X	

Integration and process skills

Students show the ability to blend relevant disciplinary knowledge, concepts and skills in innovative ways to address the situation presented. They show:

- understanding of the interplay between disciplines - how disciplines integrate in order to support/contradict each other – do they interlock, intertwine, blend, build upon?
- an ability to communicate between disciplines to generate mutual understanding of the situation presented and enable a solution/product (including the use of an interdisciplinary vocabulary)
- an ability to reflect upon and analyse the disciplinary combination (particularly if disciplines are contradictory in any sense): how do the disciplines illuminate the issue/problem/challenge?
- creativity in choosing and combining the disciplines

Description **The student shows:**	**Level, grade** (align with disciplinary style)	**When assessed?**
Limited understanding of the interplay between disciplines • can identify the disciplines involved • struggles to describe the connections between disciplines **Limited** ability to communicate between disciplines • uses discipline-specific vocabulary • shows little or no awareness of the interdisciplinary audience **Limited** reflection on and analysis of the disciplinary combination and how it illuminates the issue/problem/challenge • can identify the disciplines involved, but shows little or no awareness of how multiple disciplines can help address the issue/problem/challenge **Shows limited** creativity in choosing and combining disciplines • needs assistance to identify which disciplines could help address the issue/problem/challenge • can choose and combine disciplines with assistance (continued below)	1-2 D ☹ Beginning *Year 6	(start, mid, end, throughout?)

Figure 4.9: Updated assessment rubrics, to fit within the first full framework draft (Figure 4.8) (1 of 4)

Some understanding of the interplay between disciplines • can provide an explanation of how the disciplines connect, combine, intertwine or blend together **Some** ability to communicate between disciplines • uses discipline-specific vocabulary • shows some awareness of the interdisciplinary audience **Some** reflection on and analysis of the disciplinary combination and how it illuminates the issue/problem/challenge • can explain simply how multiple disciplines help address the issue/problem/challenge **With support, shows** creativity in choosing and combining disciplines • can identify disciplines that might help address the issue/problem/challenge • can choose and combine disciplines with minimal assistance	3-4 C 😐 Improving *Year 7	
Good understanding of the interplay between disciplines • can explain how the disciplines connect, combine, intertwine or blend together • can explain how and why the disciplines support each other **Requisite** ability to communicate between disciplines • uses discipline-specific vocabulary • shows an awareness of the interdisciplinary audience through clarifications and explanations **Adequate** reflection on and analysis of the disciplinary combination and how it illuminates the issue/problem/challenge • explains in detail how multiple disciplines contribute to addressing the issue/problem/challenge • makes some suggestions to improve the disciplinary combination **Shows some** creativity in choosing and combining disciplines • chooses and combines disciplines independently • proposes and explains their choice of multiple disciplines that might address the issue/problem/challenge	5-6 B ☺ Meeting *Year 8	
Thorough, detailed understanding of the interplay between disciplines • can explain how the disciplines connect, combine, intertwine or blend together, showing awareness that the interplay may be invisible at times • explains in detail how and why the disciplines support each other **Sophisticated** ability to communicate between disciplines • uses discipline-specific vocabulary • communicates seamlessly to an interdisciplinary audience through clarifications, explanations and disciplinary translations where needed **Deep** reflection on and **thorough** analysis of the disciplinary combination and how it illuminates the issue/problem/challenge • evaluates how multiple disciplines contribute to addressing the issue/problem/challenge, describing the strengths and weaknesses of the combination • makes suggestions to counter the disciplinary- or combination-related challenges **Shows** creativity in choosing and combining disciplines • proposes and justifies their choice of a range of disciplines that might address the issue/problem/challenge: justifications may be insightful • chooses and combines disciplines independently	7-8 A ☺☺ Exceeding *Year 9/10	

Figure 4.9: continued (2 of 4)

Advancement

Students show an advancement of knowledge, understanding, skills or attitudes that could not have been achieved through a single discipline. They show:

- a quantitative or qualitative advancement of knowledge/concepts/skills/attitudes in an integrated context. Advancement may be reflected in innovation, creativity and/or perceptive analysis
- elements of synergy or serendipity: deliberate or unexpected advancements that arise from skilful integration of disciplines
- the ability to reflect upon and evaluate their own advancement of knowledge/concepts/skills/ attitudes from an integrated context

Description The student shows:	**Level, grade, etc** (align with disciplinary style)	**When assessed?** (start, mid, end, throughout?)
Limited or no advancement of knowledge, concepts, skills or attitudes in an integrated context • shows disciplinary knowledge, concepts, skills or attitudes but these are not integrated • little or no awareness of the potential to integrate disciplines shown **Limited or no** elements of synergy or serendipity • has difficulty using disciplinary grounding and integration and process skills in combination, even with support • considers only one integration, solution or way of knowing before choosing a course of action, even with support **Limited** ability to reflect upon their own advancement • has difficulty considering how the integration of disciplines might help in advancing their own knowledge, concepts, skills or attitudes	1-2 D Beginning ☹ *Year 6	
Supported advancement of knowledge, concepts, skills or attitudes in an integrated context • has heavily used support structures (scaffolding) to enable creativity and/or analysis **Some** elements of synergy or serendipity, achieved **with support** • has used the disciplinary grounding and integration and process skills in combination, with support • consideration, with support, of more than one potential integration, solution or way of knowing has helped enable the advancement **Some** ability to reflect upon their own advancement • has heavily used support structures (scaffolding) to consider how the integration of disciplines has enabled their own advancement of knowledge, concepts, skills or attitudes (continued below)	3-4 C Improving 😐 *Year 7	

Figure 4.9: continued (3 of 4)

Some advancement of knowledge, concepts, skills or attitudes in an integrated context • shows the beginnings of innovation, creativity and/or perceptive analysis **Some** elements of synergy or serendipity • has used the disciplinary grounding and integration and process skills in combination • consideration of two or three potential integrations, solutions or ways of knowing has helped enable the advancement **Requisite** ability to reflect upon their own advancement • considers how the integration of disciplines has enabled their own advancement of knowledge, concepts, skills or attitudes	5-6 B Meeting ☺ *Year 8	
Clear advancement of knowledge, concepts, skills or attitudes in an integrated context • innovation, creativity and/or perceptive analysis is shown **Clear** elements of synergy or serendipity • student has used the disciplinary grounding and integration and process skills to leverage an advancement • consideration of multiple potential integrations, solutions or ways of knowing has helped enable the advancement **Sophisticated** ability to reflect upon their own advancement • considers in detail how the integration of disciplines has enabled their own advancement of knowledge, concepts, skills or attitudes	7-8 A Exceeding ☺☺ *Year 9/10	Throughout End Throughout

Figure 4.9: continued (4 of 4)

Cycle 5: Full framework independent review

Cycle 5 (Figures 4.2 and 4.10) initiated Phase 3 of the research, the final synthesis, evaluation and reflection stage. Cycle 5 of the research aimed for an independent review of the draft framework by a school that had not been involved in the Phase 2 development cycles. This method was primarily used to evaluate the immediate accessibility of the full framework, in addition to soliciting feedback on the framework's academic rigour, general accessibility and ability to enable interdisciplinary teaching and learning in a classroom, as per the previous development cycles.

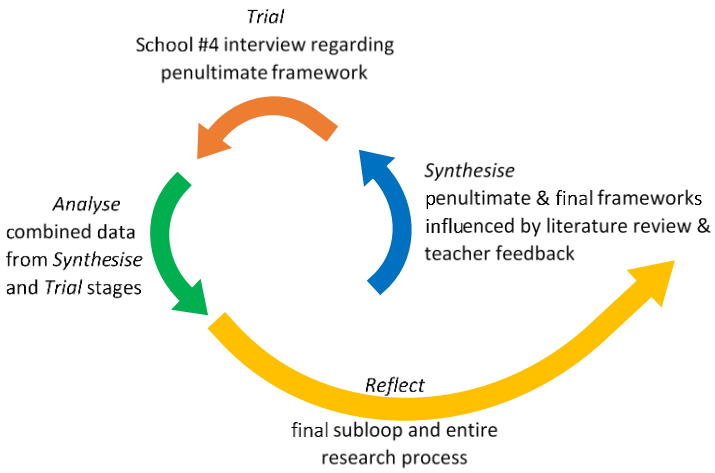

Figure 4.10: Phase 3 design cycle for framework evaluation

Refining the penultimate framework

The findings from Cycle 4 of the assessment framework development are presented in Chapter Five but summarised here to provide context to the Cycle 5 Synthesise stage. The Cycle 4 findings indicated that embedding the newly developed interdisciplinary assessment rubrics within a broader planning teaching and learning framework was a positive step. Teachers had found that even if they did not use the rubrics for summative assessment, the influence of the indicators of interdisciplinary quality and the assessment section were having a positive effect on planning, teaching and learning.

The planned modifications for Cycle 5 included an emphasis on flexibility of the framework so that teachers could choose to include or omit elements as appropriate to their context, as well as guidance towards timing of assessment and task types that help make interdisciplinary learning visible. Further examples of interdisciplinary purpose would be added and terminology within the framework model would be revised.

Feedback from Cycle 4 had also suggested that examples of what the framework may look like when adapted to local curriculums would be helpful, as well as examples of student work that had been

assessed against the rubrics. This was scheduled for development after the final framework had been completed.

By the time of the meeting with School D, modifications had been made to the presentation of the framework, however, some of the minor content adjustments had not yet been made, for example, 'advancement' was still in the body text of the second assessment rubric. It was intended to use these as key discussion points within the interview to gain richer feedback on issues that had been ongoing throughout the framework development.

The revised framework, as presented to School D, is presented in Figure 4.11.

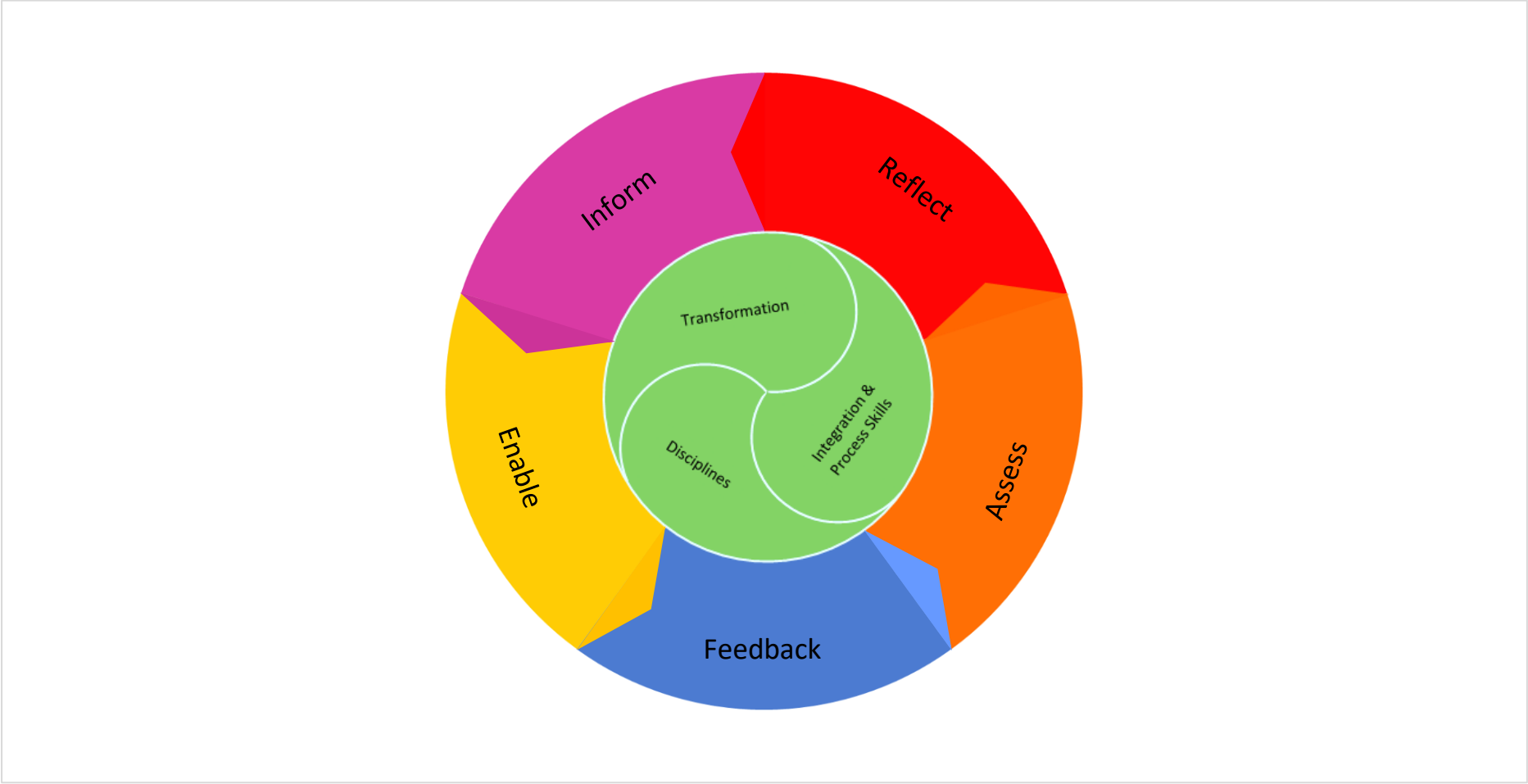

Figure 4.11: Cycle 5, full framework draft for discussion with School D (1 of 10)

Core Elements

Disciplines

Students show achievement of the disciplinary objectives as defined by their local curriculum (Australian Curriculum, MYP, SACE, school-based disciplinary assessment)

Level	Description
X	
X	
X	
X	

Level	Description
X	
X	
X	
X	

Level	Description
X	
X	
X	
X	

Integration and process skills

Students show the ability to blend relevant disciplinary knowledge, concepts and skills in innovative ways to address the situation presented.

Description Students blend relevant disciplinary knowledge/concepts/skills in innovative ways. They show:	**When assessed?** (start, mid, end, throughout?)
• understanding of the interplay between disciplines - how disciplines integrate in order to support/contradict each other (do they interlock, intertwine, blend, build upon?)	
• an ability to communicate between disciplines to generate mutual understanding of the situation presented and enable a solution/product (including the use of an interdisciplinary vocabulary)	
• an ability to reflect upon and analyse the disciplinary combination (particularly if disciplines are contradictory in any sense): how do the disciplines illuminate the issue/problem/challenge?	
• creativity in choosing and combining the disciplines	

Transformation

Students show an advancement of knowledge, understanding, skills or attitudes that could not have been achieved through a single discipline

Description Students demonstrate an advancement of knowledge/concepts/skills/attitudes that could not have been achieved through a single discipline. They show:	**When assessed?** (start, mid, end, throughout?)
• a quantitative or qualitative advancement of knowledge/concepts/skills/attitudes in an integrated context. Advancement may be reflected in innovation, creativity and/or perceptive analysis.	
• elements of synergy or serendipity: deliberate or unexpected advancements that arise from skilful integration of disciplines	
• the ability to reflect upon and evaluate their own advancement of knowledge/concepts/skills from an integrated context	

Figure 4.11: continued (2 of 10)

Inform Interdisciplinary Task Design

How do the core elements influence task design?

What is the purpose for interdisciplinarity?

Purpose of the interdisciplinary effort	**Questions for Planning**
Task/Outcome-focused • Will it be an aesthetic or literary synthesis: a symbolic work that can help viewers make sense of complex ideas? (IBO, 2014) • Will it be personal expression: a song/performance or similar that expresses a concept? (IBO, 2014)	What is the purpose of this interdisciplinary unit/task? (Choose one from the column at left) **Core elements** With the purpose in mind: What disciplinary objectives will be met? What existing disciplinary assessment will this involve? What integration and process skills* do students need? What transformation* might happen? *Check the core elements/rubrics for tips
Skill-focused • Will it involve cross-over tooling: use of a skill or concept in multiple disciplines to understand a new issue? (IBO, 2014)	
Knowledge- or Concept-focused • Will it be a complex explanation: combining expertise from multiple disciplines to develop a more complete/complex understanding? (IBO, 2014; Nikitina, 2006) • Will it be a contextualisation: embedding ideas from one discipline into another disciplinary context or into a larger philosophical framework? (IBO, 2014; Nikitina, 2006)	
Problem-focused • Will it be a practical solution: multiple disciplines combine to address a problem and create a product, find a solution, develop an intervention? (IBO, 2014; Nikitina, 2006)	

Figure 4.11: continued (3 of 10)

Enable Interdisciplinary Task

How do the core elements enable the task?

Core Elements	Questioning	Scaffolding
Disciplines	• What do students need to know from the disciplines? • How will we learn this?	• What are the disciplinary objectives? • Where do they come from? • How will the objectives be assessed? And when? • Could we design the task-specific rubric together? • How can the disciplinary objectives be taught/learned? • What activities will the students need to come to grips with these building blocks?
Integration and Process Skills	• How are will the students (or we) combine the disciplinary knowledge, concepts, skills or attitudes?	• What are the integration skills needed for this task? • How will students combine disciplines? • What skills do students need to think about disciplinary combination? • How can students act upon their integrative thinking? • How can students show their integrative thinking? • How and when will these skills be assessed?
Transformation	• What will students produce? • How will students show their learning? • How will students show their transformed awareness?	• What do we imagine will be the outcome of this task? A product, solution, explanation? Will students choose? • How will the outcome show the disciplines? • How will the outcome show the integration? • Within the above, is the task open enough to allow synergy or serendipity to happen? • How will students recognise the transformation? (By using multiple disciplines, do you think you have a better understanding?) • How will students talk about the transformation?

Figure 4.11: continued (4 of 10)

Formative Feedback

How do the core elements enable formative feedback?

Core Elements	Scaffolding to enable task (from previous, Enable Interdisciplinary Task)	Targeted performance descriptors (from next, Generic Interdisciplinary Rubrics)	Feedback – example guiding questions
Disciplines	• What are the disciplinary objectives? • Where do they come from? • How will the objectives be assessed? And when? • Could we design the task-specific rubric together? • How can the disciplinary objectives be taught/learned? • What activities will the students need in order to come to grips with these building blocks?	**Sophisticated** performance of the objectives in each discipline	• How can the student improve the disciplinary building blocks – knowledge, concepts, skills or attitudes – required?
Integration and Process Skills	• What are the integration skills needed for this task? • How will students combine disciplines? • What skills do students need to think about disciplinary combination? • How can students act upon their integrative thinking? • How can students show their integrative thinking? • How and when will these skills be assessed?	**Thorough, detailed** understanding of the interplay between disciplines. **Sophisticated** ability to communicate between disciplines **Deep** reflection on and **thorough** analysis of the disciplinary combination and how it illuminates the issue/problem/challenge **Shows** creativity in choosing and combining disciplines	• How can the student improve their demonstration of disciplinary interplay? • How can the student improve their communication between disciplines? • How can the student improve their analysis of the disciplinary combination? • Does the student need to experiment with more disciplinary combinations, ratios or integration methods?
Transformation	• What do we imagine will be the outcome of this task? A product, solution, explanation? • How will the outcome show the disciplines? • How will the outcome show the integration? • Within the above, is the task open enough to allow synergy or serendipity to happen? • How will students recognise the transformation? (By using multiple disciplines, do you think you have a better understanding?) • How will students talk about the transformation?	**Clear** advancement of knowledge/ concepts/skills/attitudes in an integrated context **Clear** elements of synergy or serendipity **Sophisticated** ability to reflect upon their own advancement of knowledge/ concepts/skills/ attitudes	• How can the advancement – over and above the disciplinary standard – of knowledge, concepts, skills or attitudes be made clearer? Will it be part of the outcome or reflection? • Have there been elements of synergy or serendipity? How can the students highlight these? • Can students recognise and reflect upon their transformation? How can the student improve their reflection on the task?

Figure 4.11: continued (5 of 10)

Assess Interdisciplinary Task

Disciplines

Students show achievement of the disciplinary objectives as defined by their local curriculum (Australian Curriculum, IBMYP or DP, SACE, school-based disciplinary assessment)

Description	Level
	X
	X
	X
	X

Description	Level
	X
	X
	X
	X

Description	Level
	X
	X
	X
	X

Integration and process skills

Students show the ability to blend relevant disciplinary knowledge, concepts and skills in innovative ways to address the situation presented. They show:

- understanding of the interplay between disciplines - how disciplines integrate in order to support/contradict each other – do they interlock, intertwine, blend, build upon?
- an ability to communicate between disciplines to generate mutual understanding of the situation presented and enable a solution/product (including the use of an interdisciplinary vocabulary)
- an ability to reflect upon and analyse the disciplinary combination (particularly if disciplines are contradictory in any sense): how do the disciplines illuminate the issue/problem/challenge?
- creativity in choosing and combining the disciplines

Description **The student shows:**	**Level, grade** (align with disciplinary style)	**When assessed?**
Limited understanding of the interplay between disciplines • can identify the disciplines involved • struggles to describe the connections between disciplines **Limited** ability to communicate between disciplines • uses discipline-specific vocabulary • shows little or no awareness of the interdisciplinary audience **Limited** reflection on and analysis of the disciplinary combination and how it illuminates the issue/problem/challenge • can identify the disciplines involved, but shows little or no awareness of how multiple disciplines can help address the issue/problem/challenge **Shows limited** creativity in choosing and combining disciplines • needs assistance to identify which disciplines could help address the issue/problem/challenge • can choose and combine disciplines with assistance	1-2 D ☹ Beginning *Year 6	(start, mid, end, throughout?)

Figure 4.11: continued (6 of 10)

Some understanding of the interplay between disciplines • can provide an explanation of how the disciplines connect, combine, intertwine or blend together **Some** ability to communicate between disciplines • uses discipline-specific vocabulary • shows some awareness of the interdisciplinary audience **Some** reflection on and analysis of the disciplinary combination and how it illuminates the issue/problem/challenge • can explain simply how multiple disciplines help address the issue/problem/challenge **With support, shows** creativity in choosing and combining disciplines • can identify disciplines that might help address the issue/problem/challenge • can choose and combine disciplines with minimal assistance	3-4 C 😐 Improving *Year 7	
Good understanding of the interplay between disciplines • can explain how the disciplines connect, combine, intertwine or blend together • can explain how and why the disciplines support each other **Requisite** ability to communicate between disciplines • uses discipline-specific vocabulary • shows an awareness of the interdisciplinary audience through clarifications and explanations **Adequate** reflection on and analysis of the disciplinary combination and how it illuminates the issue/problem/challenge • explains in detail how multiple disciplines contribute to addressing the issue/problem/challenge • makes some suggestions to improve the disciplinary combination **Shows some** creativity in choosing and combining disciplines • chooses and combines disciplines independently • proposes and explains their choice of multiple disciplines that might address the issue/problem/challenge	5-6 B ☺ Meeting *Year 8	
Thorough, detailed understanding of the interplay between disciplines • can explain how the disciplines connect, combine, intertwine or blend together, showing awareness that the interplay may be invisible at times • explains in detail how and why the disciplines support each other **Sophisticated** ability to communicate between disciplines • uses discipline-specific vocabulary • communicates seamlessly to an interdisciplinary audience through clarifications, explanations and disciplinary translations where needed **Deep** reflection on and **thorough** analysis of the disciplinary combination and how it illuminates the issue/problem/challenge • evaluates how multiple disciplines contribute to addressing the issue/problem/challenge, describing the strengths and weaknesses of the combination • makes suggestions to counter the disciplinary- or combination-related challenges **Shows** creativity in choosing and combining disciplines • proposes and justifies their choice of a range of disciplines that might address the issue/problem/challenge: justifications may be insightful • chooses and combines disciplines independently	7-8 A ☺☺ Exceeding *Year 9/10	

Figure 4.11: continued (7 of 10)

Transformation

Students show an advancement of knowledge, understanding, skills or attitudes that could not have been achieved through a single discipline. They show:

- a quantitative or qualitative advancement of knowledge/concepts/skills/attitudes in an integrated context. Advancement may be reflected in innovation, creativity and/or perceptive analysis
- elements of synergy or serendipity: deliberate or unexpected advancements that arise from skilful integration of disciplines
- the ability to reflect upon and evaluate their own advancement of knowledge/concepts/skills/ attitudes (KCSA) from an integrated context

Description The student shows:	**Level, grade, etc** (align with disciplinary style)	**When assessed?** (start, mid, end, throughout?)
Limited or no advancement of knowledge, concepts, skills or attitudes in an integrated context • shows disciplinary knowledge, concepts, skills or attitudes but these are not integrated • little or no awareness of the potential to integrate disciplines shown **Limited or no** elements of synergy or serendipity • has difficulty using disciplinary grounding and integration and process skills in combination, even with support • considers only one integration, solution or way of knowing before choosing a course of action, even with support **Limited** ability to reflect upon their own advancement • has difficulty considering how the integration of disciplines might help in advancing their own knowledge, concepts, skills or attitudes	1-2 D Beginning ☹ *Year 6	
Supported advancement of knowledge, concepts, skills or attitudes in an integrated context • has heavily used support structures (scaffolding) to enable creativity and/or analysis **Some** elements of synergy or serendipity, achieved **with support** • has used the disciplinary grounding and integration and process skills in combination, with support • consideration, with support, of more than one potential integration, solution or way of knowing has helped enable the advancement **Some** ability to reflect upon their own advancement • has heavily used support structures (scaffolding) to consider how the integration of disciplines has enabled their own advancement of knowledge, concepts, skills or attitudes (cont. below)	3-4 C Improving 😐 *Year 7	

Figure 4.11: continued (8 of 10)

Some advancement of knowledge, concepts, skills or attitudes in an integrated context • shows the beginnings of innovation, creativity and/or perceptive analysis **Some** elements of synergy or serendipity • has used the disciplinary grounding and integration and process skills in combination • consideration of two or three potential integrations, solutions or ways of knowing has helped enable the advancement **Requisite** ability to reflect upon their own advancement • considers how the integration of disciplines has enabled their own advancement of knowledge, concepts, skills or attitudes	5-6 B Meeting ☺ *Year 8	
Clear advancement of knowledge, concepts, skills or attitudes in an integrated context • innovation, creativity and/or perceptive analysis is shown **Clear** elements of synergy or serendipity • has used the disciplinary grounding and integration and process skills to leverage an advancement • consideration of multiple potential integrations, solutions or ways of knowing has helped enable the advancement **Sophisticated** ability to reflect upon their own advancement • considers in detail how the integration of disciplines has enabled their own advancement of knowledge, concepts, skills or attitudes	7-8 A Exceeding ☺☺ *Year 9/10	Throughout End Throughout

Figure 4.11: continued (9 of 10)

Reflect – Evaluate – Reconnect

How do the core elements enable reflection for future tasks?

Core Elements	Reflection on performance	Reflection leading forward
Disciplines 	• Were the disciplinary objectives fit for purpose? Do we need to modify/add to/swap them? • Were the objectives assessable? Do we need to modify disciplinary assessment? • Do we need to change the timing of assessment? • Could there be other ways for students to develop knowledge/concepts/skills/ attitudes to address the disciplinary objectives?	Where will we go next time? Will the interdisciplinary effort be: • Task/outcome focused? • Skill focused? • Knowledge- or concept-focused? • Problem focused? With the above purpose in mind (see reflections from column at left): • What disciplinary objectives will be met? What existing disciplinary assessment will this involve? • What integration and process skills will students need? ▪ Connection skills? (connect, combine, intertwine, blend) ▪ Communication skills? ▪ Reflection skills? ▪ Thinking skills? ▪ Creativity? • What transformation might happen? ▪ Knowledge? ▪ Concepts? ▪ Skills? ▪ Attitudes?
Integration and Process Skills 	• Did students understand the need to integrate disciplines? How can this be improved? • Were the integration skills fit for purpose? Did students need more skills, more practice, or both? • Were the disciplinary combinations effective? How can we further enable this step? • Were students able to show their integrative thinking? How can this be enabled further? • Do we need to change the timing of assessment of integration and process skills?	
Transformation 	• What were the various outcomes of this interdisciplinary endeavour? As predicted? Were there any unpredicted outcomes? • How did the outcomes show the disciplines? How did the outcomes show the integration? Were they appropriate to the task or does this need modifying? • Was the task open enough to allow synergy? Serendipity? Unpredictability? Could it be modified to do so? • Did students recognise the transformation? Do we need to enable this further? • Were students able to talk about the transformation? Do we need to enable this further?	

Figure 4.11: continued (10 of 10)

Chapter Four: Summary

Chapter Four presented the evolution of the interdisciplinary assessment framework prototypes by displaying the products generated in each *Synthesise* stage of design Cycles 1-5. Chapter Four presents 'what we created', in order to facilitate replicability, building on the methodological choices described in Chapter Three.

Chapter Five continues this effort to facilitate replicability. It describes the data gathered from the research contexts, based on the analysis of the working prototype, along with the reasoning that contributed to the evolution of each subsequent prototype.

Chapter 5 – Data Collection and Analysis

Chapter Five provides a detailed description of the feedback on the assessment framework prototypes from the volunteer teachers and how this feedback was analysed in order to develop each subsequent prototype. The five interdisciplinary framework prototypes and the final framework were developed during the *Synthesise* stage of each design cycle and these outcomes have been shown in Chapter Four. Chapter Five describes the evidence for the development choices of these prototypes.

Direct feedback on the interdisciplinary framework prototypes was collected from the volunteer teachers during the *Trial* stages. Teachers were provided with the current (at the time) prototype to use as a focus for their comments, which were recorded and transcribed for further analysis. Relevant selections of this transcribed data are presented within the *Trial* sections of this chapter and represents 'what we found'.

The raw transcriptions of the teachers' feedback were analysed by the researcher, during the *Analyse* stages of the design cycles, using the themes for interview analysis described in Chapter Three (Table 3.4). These analytical themes highlighted data that showed whether the prototype framework was academically rigorous (had content validity), was accessible for teachers (had construct validity), was enabling for teachers, and also highlighted any other feedback that might be relevant to the ongoing development of the framework. There was one exception to this: Cycle 1 did not use the analytical themes as in this cycle there was not yet a prototype that could be subjected to the *rigorous-accessible-enabling* analysis.

Conversations with the volunteer teachers in each cycle not only sought to gain direct feedback for the interdisciplinary framework but also sought to identify contextual enablers and barriers to interdisciplinary curriculum approaches in their schools. This latter element is considered to be emergent data and was analysed using the analytical themes described in Chapter Three (Table 3.5). These themes related to:

- teachers' conceptual understandings of interdisciplinary pedagogy,
- how school contexts enabled or restricted implementation of innovative curriculum,
- how interdisciplinary practice had enabled change, and
- how some changes had occurred as a result of the research process.

The *Reflect* stages of the design cycles were also researcher-driven and were used to make decisions about how to transform the data analysis into action that contributed to the development of each subsequent framework prototype. This stage focused on ensuring that the framework modifications

were justified through both the reviewed and analysed literature and the analysed teacher feedback. The decisions made in the *Analyse* and *Reflect* stages are presented together and elaborate 'how we used what we found'.

Chapter Five presents the *Trial, Analyse* and *Reflect* stages by Cycle (Figure 5.1). Relevant data from the teacher interviews are presented under *Trial*; analysis of this data is presented under *Analyse-Reflect*, according to the themes for interview analysis and including decisions made that enabled each subsequent framework prototype in the *Synthesise* stage that followed.

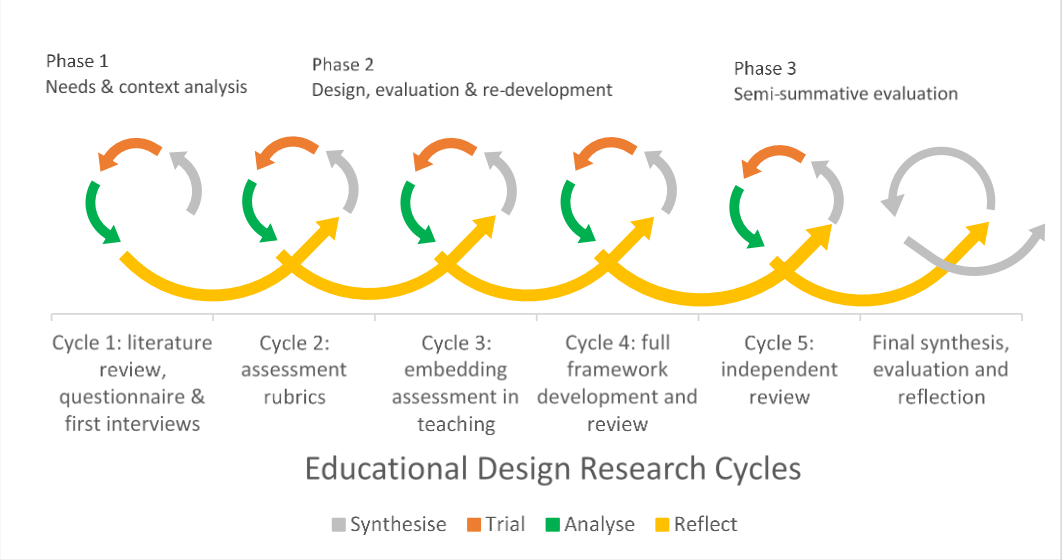

Figure 5.1: Trial, Analyse and Reflect stages that influenced each framework prototype

Cycle 1: Questionnaire and first interviews

Cycle 1, the single cycle in Phase 1, included a literature review and analysis, a questionnaire and first interviews with volunteer teachers. The outcomes of the literature review and analysis have been described in Chapters Two and Four; the results from the recruitment element of the questionnaire have been presented in Chapter Three.

The questionnaire and first interviews were also designed to ascertain whether teachers perceived the need for more resources for interdisciplinary pedagogy and assessment and whether the findings from the literature review and analysis could be applicable to a school context. Data collected from these methods contributed to the needs and context analysis, supporting or contradicting the research premise, namely, that there was a need for a school-specific interdisciplinary pedagogy and assessment resource.

Trial – Questionnaire results

The total number of respondents to the questionnaire was thirty-three although not all respondents answered every question. Demographic data from the respondents was presented in Chapter Three. After demographic data, questions were designed to elicit information on the compulsory or optional nature of interdisciplinary teaching and learning in the school and whether professional development specific to supporting interdisciplinarity was available and accessible. Most respondents, (83%) stated that their school did offer (or enable) professional development in this area and approximately 75% of respondents had accessed one or more professional learning opportunities.

The next group of questions asked the teachers about the processes used for interdisciplinary planning and assessment within the school, including quality controls for assessment and their own satisfaction levels regarding these planning and assessment processes. Answers regarding existing processes for assessment were very clear, showing that schools used either prescribed International Baccalaureate Middle Years Programme (IBMYP) criteria (IBMYP schools only), or they separated the interdisciplinary work back into disciplines for assessment. Two schools used both of these assessment methods (Table 5.1).

Table 5.1: Do you use any specific criteria for assessing interdisciplinary work? (respondents n=28)

Answer Choices	Responses
IB Middle Years Programme criteria	20
We split the work back into disciplines for assessment	10

These answers clearly supported a need for further research, given that two thirds of schools use the IBMYP assessment criteria, which, as noted in the literature review and analysis, do not include assessment of all four of the accepted indicators of interdisciplinary quality. The IBMYP criteria include three of the four quality indicators, namely, disciplinary grounding, integration and two of the academic processing skills needed to manage the disciplinary integration, communication and reflection. While these assessment criteria help support interdisciplinary learning, the fourth indicator of quality, that which identifies an overall advancement or a synergistic effect, is absent.

The remaining third of schools separated the interdisciplinary work back into its component disciplines and assessed the learning according to disciplinary requirements. This suggests that any integration, interdisciplinary processing skills and any overall advancement might not be captured as part of their assessment processes.

Responses to items on quality control of assessment were also uncomplicated, with most schools indicating that teachers collaborate to align their assessment practices and a significant number of teachers using both collaboration and standardised criteria for quality control (Table 5.2).

Table 5.2: How do you ensure quality control of interdisciplinary assessment? (respondents n=28)

Answer Choices	Responses
Through use of standardised assessment criteria	16
Teachers collaborate to standardise their marking	23

In addition, while most teachers were generally satisfied with interdisciplinary planning and assessment processes in their school, the overwhelming consensus was that improvement was needed (see Tables 5.3 and 5.4).

Table 5.3[17]: How satisfied are you with the interdisciplinary (1) planning / (2) assessment process in your school? (respondents n=28)

	Highly dissatisfied	Dissatisfied: process needs changing	Satisfied but improvement needed	Highly satisfied
Interdisciplinary planning processes	4%	18%	68%	11%
	1	5	19	3
Interdisciplinary assessment processes	4%	7%	79%	11%
	1	2	22	3

Table 5.4: If you are less than highly satisfied with interdisciplinary processes in your school, please highlight the extent to which you would like to improve each category (respondents n=23)

	Needs much improvement	Needs moderate improvement	Needs some improvement	Needs minor adjustments only
Management/coordination of interdisciplinary units	13%	52%	26%	9%
	3	12	6	2
Professional learning opportunities in interdisciplinary learning	13%	57%	26%	4%
	3	13	6	1
Interdisciplinary planning processes	22%	43%	30%	4%
	5	10	7	1
Interdisciplinary assessment methods	13%	57%	22%	9%
	3	13	5	2

[17] Percentages in Tables 5.3 and 5.4 are rounded to whole numbers.

The data collected from the questionnaire shown through Tables 5.1 to 5.4 was the extent of teacher opinion sought through this quantitative format. The data, particularly that which showed teachers were looking for ways to improve interdisciplinary practice, was sufficient to support further research; more-detailed, qualitative teacher opinions and feedback could be better sought through in-school consultation processes.

The final section of the questionnaire described the proposed research in brief and asked whether teachers would be willing to volunteer for an in-school trial of a new interdisciplinary assessment tool. Twelve teachers responded in the affirmative and provided their contact emails for follow up. Details on these twelve teachers, and others who subsequently volunteered, are presented in Chapter Three.

Trial – Findings from first interviews

The first interview meetings with volunteer teachers had two primary goals. The first was to introduce the volunteer teachers to the research project overall, which included an introduction to the idea of developing an interdisciplinary resource that was *rigorous*, *accessible* and *enabling* and a presentation of the literature analysis findings to date (Table 4.2). This also included some follow-up questions related to the questionnaire that confirmed teachers' responses and ascertained whether a new interdisciplinary planning, teaching and assessment resource would indeed be useful in their context. The second goal for these meetings was to gather data on the context of the volunteer teacher and their school and how this might influence the teachers' expectations of participation in the research. The full interview protocol is included as Appendix B and the outcomes of these first interviews are described below.

Introduction to the research project

This element of the meetings gave the teachers the general background to the research project, which included presenting the simplified results from the literature review, as per Table 4.2 (Chapter Four). Use of this table guided discussion on the implications of the reviewed literature not yet offering a complete planning-teaching-learning-assessment cycle that is supported by robust assessment practices, and not yet showing how research on interdisciplinary planning, teaching and learning can be transferred easily to the middle- or high-school classroom. Teachers interviewed were interested to see what was happening in the field of research related to interdisciplinary teaching and learning and commented on the potential applications of the analysed interdisciplinary literature to their practice:

"We've been talking a lot about that synergistic effect: The Science makes your English better and because the English is better therefore the Science is better…" – Jamie, Cycle 1

"How do you mark advancement? If you're using these criteria [from the literature] every time you mark something, that might be simpler but …" – Mel, Cycle 1

"In a secondary setting though, and this might be old knowledge, like pre-2011, there was no need to get together and come up with a final grade for interdisciplinary. You just simply reported on the meeting of particular Science objectives…" – Max, Cycle 1

"I guess the other thing we need to be careful of is that the disciplines by themselves are valuable and there are still certain disciplinary skills that students may need, and we can't get lost in the bigger picture and not address them." – Jamie, Cycle 1

The comments above show that while some teachers were familiar with the synergistic goals of interdisciplinarity (Jamie), other teachers showed immediate concern for the practicalities of its application in the classroom.

Context of the volunteer teachers

Conversations in the first meeting also covered the context in which the teachers worked, including what their role was in the school and whether they were required to do interdisciplinary units. For teachers who had experience with interdisciplinary units at this stage, questions in this part of the conversation sought to identify whether teachers were confident that the IBMYP- or their school-created curriculum documents were generally meeting their needs, even though there was clearly room for improvement in some areas. Examples of responses include:

(Confidence in existing curriculum)

"So, in some cases the assessment happens from a discipline point of view and in some cases when we can coordinate it across the whole school … it happens as an interdisciplinary assessment" – Jordan, Cycle 1

"I think that the MYP and the DP are really good for allowing you to draw connections implicitly" – Mel, Cycle 1

"There are multiple levels of assessment – we have the [IBMYP] IDU criteria, which are separate, which also brings in criterion A, the disciplinary understanding, and in this [year 8] unit it'll be from four subjects. And then we also have disciplinary assessment, which happens side by side with the interdisciplinary assessment…" – Rohan, Cycle 1

(Room for improvement)

> "And those kinds of [command] terms should then actually be in the descriptors. We as a school or as individual teachers can clarify to include those, but I would think, well, [the IB is] making this a requirement and it's extra work and there doesn't seem to have been the time put into creating those [IBMYP] descriptors" – Rohan, Cycle 1

> "Yes, I think [the IBMYP document] is more about using the planner and those sorts of things and here's the criteria, but it hasn't unpacked what interdisciplinary learning is, it doesn't actually, it almost avoids the elephant in the room … What actually is interdisciplinary understanding? And how do we measure it? And that remains unanswered with this guide" – Rohan, Cycle 1

These comments indicated that while teachers were literate in the existing interdisciplinary practices in their schools, some could clearly identify areas where improvement was needed. In addition, some teachers were clearly interrogating their interdisciplinary assessment practices, even though they were not sure where a solution might lie:

> "…it gets very difficult, because in a task that, for all intents and purposes is an interdisciplinary task, like for example a Science magazine article where there's quite clearly a massive science component, there is equally an English component. What it comes down to is, we can't assess that task – we can't assess the same thing twice. So, what we can assess is, is the science correct? But we can't assess the Science Communication and the English Communication, we can't double-credit things. So, I guess we're at the tricky point now where we need to decide, is it a Science task or is it an English task as far as the assessment framework is concerned?" – Jamie, Cycle 1

> "…we're just about to come up to [task name], where it's a 3-week task that will have an English component that we'll draw out and there will also be the science that will come out of that … SACE make it very complex to be able to do assessment in an interdisciplinary way, so [even though] we can set a truly interdisciplinary task and give it a grade at that level, it really still does need to be broken down into the disciplines … I think our assessment is too heavily content-driven and that's when you get the assessment drawing back into the disciplines so, we're focused on whether they understand a specific concept or content, not how they've taken a particular problem and applied multiple lenses to solve that problem" – Jordan, Cycle 1

> "…sometimes we put the knowledge back together, but we don't recognise that we have because someone else has told us how to do it" – Marie, Cycle 1

This uncertainty regarding how an improvement to interdisciplinary assessment practice might be realised further supported the need to deliberately interrogate this problem.

During the discussions around school context, there were already some clear barriers to implementation of interdisciplinary teaching and learning beginning to emerge, noticeably related to collaborative practice:

> "I got told that we already have our IDU people organised … So, I'm catching up with [colleague] to find out what that looks like before I say I've got this great idea. Because my experience being, certainly in the last few years, when you put up an idea it can be squashed. There are people who have their own vested interests in their empires and even though you can have all the evidence-based research practice in the world behind you it's 'no'" – Max, Cycle 1

> "… part of our context is feeling like if you've got an idea and the idea is around interdisciplinary units there's got to be a forum where you can present that idea and have it *really* [teacher's emphasis] heard, not just quashed because it's not fitting with what [someone else has] already got planned, there's got to be that opportunity for, you know, trying that thing" – Marie, Cycle 1

> "…the whole notion of collaborative planning at the secondary level is a very foreign concept and I really think that's a disservice to good learning and teaching practices" – Max, Cycle 1

Teachers' expectations of participation in the research

After talking through the nature of the research project and how the teachers' own contexts might influence it, the discussion moved to what the teachers expected to gain from participation in the project. All volunteer teachers were keen to see where the project might take them and what benefit it might have for their own interdisciplinary assessment practices:

> "…it would be handy for us to have an interdisciplinary framework, … so I guess what we're looking at for next year is coming back to that because I think we've drifted away, we need 'this is the task and here's the rubric' and you can see the stuff above the line is the English and the stuff below is Science but as a whole it's [together] … what we need to look at is we want interdisciplinary learning and if that creates some minor work then maybe that's what we need to try and see" – Jamie, Cycle 1

"I'm really keen, because this is where we've been struggling, we want tasks that involve interdisciplinary learning but when it comes to the rubric it's all falling over. So, the question has been how can we actually acknowledge that? That it's more than an English/Science task?" – Jamie, Cycle 1

"…something like this, it would be very interesting whether it worked for every student. Often, prototypes or things like this work for the majority, but for the ones that sit either side, very high or very low in that spectrum, often assessment doesn't work for them, because it doesn't account for those [students]" – Jordan, Cycle 1

"…if there's something I like [I can use it]?... this isn't just pure research, it's developing something as well?" – Morgan, Cycle 1

Analyse-Reflect

Each of the research components in Phase 1, the literature review, questionnaire and first meetings, were analysed individually and as a whole in order to confirm the premise and need for the research. This holistic analysis provided guiding concepts for interdisciplinary assessment from the analysed literature (Table 4.1) and an overall picture of teachers' levels of satisfaction with current interdisciplinary planning, teaching, learning and assessment processes in their schools. Phase 1 Cycle 1 was the only Cycle that did not use the analytical themes as per the ongoing methodology. This is because in the first cycle there was not yet a prototype that could be subjected to the *rigorous-accessible-enabling* analysis. The analysis and reflection at this stage focused on confirming whether the premise of the research was justified and whether the development of an interdisciplinary resource that might be rigorous, accessible and enabling was a viable proposition. The analysis and reflection combined suggested the first way forward might be the development of interdisciplinary assessment rubrics.

Questionnaire analysis

The questionnaire responses supported the research premise overall, that there would be a benefit in developing an interdisciplinary assessment framework to assist teachers in the middle school context in the planning, teaching and assessment of interdisciplinary courses. This further built upon the findings from the literature review analysis shown in Chapter Four.

The questionnaire results were analysed to see whether the premise of the research was further justified. At the point of distributing the questionnaire, the interdisciplinary assessment literature had been analysed and the questionnaire sought feedback on whether these findings were reflected in schools' realities.

The questionnaire addressed, apart from demographic data, three main areas: professional development specific to interdisciplinary teaching and learning, processes used for interdisciplinary planning and assessment within the school and teachers' levels of satisfaction with these processes.

The first of these areas, professional development, seemed less problematic on the surface, given that most respondents (83%) said their school offered or enabled professional development in interdisciplinary teaching and learning and that 75% of them had attended one or more professional learning opportunities. This still indicates, however, that one in four teachers who are involved in interdisciplinary programs have not undertaken any formal professional development and that some further resources in this area might be helpful.

The responses regarding processes used for interdisciplinary planning and assessment within the school led to some potentially interesting assumptions. For example, the questionnaire data in Table 5.1 shows that respondent schools used one of two processes (two schools used both processes) to assess interdisciplinary work. They either use the published IBMYP interdisciplinary assessment criteria, which the literature review analysis demonstrated to not completely address the accepted indicators of interdisciplinary quality, or schools separated interdisciplinary work back into its disciplinary components for assessment thus potentially omitting interdisciplinary considerations from the assessment process. This demonstrated a disconnect between current assessment practice and what the reviewed literature proposed as quality practice.

The responses to collaborative processes for quality control of assessment were generally positive, as were those on the interdisciplinary planning and assessment processes. There was a consistent opinion that improvement was still needed in these areas, for example, even though teachers were generally satisfied with quality control of assessment, 89% responded that improvement was needed in both planning and assessment processes. This finding alone gave a clear mandate to the research to see whether an interdisciplinary assessment resource might enable improvement.

It was interesting to note within these findings that the three teachers who indicated that they were highly satisfied with the assessment processes in their schools also indicated that they de-integrated interdisciplinary work back into disciplines for assessment (2) or used the IBMYP criteria (1), both methods that have been critiqued in this thesis. Unfortunately, these three teachers did not take part in the assessment framework trial (one volunteered but dropped out before data collection; two did not volunteer), so no further information could be gathered in this instance.

Interviews – Analysis of findings from first meetings

The first meetings with volunteer teachers sought to introduce the teachers to the research project in more detail, gauging whether they agreed that a new tool might be helpful. This meeting also sought to gather further data around the teacher's school context and their expectations of the research process.

The four indicators for quality interdisciplinarity that had been collected from the literature review were used to guide the introduction of the research project, comparing and contrasting the analysed literature with the lived reality of teachers in the classroom. By means of a discussion centred on Table 4.2 (simplified version of the indicators of interdisciplinary quality), teachers were introduced to the goal that the research would attempt to merge the two fields, research and practice, in order to allow findings from the reviewed and analysed literature to be enabled in the classroom. This goal would be guided by the ideas, formulated through the literature review and methodology used, that an interdisciplinary tool would be *rigorous* according to the reviewed literature, *accessible* and *enabling*. Teachers were accepting of the presentation of the simplified literature findings and were curious to see how it could be transformed into practice, as quoted in the *Trial* section above, even though there were some concerns about how an interdisciplinary advancement might be assessed.

As discussions around the quality indicators progressed, it was notable in the analysis of the transcripts that the category that identified *integration of disciplinary components* could be considered an *academic processing skill*. When it was suggested to the teachers that these categories be combined for assessment, they agreed that they could be incorporated into the *Synthesise* stage at the beginning of Phase 2.

From the interview data it became clear that teachers' school contexts had significant impact on what teachers could and could not do within their classrooms. This ranged from overt curriculum, assessment and timetabling decisions made by school management to more-hidden enablers and barriers within a school's culture, practices that affected engagement in interdisciplinary collaboration. At this early stage, teachers shared the overt enablers for interdisciplinarity, for example, their school's curriculum policies or design as commented on by Jordan, Mel and Rohan. Some teachers identified the covert barriers, for example, collaborative curriculum issues as well as interpersonal and power constraints, as commented on by Max and Marie.

This indicated that not only was existing research literature needed to create a quality interdisciplinary assessment framework, but also a detailed understanding of schools' overt and covert policies and practices was also going to be necessary to enable the recommendations from research literature to be transferred to a classroom context. These findings reinforced the need to

create analytical themes that could organise the data that emerged from school contexts in addition to the data directly related to development of the interdisciplinary framework.

Literature review analysis

The literature review and analysis, presented in Chapters Two and Four, supported the premise that there is little practical guidance for teachers who wish to implement interdisciplinary teaching and learning in their school or individual classroom. When combined with the analyses from the questionnaire and first interviews, there were further reflections as follows.

During the first interviews, the volunteer teachers confirmed that the indicators of interdisciplinary quality as identified in the analysed literature (Tables 4.1 and 4.2) should be adaptable to a classroom context and that an attempt to show what assessment of these indicators of quality might look like would be helpful. The quality indicators came from a combination of the reviewed literature on interdisciplinarity and interdisciplinary assessment. Reflecting on this, it seemed prudent to view these quality indicators in combination with the educational assessment literature as well. This idea was further justified by the finding that an omission from much of the interdisciplinary literature is that of examples of quality assessment practice. There are very few examples of assessment rubrics and, where there are examples of assessment, they are not aligned with the indicators of quality as described in the interdisciplinary planning, teaching and learning literature.

Disciplinary grounding

Teachers had already indicated some interdisciplinary assessment strategies through the questionnaire. Some teachers were using designated subject-based or interdisciplinary assessment criteria (particularly IBMYP schools) and some teachers were separating interdisciplinary work back into its disciplinary components for assessment. Teachers were confident with this latter practice, given that they were already highly literate in disciplinary assessment practices.

> "I guess the other thing we need to be careful of is that the disciplines by themselves are valuable and there are still certain disciplinary skills that students may need, and we can't get lost in the bigger picture and not address them" – Jamie, Cycle 1

> "…SACE make it very complex to be able to do assessment in an interdisciplinary way, so [while] we can set a truly interdisciplinary task and give it a grade at that level, it really still does need to be broken down into the disciplines" – Jordan, Cycle 1

Through these types of comments, teachers confirmed that academic grounding in the disciplines and assessment at a disciplinary level was of high importance.

Questions arose in the interviews about how marks or grades were to be recorded, and which disciplines got to keep the recorded grades, that concerned some teachers. In a school system that has mandatory assessment and reporting practices, how would teachers ensure that they would have the required number of disciplinary grades at the end of a reporting period?

> "… even though you assess as a whole you also assess the components – that was one of my concerns with the interdisciplinary, because when I asked someone else at the school about it they said you couldn't use any of the [interdisciplinary] assessment for the Science, so that meant that you had to do another lot of assessment for the kids and I thought, 'well, that's ridiculous' because if it's going to be interdisciplinary then yes, it needs to be assessed, but you should still be able to use the components that relate back to your subject in your assessment" – Marie, Cycle 1

Based on these discussions, it seemed reasonable that if interdisciplinary assessment needed to include an element of *disciplinary grounding*, then it would be efficient to use the existing disciplinary assessment practices that teachers were already using for this first component of interdisciplinary assessment. These existing practices could be used to assess disciplinary grounding and would have the following benefits:

1. Disciplinary objectives, including knowledge, concepts, skills and attitudes, are already clearly defined in most school curriculums and teachers are highly familiar with their existing disciplinary requirements;
2. Incorporating assessment of existing disciplinary learning objectives would reinforce the notion that interdisciplinarity builds upon disciplinary rigour (Boix Mansilla & Gardner, 2003; Repko & Szostak, 2017; Strober, 2011) and that keeping the disciplinary component the same would clearly identify the disciplines as building blocks for interdisciplinary endeavours; and
3. This would go some way towards resolving the question of 'who keeps the grade(s)?'. If there was a disciplinary assessment component within an interdisciplinary assessment process, then the contributing disciplines would keep their own disciplinary grade(s).

For these reasons, it was decided to leave the *disciplinary grounding* section of the interdisciplinary assessment rubrics blank in Cycle 2 (Figure 4.5). The intention was that teachers would simply insert their own, existing disciplinary criteria for this component.

Integration and process skills, and, Advancement of understanding

The creation of assessment rubrics for the other two indicators of interdisciplinary quality was to be based heavily on propositions from the reviewed and analysed literature (see Tables 2.3 and 4.1) and would be further justified based on feedback from the first interviews.

> "…if you were looking to assess how they did it [the interdisciplinary work] as a *togetherness* then there needs to be a piece that was about how the student put everything together and used the different aspects" – Marie, Cycle 1

> "…as teachers when we design the interdisciplinary curriculum, we're going in with a state of mind that if they just do the Science bit they're going to get a certain level of understanding, if they just do the Humanities bit they're going to get a certain level, if they just do the English they'll just get a certain level, but at the end of the day it's not just the addition of those three bits, it's going to be catalysing, it's going to be even more so, it's more than the sum of its parts" – Jamie, Cycle 1

These comments indicated that teachers were indeed searching for a way to assess the interdisciplinary elements in a task. As a result, the intention generated in the *Synthesise* stage of Cycle 2, became the development of a basic rubric for each interdisciplinary quality indicator. This rubric would simply describe interdisciplinary characteristics as identified in the analysed literature (see Tables 4.1, 4.2 and 4.3), positioned against some generic, hypothetical achievement levels. This would then be trialled with the volunteer teachers to gain feedback on whether these characteristics could be made visible in a classroom or in student work. If favourable, the rubrics would then be developed further to be more specific and contain more guidance for teachers; if teachers thought there were still challenges, these would be revised during the subsequent cycle.

End of Phase 1, Cycle 1

Phase 1 Cycle 1 of the Educational Design Research cycle was a needs and context analysis. This initial phase intended to determine whether the research was necessary and potentially useful. The data collected and analysed, as shown in this chapter, justified the premise of the research through both the interpretation of the reviewed literature and the stated experiences, opinions and attitudes of the questionnaire respondents and the volunteer teachers who were engaging in interdisciplinary teaching.

Analysis of the Cycle 1 data led to the decision that the *Synthesise* stage of Phase 2 Cycle 2 would involve the creation of a prototype of an assessment tool. This would take the form of interdisciplinary assessment rubrics that were directly based upon the indicators of interdisciplinary

quality from the reviewed and analysed literature, allowing for integration of research theory and practice. It was at this point that the first *Synthesise* stage of Cycle 2 began. The interdisciplinary assessment rubrics synthesised in Cycle 2 are shown in Chapter Four.

Cycle 2: Assessment rubrics

The second design cycle, *Cycle 2* (Figure 5.1) involved taking the findings from Phase 1 and transforming these into the beginnings of a classroom tool to be used by teachers. That is, the data gathered from the literature review, the questionnaire and first interview meetings were synthesised to inform the development of a first prototype for interdisciplinary assessment, the assessment rubrics. These rubrics were presented in Chapter Four (Figure 4.5).

Trial

The rubrics from the Cycle 2 *Synthesise* stage, were sent to the volunteer teachers electronically prior to meeting and were to be used as the focus for discussions in the interviews for Schools A and B. School C was not able to participate during Cycle 2 due to existing school workload.

In addition to the rubrics themselves, teachers were given background information on the literature behind the rubric development, as well as some information on how the assessment might fit into the broader process of planning, teaching and learning in schools. The information in Figure 5.2 provides an overview as it was presented teachers.

These two documents, the first draft of the assessment rubrics and the background to rubric development (Figures 4.5 and 5.2), were the focus of discussion in the interviews for Cycle 2. The background information was presented first and built upon the simplified version of the indicators of quality that had been presented to the teachers and discussed in the Cycle 1 meetings.

There were two main points of discussion with regard to the background information (Figure 5.2). First, the sections coded in red were intended to be trialled with the volunteer schools, specifically, the assessment of interdisciplinary teaching and learning. These sections had been transferred directly into the draft assessment rubrics. The sections coded in yellow were not intended to be trialled, as it was considered that there was already a significant, helpful field of literature around *planning* interdisciplinarity approaches in schools, however, these planning elements needed to be acknowledged as it was considered that they would still have influence on the developing assessment tool.

The second main point for discussion of the background information was an explanation of how the reviewed literature had influenced the creation of the assessment rubrics to this point. The two right-hand columns in the background information (Figure 5.2) gave a brief overview of the literature that had had the most impact to this stage. Rowntree's (1987) five dimensions of assessment organised the range of assessment literature reviewed and the far-right column showed

the range of literature on interdisciplinarity and interdisciplinary assessment that had helped generate the indicators of quality.

Stage		Proposed Assessment	Influence	
1	Collaboration *Speed dating* and *jam sessions*, or identified areas of potential. Teachers collaborate to find meaningful links in their curriculum		Rowntree (1987)	Others
2	Defining the purpose What is the goal of this unit? Create a product? Explain a phenomenon? Interpret and/or combine variables to generate new understanding? What performance will show student achievement of the goal?	Not assessed, though teachers will need to ensure natural connections. Defined by the teacher and developed with the students (age dependent)	Why assess? What to assess?	Boix Mansilla (2005), IBO (2017a), Nikitina (2006)
3	Defining disciplinary input Which disciplines will contribute and to what extent? What disciplinary objectives will be achieved?	Although integrated in the goal, these elements are assessed <u>in</u> the disciplines, with <u>disciplinary criteria</u>, taking care not to double-assess. Levels are owned by the disciplines.	How to assess? How to interpret? How to respond?	Boix Mansilla & Gardner (2003), IBO (2017a), Nikitina (2006)
4	Defining the integration What does the integration look like? How do the disciplines intertwine to become mutually supportive/generative? What skills do students need to integrate their knowledge, understanding and skills?	New criterion focussed on quality of integration and integration skills	How to assess? How to interpret? How to respond?	IBO (2017a), Boix Mansilla & Gardner (2003), Martin-Kniep, Feige & Soodak (1995), Fogarty & Pete (2009), Clarke & Agne (1997), Repko (2012), Boix Mansilla, Duraisingh, Wolfe, & Haynes (2009)
5	Advancement of understanding What new knowledge has been generated? For the student? In general?	New criterion focussed on quality and/or quantity of advancement	How to assess? How to interpret? How to respond?	Boix Mansilla & Gardner (2003), Fogarty & Pete (2009)

Figure 5.2: Background information to the first rubrics

After discussion of the background information, the draft assessment rubrics (Figure 4.5) were presented to the teachers for discussion. At this stage, the rubrics were intended as a first step towards developing a more-complete assessment tool. The guiding questions for the meetings with teachers, as explained in the *Methodology* chapter and shown in Appendix B, centred on whether the rubrics were:

- *Rigorous*, according to the reviewed literature
- *Accessible*, so teachers could use them with little need for further access to literature or professional learning
- *Enabling*, that they had the potential to show what interdisciplinary quality looks like and therefore enable interdisciplinary teaching and learning in the classroom

It is important to reiterate that at this stage, the assessment rubrics were a first-draft of descriptive statements of what was meant by the indicators of quality, rather than fully developed (summative) assessment rubrics with descriptors of increasing achievement. The interview discussions therefore, were used to ascertain whether the indicators were already, or had the potential to be, rigorous, accessible and enabling. A shared intention between researcher and teachers was to develop the assessment rubrics further, which included detailed descriptors, descriptors of increasing achievement and situating the assessment more explicitly within broader planning and teaching considerations. From this point rubrics could be modified or even changed completely based on the teacher feedback regarding challenges that arose.

Rigorous

During the Cycle 2 interviews, the teachers generally affirmed that the rubrics directly aligned with the analysed literature as had been presented in Table 4.2. This alignment had been identified as a gap, particularly in schools where interdisciplinary assessment processes had formerly involved disciplinary disaggregation of the students' learning products.

> "We've been talking a lot about that synergistic effect: the Science makes your English better and because the English is better therefore the Science is better … you're not doing an English task and a Science task, you're doing this combined task which is even better than two small parts … this is exciting, it's been hard to get a rubric that we're happy with – what we have is tolerable at the moment … this is where we've been struggling, we want tasks that involve interdisciplinary learning but when it comes to the rubric it's all falling over. So, the question has been how can we actually acknowledge that? That it's more than an English/Science task?" – Jamie, Cycle 2

Even though teachers affirmed the value of directly assessing the purpose of interdisciplinarity, there were initial concerns about how to do that in a practical way:

> "I think your huge challenge is going to be assessing the students' advancement of understanding because you would have to do something beforehand to know what their starting point is. It's the one area, the one unit where you would have to have that knowledge first, whereas a lot of the time you are measuring where they're at, here you would be measuring how that's changed. That this activity has broadened their horizons rather than just looking at where they're at, because where they're at is where they could have been at whether you'd done the unit as an interdisciplinary unit or two separate units. So that would be, I think, part of the challenge: creating that assessment at the beginning to know where they're actually at…" – Marie, Cycle 2

This concern had lasting implications throughout the project, as one notion of 'advancement' implies movement from one point to another. How can advancement be judged if there is no starting point, or at least an idea of progression? This challenge was highlighted to be addressed in future iterations of the rubrics.

Accessible

Accessibility at this stage was interpreted both through direct questioning and through how often teachers needed clarification on aspects of the draft rubrics. When questions or comments arose, whether around interdisciplinary concepts or language use, these were noted to be clarified in the next draft. Questions and comments such as these included:

> "Right, so just to be clear, this bit here [integration and process skills indicator] is… so students both have the concepts and can connect them. And this one here [advancement of ideas indicator] is, because they can connect them, things are even better." – Jamie, Cycle 2

Accessibility was also confirmed by teachers through comments that showed they could see how the interdisciplinary concepts in the rubrics could be transferred to their own practice, for example:

> "Because if we're talking advancement of ideas, we've got things like attitudes, prior knowledge, that sort of stuff and you can determine that through, you could get kids to do values walks, you could get them to look at some articles, show them a video clip, all that sort of stuff. You could get some sort of idea about what they think about [for example] zoos and their purposes…" – Max, Cycle 2

> "What about from the perspective of transdisciplinary, I mean, I know they're slightly different, but that has often looked at assessing a product from all the different levels, from

all the different integrations. So, whether that area would have some kind of support for… coz in a lot of ways, to me, I mean it's still, it may be a smaller version, but I can still see that this is transdisciplinary in the sense that you're wanting two things to come together in a seamless way, so they use it as one big picture." – Marie, Cycle 2

Enabling

The notion of interdisciplinary assessment rubrics as *enabling* built upon the previous two components, *academic rigour* and *accessibility*, so that quality interdisciplinary teaching and learning could be transferred to classroom practice. To identify this factor of *enabling*, the researcher analysed the teachers' discussions to identify indicators that the rubrics might be catalysts for, or impediments to, implementation or improvement of interdisciplinary teaching and learning.

Jamie explained existing attempts to enable interdisciplinary teaching and learning in the classroom. Teachers in Jamie's school worked with students on their integration and process skills by explicitly talking students through the process of integrating subjects, for example, using Philosophy to help argue a scientific point.

> "… in biodiversity, one of the flavours is Philosophy, "Should we preserve biodiversity? Should we look after endangered/extinct languages? Why have the pandas? – they cost millions of dollars and they're not breeding. What can we do better with that money? What's our view? Is it the right thing to do?" So, that Philosophy stuff says it's really important because of that synergy [integration of Philosophy with Science]. It enables students to actually … because we found before when we didn't make it such a big deal, it was just a yes/no, black/white, or students would say, "it's just wrong, you know, coz it's not right". They didn't have the scaffold to address the higher ideas. Whereas now they can say, "according to the Utilitarian framework or the Bioethics framework or Anthropocentrism…" and they can frame their argument. So, they can show off a deeper knowledge with this other skill." – Jamie, Cycle 2

Through these types of discussion, Jamie hoped students would gain an interdisciplinary advancement and the draft descriptions of indicators of quality would be helpful towards that goal.

Additional feedback

In addition to monitoring conceptual rigour, linguistic clarity and usefulness of the assessment tool, general feedback was also sought from the teachers. The researcher had indicated that any feedback regarding the tool was helpful, whether it was from teachers' own individual or broader school context.

During research Cycle 2, feedback from teachers addressed some practicalities of assessment, particularly *when* and *how* interdisciplinary assessment might be conducted in a classroom. One teacher talked through the idea that interdisciplinary process skills are not always evident in a finished product, but they are certainly visible at the earlier stages of interdisciplinary learning.

> "When [students are] grappling with the ideas… when they're dealing with an ethical issue, that bit when they're doing their draft and exploring all avenues and drawing a big mind map, going through the yes-no-yes-no-I-don't-know-which-one-it-is, etc. The final piece may argue just one position so you're losing that richness. So, some of those things, like why is this issue complex, if that's not evident in the final piece, you're going to lose it. I guess what we try and do is make sure that as part of the planning you keep that as it's part of it, we want to give you credit for that. And that's important for us as it's the idea that evidence for assessment doesn't have to appear in that polished 800 words. It also comes through in your planning and your peer-reviews and all those other bits and pieces." – Jamie, Cycle 2

From these types of comments, that the timing of when certain components were assessed was very important, it was clear that this challenge was something to consider for future drafts.

Another teacher questioned the practicality of organising the marking of student work when multiple teachers are involved in an interdisciplinary project:

> "Would you envisage that both teachers – assuming it is two teachers involved, it isn't always – would be marking together? Or just one of them? Or both separately?" – Mel, Cycle 2

These issues were noted as requiring attention in future iterations of the framework. Due to these types of questions it was becoming clear that instructions related to planning and teaching, ones that situated the assessment rubrics in context and explained how to use them, would be useful and important to include.

Analyse-Reflect

In each design cycle of Phases 2 and 3, the analysis stage focused on collating the feedback from teachers and viewing the feedback through the themes for analysis (Table 3.4). To design an effective assessment tool, the intention was to transfer best practice from the reviewed literature into the realities of the classroom without compromising quality in either. Therefore, after generating a new prototype from both the reviewed literature and previous feedback and trialling it with teachers, the *Analyse* and *Reflect* stages were where the feedback gained would be analysed in order to modify, improve and expand the prototype.

The feedback from teachers in Cycle 2, based on the first draft of the assessment rubrics and corresponding background information (Figures 4.5 and 5.2), was collated, analysed and reflected upon as displayed in Table 5.5.

Table 5.5: Analysis of teacher feedback and decisions made, Cycle 2

Feedback code	Feedback overview	Decisions made by researcher
Rigorous	Teachers validated that the rubrics aligned with the analysed literature (Table 4.2) Teachers were pleased that interdisciplinary-specific performance elements were being included.	The first two indicators of quality, *disciplinary grounding* and *integration and process skills*, received positive feedback with no particular suggestions for changes or additions. These would remain in the next draft.
	The *advancement* criterion was well received, but there were some concerns about how to assess it in a practical way – would teachers need to identify and assess a *progression* of knowledge or skills?	The third indicator, advancement of understanding, would need to be clarified in the next draft in terms of how to assess it. Did it denote a student's individual progression, or an advancement on expected progression?
Accessible	Concepts behind the rubrics were reported as understood at this stage. Teachers could make connections with their own classroom practice.	The current draft was acknowledged as being accessible in terms of language and concepts. This clarity would remain in the next draft.
Enabling	Teachers could see how to use the Cycle 2 drafts to enable practice in the classroom. For example, Jamie had used the ideas to lead students through the process of integrating disciplines.	The current draft was acknowledged as being generally enabling at this stage. This utility would need to be maintained into the next draft.
Additional feedback	Further explanation was needed on how the assessment rubrics were expected to be used, including • When to assess? for example, the integration and process skills are more easily identified at the beginning or during an interdisciplinary endeavour, rather than in a final product • Who should assess? Teachers need to have clear guidance on who is expected to carry out the assessment processes and which parts thereof.	The next draft should contain explanatory material on the practicalities of using the assessment rubrics: • When to assess – at which stage of an interdisciplinary project should each indicator be assessed? • Who assesses? Which teachers should be involved in planning and conducting the assessments?

Moving to the next Synthesise *stage*

The reflection stage of Cycle 2 involved the researcher reflecting on the completed design cycle. This involved ensuring that the planned changes for the next prototype were justified and that the guiding questions for the development of the assessment tool, whether the draft was *rigorous, accessible* and *enabling,* were being addressed.

At the end of Cycle 2 the conclusions drawn in the literature review and from the analysis therein had been accepted as appropriate by the teachers and therefore fit to guide the assessment tool. This integration of interdisciplinary planning and teaching literature and classroom practice appeared to be generally unproblematic apart from two elements. Firstly, it was accepted that the term "advancement" was at times unclear. The concept behind interdisciplinary advancement, that of a synergistic effect due to the integration of disciplines (summarised in Table 4.1), is clear in the literature review. When abbreviating this concept to "advancement" (or similar), however, there is room for misunderstanding. This term needed modification. Secondly, while teachers accepted that the draft rubrics aligned with the analysed literature, most teachers based their acceptance on the researcher's presentations rather than their own investigations. Only Jamie was directly familiar with Boix Mansilla's ideas on interdisciplinary assessment (for example, Boix Mansilla, 2005, 2012a; Boix Mansilla & Gardner, 2003) and Marie had previous experience in a transdisciplinary teaching environment.

At this early stage, the first drafts of the assessment rubrics were at a basic level. They were descriptive statements of what was meant by the indicators of quality, rather than fully developed assessment rubrics with descriptors of increasing achievement. Therefore, while the teachers interviewed indicated that the rubrics were accessible (for example, Jamie's comments under *Accessible*, Cycle 2), the researcher noted that at least similar, if not greater clarity and explanation of concepts of practical guidance would be needed for future drafts. This is because it was envisaged that the assessment tool would grow more complex as it developed.

At this stage of reflection, it appeared that the feedback identified through the themes of rigorous, accessible and enabling was useful but did not indicate that the prototype should take a different course. The feedback identified through the 'additional feedback' theme, however, did indicate that the subsequent prototype needed to address the concerns of who assesses and at what stage assessment is conducted. These practical considerations reflect the reality of classroom teaching and could not be ignored if the assessment tool was to continue to be accessible and enabling. The next level of complexity to be included in the subsequent prototype was therefore an expansion of the assessment rubrics to include both formative and summative purposes and this is illustrated in the

prototype developed in the *Synthesise* stage of Cycle 3. This distinction would aim to provide a formative version of the rubrics that could provide for flexibility in who assesses and at what stage assessment is conducted, particularly assessment of integration and interdisciplinary process skills, which are often not evident in a final piece of student work. A summative version of the rubrics would continue on the original course of providing further detail regarding how interdisciplinary quality might appear in a classroom context.

This reflective stage completed the first development cycle for an assessment tool, the draft interdisciplinary assessment rubrics, that build on the investigative cycle from Phase 1. Keeping the feedback, decisions and reflections from Cycle 2 in mind, the researcher moved on to create the next draft of the assessment tool, as part of the *Synthesise* stage of Cycle 3.

Cycle 3: Embedding assessment in teaching

Within Phase 2, the next cycle of development involved utilising the feedback, decisions and reflections from Cycle 2 to improve and extend the first draft of the assessment rubrics. Cycle 3 (Figure 5.1), therefore, used cumulative data gathered from Cycle 2, as well as from the literature review, the questionnaire and first interview meetings in Cycle 1.

Trial

The rubrics from the Cycle 3 *Synthesise* stage, as shown in Figures 4.6 and 4.7, were sent to the volunteer teachers electronically prior to meeting and were to be used as the focus for discussions in the subsequent interviews for Schools A, B and C. In addition to the rubrics themselves, teachers were given the overview of the "two-way assessment option" (Table 4.4).

These documents, the overview and the two sets of assessment rubrics, were the focus for discussions in the interviews for Cycle 3. The researcher led the meetings, presenting the overview first, then the rubrics themselves, describing how they had developed from the reviewed literature as well as the teacher feedback in Cycles 1 and 2.

The assessment rubrics developed in the *Synthesise* stage of Cycle 3 were at a second-draft stage. While these versions showed improvement on the first draft from Cycle 2, the ongoing intention was to expand and elaborate on them even further, based on feedback from this *Trial* stage.

The guiding questions for the meetings with teachers were the same as those described in Cycle 2 and focused on whether the rubrics were:

- *Rigorous*, according to the reviewed literature
- *Accessible*, so teachers could use them with little need for further access to literature or professional learning
- *Enabling*, that they had the potential to show what interdisciplinary quality looks like and therefore enable interdisciplinary teaching and learning in the classroom

Rigorous

Teachers remained confident that the alignment of the assessment rubrics to the reviewed and analysed literature was a positive element. Now that they could see some further elaboration of the indicators of quality, there was agreement that this would be useful in transferring the concepts into classroom practice. Elaboration on what 'integration' and 'transfer' of skills looked like was particularly useful.

> "…and that's the transfer that's been completely missed [in the past]. The idea that you've done an English essay and now we're asking you to do a Science essay, they're the same thing… [but the student thinks] nope, it's a Science essay … so now we've gone, 'it's the same thing and here's why' and we've certainly been able to say, 'well, you're doing this here [in English] and this is kind of the same thing [in Science] and this is how it's maybe subtly different'." – Jamie, Cycle 3

There were still challenges with the idea of "advancement", however. The title of this second rubric had been changed to *Synergy*, with attempts to make the idea of advancement better reflect the overarching concept from the analysed literature (see Table 4.1), that of a synergistic effect due to the integration of disciplines. Despite this, since the second rubric still spoke of an "advancement of knowledge, concepts, skills or attitudes in an integrated context", the inference was still present that there needed to be 'progression' shown from one point to another.

> "So, the advancement would have questions about… because the implication is that you would assess that particular skill before, which in English is not necessarily the case term to term or semester to semester…?" – Mel, Cycle 3

Another challenge was that teachers were unsure whether all the indicator descriptions within the rubrics needed to be addressed in every task. For an interdisciplinary endeavour to be considered high quality, did all the indicators of interdisciplinary quality need to be present every time? There were comments that some descriptions might *not* apply, simply due to the nature of a task or due to teacher instructions, or that students might need to be prompted to show a particular skill.

> "*'Ability to reflect on and analyse the disciplinary combination'* – we didn't really do that and that's where connecting the disciplines, well, we didn't ask the students, 'how does this connect to this', it was basically one discipline supporting the other and it wasn't that explicit … [And] *creativity*, that's where we got a bit stuck. Creativity, maybe, but because we [the teachers] were giving a structure…" – Jamie, Cycle 3

> "Can I just ask about the strand *the ability to reflect upon and analyse [the disciplinary combination]*, I'm a little conflicted about how we could have that in a task without explicitly directing [students] to analyse that" – Mel, Cycle 3

These comments indicated that the interdisciplinary assessment resource would need to clarify how the indicators of interdisciplinary quality should be used.

Accessible

The feedback on whether the draft assessment rubrics were accessible was minimal in the interviews in Cycle 3. Teachers reported that the language and interdisciplinary concepts used in the drafts were understandable and affirmed that the format of the rubrics aided accessibility since they were beginning to look like familiar teaching materials. Some feedback that related to accessibility, particularly the transfer of the concept of "advancement" from the reviewed literature has been covered under the *rigorous* code for this cycle.

One teacher had shared the draft rubrics with other teachers and commented that these colleagues had found the rubrics equally accessible. The rubrics had been helpful for guiding their conversations:

> "It's been a success. [It] has been quite nice to go, 'well, we're trying to do this, here's something we can think about at the same time' … [as] a teacher rubric that helps us design tasks or learning experiences, it was really useful." – Jamie, Cycle 3

Enabling

There was much more feedback on whether the draft rubrics would help enable interdisciplinary teaching and learning in the classroom. Teachers affirmed that the disciplinary element of assessment remaining the same as per the existing practices in their schools was a positive. The intention of keeping disciplinary assessment the same, as decided moving into Cycle 2, was to clearly emphasise that the disciplines were essential building blocks that provided a strong grounding for interdisciplinary work. The teachers interviewed, however, also perceived this as a highly practical option that offered teachers a positive way to continue their existing disciplinary practice while enabling interdisciplinarity at the same time. For example, one teacher reflected on the progression of disciplines-integration-synergy as a way to build on existing curriculum,

> "[I previously used] the subject-specific criteria, which proved to me that I want something that's more generic and that flow chart from a moment ago [overview chart], I thought I might do something [with it] once we get to know what the other [integration-synergy] parts of the framework are. And make some comparisons between [the disciplinary] way of assessing and this [new] version of assessing." – Martin, Cycle 3

Another teacher reflected on the disciplinary component as an ideal way to advertise interdisciplinarity to others:

> "Teachers are reluctant – if they weren't able to get a disciplinary grade out of it, they were reluctant to do [the IDU]." – Riley, Cycle 3

The progression from disciplinary grounding to integration and synergy was also seen as a helpful way to induct students into the idea of disciplinary integration.

> "So, the ability to communicate between disciplines, … we want that, but we also want students to realise that sometimes it's not necessarily between disciplines but what you're doing is the same, like it's that crossover in the Venn diagram, it doesn't matter [which subject it is anymore], this subject is an English task *and* a Science task." – Jamie, Cycle 3

The assessment rubrics were helping enable positive changes in School A. By Cycle 3, only one teacher was directly involved in the project within this school, however, this teacher was sharing the draft rubrics in meetings with colleagues and indicated that the guidance in the rubrics was helping with their collaborative planning and implementation processes. For example, when designing an interdisciplinary English-Science task the importance of disciplinary grounding came to the fore.

> "I've found it really handy that the [subject] team has used this [draft] as a guide for us – how do we structure, what do students need support with in lessons before they do the task? In order to produce what we want after it. So, particularly this one here [integration and process skills], this is what we're trying to get, how will we ensure, how will we support students to do this? If we go, 'it's just an essay', then they're not going to get it. So, we need to have, 'this is how you write an essay', break it down – you need an introduction, you need a thesis statement, in paragraph one, what sort of stuff do you have?" – Jamie, Cycle 3

> "And that's where the task itself I don't think really changed. What changed is the time we spent before then to support students with the English side of it: rather than just saying, 'well, it's an essay!", we're saying, 'This is an essay, this is what a good essay is, this is how to structure a good essay, this is how to plan a good essay'. Actually planning the time so they can get their head around the other discipline." – Jamie, Cycle 3

This teacher argued that with these changes in the school's teaching processes there were some indications that student work might have improved as a result:

> "The learning is much better. Well, the Science learning I don't think has really changed – students already had the Science learning – what's changing is now they're demonstrating that they can actually argue a point. So, the grades that we're giving are a lot higher because they can actually insert that learning and argue a point, rather than just saying, 'here's the stuff', you're saying, 'here's the stuff and this is why this bit is more important than the others'. So, they're showing a higher level, a higher-order level of understanding and they're not getting lost, their learning isn't being misplaced in not knowing how to express it … so

> we're actually able to reward their learning a lot better now that we're spending some more time supporting the English, the language, that side of the discipline. Rather than just saying, 'explain it, argue it', now we're supporting that." – Jamie, Cycle 3

Another teacher noted the potential for students to develop skills in transfer and meta-disciplinary awareness:

> "…for instance, in Science, they've done a line graph to show their data, so from a Maths point of view you've done averages, you've created a graph, you've put in all of this, so now you're looking for them to identify, 'this is a Maths task, but it actually helps us – now I can see how to use it in another situation, because now I'm using it in Science to interpret something else', rather than just learning the skill and not knowing where else it could be used." – Marie, Cycle 3

These comments indicated that the introduction of an interdisciplinary assessment resource, perhaps combined with the interview conversations, was helping to enable positive changes in conceptual understanding of interdisciplinarity or in practice (or both) for the volunteer teachers.

Additional feedback

In the interviews held during Cycle 3, there were some informative conversations on school contexts and the immediate pressures that teachers face with assessment in general.

> "[the rubric] was handy for us as a teaching checklist but this rubric I didn't find easy to mark the students' work with…" – Jamie, Cycle 3

Teachers suggested that most schools would use the summative version of the rubrics that help determine a grade (Figure 4.7). This being the case, they would want the rubrics to provide clear guidance on the distinction between grades.

> "And that's where some of the teacher feedback is, 'what's an 'A'?' … What [do the grades] look like for that particular task? … What disciplines intertwine and support each other? … So, in my head for this task, does the structure [show], can the students actually argue a position? So, the Science is good, their evidence is good, but it's also an argument that can convince us. So that's kind of what I'd be wanting for an 'A'. 'B' it's mostly …, in 'C' it's generally…, in 'D' it's not a good argument…" – Jamie, Cycle 3

In this context, International Baccalaureate schools speak of "command terms", which are standardised instructional terms used within teaching and learning practices so that "students

understand and know what to do when asked to 'describe' as opposed to 'discuss', or to 'infer' as opposed to 'explain'" (IBO, 2017c, p. 82):

> "And those kinds of terms should then actually be in the descriptors." – Rohan, Cycle 3

These comments suggested that the interdisciplinary assessment rubrics needed further development, given that teachers felt there was still not enough guidance for determining a grade at this stage.

Teachers at School C spoke of the need to enter assessment details into an intranet-type system and how current practices with this were difficult. The implication here was that an interdisciplinary assessment tool needs to be able to generate grades that are compatible with, or can be easily converted to, schools' existing grading systems and applications.

> "One of the issues we have though is …the IDU planner is not in [software] and there's no separate marks book for it either. So, we've got an issue there as to how we [record]. And then with reporting as well, we've got to have interdisciplinary … come in as a subject on a report card." – Rohan, Cycle 3

In addition to improving the guidance within the rubrics and ensuring the results would be compatible with school systems, another challenge that arose was that of time. Teachers needed to cope with the challenge that some subjects, although ideal for interdisciplinary collaboration, were restricted by their hours on the timetable. One teacher, while eager to have input from another discipline was hesitant to take time away from a colleague's already busy curriculum:

> "My intention is not necessarily to require any time in HPD[18] because the HPD curriculum runs for one lesson a week. The year 8s are working through what's called *Healthy Minds* that's had a lot of content [description of interdisciplinary task] … So [Teacher], who is their HPD teacher, should be able to mark that to the *Healthy Minds*, well, the HPD criteria without any extra class time. She said they can have some of a lesson to discuss it with her, but they shouldn't really need it." – Mel, Cycle 3

This finding suggested that the developing resource would need to cater for organisational restrictions at a school level.

[18] 'HPD' is Health and Personal Development – in this school, the theoretical component in the practical Physical and Health Education curriculum.

Analyse-Reflect

The *Analyse-Reflect* stage of Cycle 3 involved collating the feedback gathered from teachers in the *Trial* stage and cross-referencing this feedback with the reviewed literature to ensure the assessment design remained aligned with the reviewed research in the field. This data would then be ready for reflective decisions that would inform the modifications of the prototype to be made in the next cycle.

The feedback from teachers in Cycle 3, based on the second draft of the assessment rubrics and corresponding "two-way assessment option" (Figures 4.6 and 4.7, and Table 4.4 respectively), was collated, analysed and reflected upon as shown in Table 5.6.

Table 5.6: Analysis of teacher feedback and decisions made, Cycle 3

Feedback code	Feedback overview	Decisions made by researcher
Rigorous	The alignment of the rubrics to the analysed literature continued to receive positive feedback. The idea of 'advancement', however, still had issues related to clarity – some teachers inferred that assessment of progression from one point to another was needed, rather than seeing advancement as a synergistic effect caused by disciplinary integration. The indicator descriptions as a whole were well received; now that they were separately described, teachers questioned whether every element needed to be present in every task.	The first two indicators of quality continued to receive positive feedback and would therefore continue as the guiding elements for assessment. The term 'advancement' would need clarification to emphasise the synergistic effect that comes from the integration of disciplines. This would be improved in both the rubrics and in a broader format. Guidance regarding how many elements from the analysed literature and to what extent they all need to be assessed during an interdisciplinary endeavour was needed. This also lent itself to a broader format of explanation.
Accessible	Apart from the issue with 'advancement', the rubrics continue to be understood well. The rubrics had been particularly helpful for guiding teacher-planning conversations.	Apart from the issue with 'advancement', the draft rubrics were acknowledged as being accessible, therefore, the next draft would contain a similar level of clarity and explanation of concepts.
Enabling	Maintenance of existing disciplinary assessment is a positive element. It reinforces the need for disciplinary grounding and • Minimises change – disciplines can still be organised on a timetable/classroom system • Schools can still access disciplinary grades for reporting needs. Teachers provided examples of the assessment rubrics enabling interdisciplinary planning and teaching, including • Disciplinary grounding in subjects involved (for example, explicit essay-	The draft rubrics were acknowledged as being enabling, particularly in the disciplinary grounding and integration-skill indicators. These indicators would therefore be targeted for general improvements in clarity and elaboration, while maintaining at least the current effectiveness. The 'synergy' or 'advancement' indicator is targeted for further elaboration and clarity, according to the feedback in *rigorous* and *accessible* in this cycle. This needed to be monitored to ensure it also transfers to visibility and enablement of a

	writing skills included in a Science-English collaboration) • The elaboration of what integration looks like has transferred to explicit teaching of integration of subjects • Anecdotal examples of improvement of student work	synergistic effect in interdisciplinary endeavours.
Additional feedback	Further guidance on how to determine a grade would be helpful, including • Standards (for example, what does an 'A' look like?) • The inclusion of IB *command terms* (IBO, 2017c)(or equivalent) • Compatibility with mark books or data entry systems.	The 'graded' assessment rubrics would be elaborated further to include clearer indications of what a certain grade may look like in terms of student performance and to ensure general compatibility with mark books or data entry systems. A final assessment tool would need to include assistance for adapting it to a school's own curriculum practices (for example, Australian curriculum or IB-specific guidance)
	Time, or lack thereof, can be a big challenge in schools. For example, some subjects only have one or two lessons per week, with significant content loads, which restricts their amenability towards inclusion in interdisciplinary endeavours.	The timetable has a direct effect on curriculum. This needed to be taken into consideration, given that some subjects may be needed in an interdisciplinary collaboration but have limited or inconvenient lesson times.

Moving to the next Synthesise *stage*

During Cycle 3, the volunteer teachers continued to be accepting of the indicators of quality from the analysed literature and were confident that these could be applied to the classroom assessment context. There were still some issues with the quality indicator *synergy*, but the *disciplinary grounding* and *integration and process skills* indicators had shown some promising applications at this stage.

By the reflection stage of Cycle 3, it appeared that the challenges with the term 'advancement' were more than a simple terminology problem, and while the third indicator was now called *synergy*, there were still numerous references to 'advancement' within its descriptor and this was causing some confusion. The synergistic effect that comes from disciplinary integration is the key element that has been missing from assessment exemplars in the reviewed literature and it was wondered

whether the challenges that were being encountered at this stage were shedding some light on why such exemplars are difficult to find.

It was also noted at this stage that conversations on interdisciplinary assessment were influencing interdisciplinary teaching and learning in the volunteer teachers' classrooms, particularly seen through Jamie's comments. Teachers were reporting that participation in the research process was influencing their practice, even if they had not chosen to directly use the research prototypes. These emergent findings were noted for later discussion.

The remainder of the feedback suggested a range of increased clarity and elaboration either within the descriptions of the indicators of quality or as accompanying information to guide teachers in using the assessment rubrics. These included how many of the descriptors should be used for assessment, at what stage assessment of the indicators should be carried out and by whom, what a certain level of quality looks like and whether the assessment was adaptable to specific curriculums.

Turning point

Each of these suggestions culminated in leading the researcher to a key decision. Until this point, the focus of the research had been on creating a form of assessment for interdisciplinary learning that would support the planning, teaching and learning cycle. However, it had become clear that assessment rubrics are a simple tool that are part of a broader interdisciplinary curriculum structure and many of the questions that had arisen in Cycle 3 would be better answered in the context of such a broader structure. Therefore, the key decision taken that would influence the *Synthesise* stage of Cycle 4 was to not only improve the assessment rubrics themselves, but to clearly situate them in a framework that guided teachers through an interdisciplinary planning, teaching and learning cycle. It was envisaged that this solution would help to address the practical implementation questions, as well as ensure that the new assessment rubrics did indeed support each stage of an interdisciplinary planning-teaching-learning cycle.

This was a significant conclusion that was drawn at this point in time. If the goal of the research was to create an assessment resource that was accessible for teachers without them needing to access significant amounts of professional learning elsewhere, then it was reasonable to conclude that the assessment resource itself would need to provide broader guidance in a format that surrounded and supported the assessment rubrics and additionally supported teachers' conceptual understanding of interdisciplinarity.

Remaining challenges

Ensuring that the assessment resource could be adapted to specific curriculums was a more-difficult challenge at this stage. This idea was a challenge simply because any curriculum innovation would need to be general enough to adapt to a broad range of curriculums and school contexts and thus enable implementation. Any tailoring of the framework to a specific curriculum, however, would increase accessibility for teachers who use that specific curriculum. It was decided therefore, for Cycle 4, the research would continue with the goal of creating an interdisciplinary planning, teaching, learning and assessment framework that was, as yet, non-specific to any one curriculum. A secondary decision was that after a final framework had been developed at the end of Phase 3, examples of what this framework might look like when tailored to local curriculums, in the case of this research, the Australian Curriculum and the International Baccalaureate Middle Years Programme, would also be created.

In addition to the findings that contributed to the further development of the interdisciplinary assessment framework, additional findings and underlying challenges that came to light in Cycle 3 included:

- The conversations around interdisciplinary assessment during Cycle 3 indicated even more strongly that the assessment ideas were influencing and improving interdisciplinary teaching and learning in the classroom, even if teachers were not using the rubrics to assess student work.
- School structures were having a significant impact on teaching practices in schools and this affected whether and how interdisciplinary (or disciplinary) practice could be implemented. These structures included the organisation of teachers, students and disciplines within a rigid timetable (and time allocation) system, as well as schools' requirements for grades at predetermined times and in particular formats.

The impact of these additional findings is addressed in the discussion chapter (Chapter Seven).

This reflection stage completed Cycle 3 of the framework development. Keeping the feedback, decisions and reflections from Cycles 1-3 in mind, the researcher moved on to create the next draft of the assessment tool, as shown in the *Synthesise* stage of Cycle 4.

Cycle 4: Full framework development

Within Phase 2, the last cycle of development involved taking the cumulative feedback, decisions and reflections from earlier cycles and using these to both improve the draft assessment rubrics and embed them within a planning, teaching and learning cycle. Cycle 4 (Figure 5.1) therefore used cumulative data gathered from Phase 2 Cycles 2 and 3, as well as from the literature review, questionnaire and first interview meetings in Phase 1.

The first step in creating a draft of a full interdisciplinary planning, teaching, learning and assessment framework was to return to the reviewed literature for guidance. Fortunately, as seen in the literature review chapter, there was already sufficient guidance on what planning, teaching and learning in an interdisciplinary context in schools might look like. As this first step of creating a full planning-teaching-learning-assessment framework was completed in the *Synthesise* stage of Cycle 4, decisions that guided its construction are detailed in Chapter Four.

Trial

There was an eight-week delay between the development of the first full interdisciplinary planning framework and the insertion of the revised assessment rubrics. The trial stage for Cycle 4 was therefore designated as asynchronous. Specifically, there were some feedback meetings in between the development of the first full draft of the planning framework and the subsequent elaboration of the assessment rubric component, as highlighted in the timeline below (Figure 5.3). These meetings involved the same teacher groups however and were analysed as feedback on the same draft, albeit in two instalments.

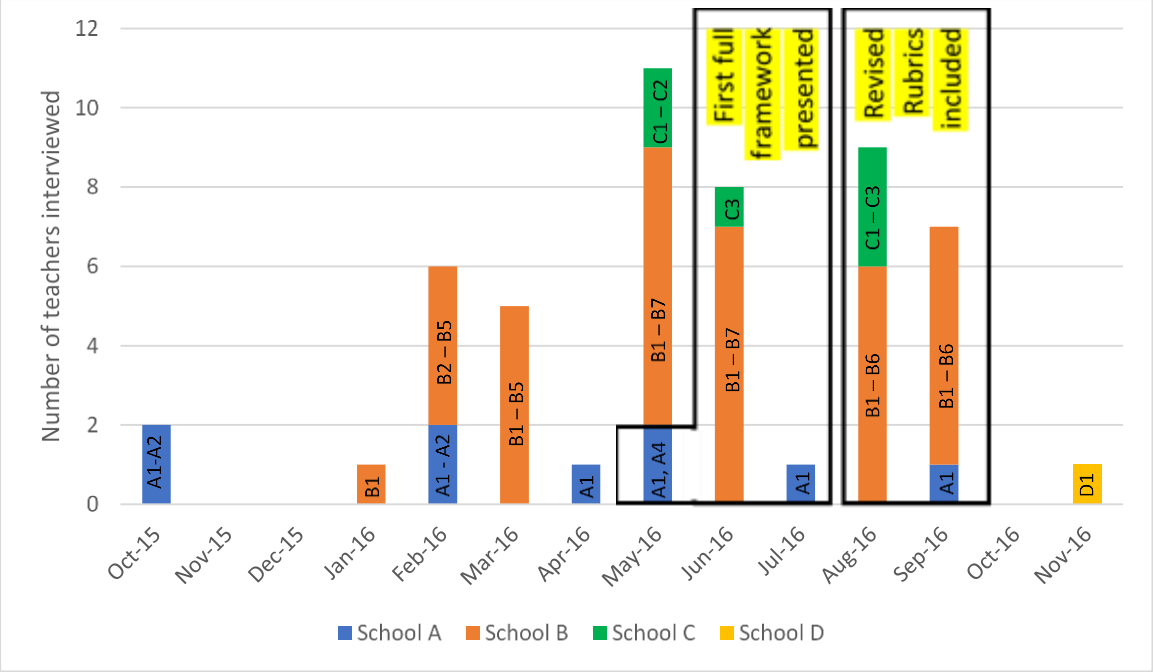

Figure 5.3: Timeline of interviews conducted with teachers, Cycle 4 asynchronicity highlighted

The trial stage of Cycle 4 is therefore presented here in two sections: feedback from the earlier meetings with the full planning framework draft (that included the old rubrics from Cycle 3) and feedback from the second meetings that included the full framework draft with revised assessment rubrics included. The first full framework draft (Figure 4.8) was sent to teachers before meetings in late May-July 2016, and time was spent discussing the presentation and self-explanation of the framework at these meetings. The second full framework draft that included the updated assessment rubrics was sent to teachers in preparation for the August-September meetings. The second full framework draft also included a cosmetic overlay that refined the model into a circular diagram and highlighted the model colours throughout the framework. The content of this second draft, however, remained largely the same as that presented in Figures 4.8 and 4.9 and is therefore not presented in Chapter Four as a new prototype. The draft that contains the revised modelling and colours is included as Appendix E.

The guiding questions for the Cycle 4 meetings with teachers were the same as those described in Cycles 2 and 3 and focused on whether the full framework drafts were:

- *Rigorous*, according to the reviewed literature
- *Accessible*, so teachers could use them with little need for further access to literature or professional learning

- *Enabling*, that the draft framework had the potential to show what interdisciplinary quality looks like and more specifically, what teachers need to do to enable interdisciplinary teaching and learning in the classroom

Rigorous

In the early meetings of Cycle 4, when viewing the first full framework draft, teachers were positive regarding the expanded format as the idea of a planning-teaching-learning cycle was familiar.

The act of drawing the three indicators of interdisciplinary quality into such a cycle prompted teachers to interrogate interdisciplinarity, as defined in the reviewed literature, in terms of how it could be presented in a classroom. For example, whether teachers should identify the disciplines used, whether students should discover disciplines for themselves, whether either or both of these strategies were better for a certain context, or whether the school's curriculum structure would even allow for such choice.

> "One thing that we're trying here is the idea that…, 'these are the disciplines we've spent time on and now we're putting them together' … [we're also] trying to get it to the point where students don't necessarily know what discipline they're working in, so within the essay task, from the teacher perspective there's significant English support and time and significant Science support and time. [But] I think as far as the students were concerned it was just a Science essay." – Jamie, Cycle 4

> "But we're still telling them what subjects to do it in, we're not giving them open slather – I just can't imagine where or how I would produce a task where I would give them open choice about what to combine with English." – Mel … "I guess if you've studied a range of different ways to present in English and then they were doing Science for instance and then they could choose whatever way [they present], then their choices are there. They are still doing English and Science though." – Marie … "Yes, we're still setting disciplines." – Mel … "Yes, but essentially you always are going to be, unless it's a Personal Project or something to that effect." – Marie, Cycle 4

> "I like the comment there – will students choose? And that's something with the interdisciplinary side of things, everyone's doing their disciplinary stuff, so on the interdisciplinary side, students choosing what the end product is, you know, 'we've studied all of this stuff' and then, by choosing something that's relevant, that shows that they've got interdisciplinary understanding." – Robin, Cycle 4

These comments indicated that the framework was useful in prompting teachers to discuss different choices for disciplinary integration, at different stages of student development, rather than leaving the choice completely open. The framework was providing direction for interdisciplinary planning.

These conversations led to discussions on students' understanding of interdisciplinarity and how this might be encouraged or taught in the classroom, particularly at the beginning stages:

> "Yes, I thought I'd do it at the starting point and just ask them – I thought the Science experiment would be a good point at which to ask them, 'Ok, in what part of this process are you using English? At what point will you need to be using your Maths? In what part will you need to use your Science?' The English was the easiest one to answer. The scientific knowledge one, a lot of them said, 'to write the hypothesis I need to use scientific knowledge, to explain the results I need to use scientific knowledge'. It didn't occur to a lot of them that just doing the graph or even working out the averages when they were doing the times that recording the times involves Maths." – Morgan, Cycle 4

> "… there's a range of levels of thinking there as well that I think they could start with – they could talk about prior knowledge, they could talk about other subjects…" – Mel, Cycle 4

> "And I guess that's the challenge that I had when assessing, using this [rubric] to assess students' work, is that the students don't necessarily see the different disciplines in it. Which I think is a good thing – like going, 'of course I'm writing an argumentative essay and there's a particular way to do that'. But they're not always making that connection. Well, there's an obvious thing to learn. And I guess that's in some ways an artefact of how we ask the question, we're *not* asking them, and if they're exposed to everything, they learn with that [already integrated] body of knowledge and they're not necessarily seeing that … 'this bit' is different from 'this bit' because from their experience it's the same 'bit'." – Jamie, Cycle 4

These comments indicated that the framework was useful in prompting teachers to think about the details of planning classroom experiences, particularly from the point of view of the student and how they would be engaged in the interdisciplinary endeavour.

Teachers also discussed the different ways interdisciplinarity could be explained to the students, in addition to what was already in the *Inform* section of the framework draft.

> "So, perhaps it needs to be more than creativity here [in the draft rubric], doesn't it, because it's like you describe, it's that idea of bouncing between subject groups because you need a bit of English now and then a bit of Maths and then some Science and then back to the Maths and it's blending everything together. It's like having a whole tool kit and thinking,

> well, I need spanners and hammers and screwdrivers, etc., but I need them together at the same time…" – Researcher … "I think it needs to be what works at that time, like you can be creative in the kitchen and make some truly awful things and you go, 'well, that's not going to work'. But if you've got basil and tomato and mozzarella cheese, then they tend to work together, so you're being creative – sometimes being creative is using the stuff that you know works." – Jamie, Cycle 4

This comment indicated that the framework was useful in prompting teachers to think about different methods of disciplinary integration, and how these different methods could be introduced to students.

Although the assessment rubrics had not yet been updated at the early meetings in this cycle, the feedback on the rubrics reinforced the feedback from Cycle 3, that the concept of *advancement* from the interdisciplinary literature was still proving to be complex.

> "When you're looking at the advancement, are you looking at a student being able to identify it, or are you looking for that you [as the teacher] can see an advancement, or are you looking for a combination? … Because the advancement is really more like a reflection in a lot of ways, so whether there's a better terminology than advancement?" – Marie, Cycle 4

> "The advancement I'm having trouble with, because how do you judge an advancement from no base position? I guess I was looking for an advancement of attitude, that they recognise it [interdisciplinarity] as a way of thinking and I think that was what I was looking for. But I did find that really hard … I guess *advancement* to me reads like, well, in English we have a 'range of texts' yet we're only looking at one text at a time … how do we mark that on an individual occasion? How do you mark *advancement*? If you're using these criteria every time you mark something that might be simpler, but I did hit a bit of a wall with that." – Mel, Cycle 4

These comments indicated the need for further clarity in transferring the idea of interdisciplinary advancement from the reviewed literature to the interdisciplinary framework. In the later meetings that included discussions on the updated rubrics, the concept of advancement appeared to be clearer. Teachers began to give suggestions for alternative terms and suggested a glossary might be a way of further ensuring clarity.

> "I'm reading some of the key phrases and words there and it strikes me that, in effect, advancement is that student's learning has been enhanced or developed further through working in an interdisciplinary way … is that a fair assessment?" – Max, Cycle 4

The discussion on alternative terms indicated that the concept of interdisciplinary advancement was indeed transferable to the classroom context but needed different modes of support (explanation in introductions and glossary, representation in rubrics) to ensure clarity.

There remained some cautionary comments on 'innovation', that perhaps this might not be age- or context-appropriate in some cases.

> "I had a question around that one as well because it says about, 'skills and concepts in innovative ways', …but they might not, well, a lot of it I wouldn't imagine that it would be in an innovative way, it would just be leading to a deeper level of understanding." – Marie, Cycle 4

This comment further reinforced the need for the framework to encourage interdisciplinary processes and outcomes but to remain flexible enough that it could be tailored to different student cohorts.

Accessible

When viewing the first full framework draft, there was a clear focus on the planning and teaching opportunities of the framework. School A was finding the framework and the prompts therein particularly useful in ensuring that interdisciplinary units of work were planned from the perspective of all disciplines involved.

> "I think that's where we've found this [framework] more useful is not necessarily to mark student work but in designing tasks. Or in assessing the task before it gets to the student… [For example] looking at this one and asking, 'are we setting opportunities for students to see how the disciplines intertwine?', so [it's like] a checklist kind of thing." – Jamie, Cycle 4

This feedback indicated that the act of considering assessment at the planning stage gave teachers a method for accessing an interdisciplinary initiative from a simpler standpoint. If they knew the potential outcome, then it was easier to plan learning experiences.

There were also further comments on the multiple descriptors within the rubrics at this stage, noting that not all descriptors were appropriate for all tasks and reinforcing the need for flexibility to include or omit elements as appropriate:

> "But yes, there are some of them [descriptors] that just aren't relevant, and I can't see how they can be relevant for the most part because of the way we teach at [School B]. At the moment, I can't envisage a task where we would say, "Combine English with "something" to

do [this]" – Mel, Cycle 4 (commenting on students showing '*creativity in choosing and combining disciplines'*)

"It's giving the option that here are integration and process skills, here are 10 different ways it might be done in the task, you might not do 8 of them but for these 2 there's an opportunity to do them really, really well." – Jamie, Cycle 4

"…depending on what your project was, is there potential that you could be just looking at Integration and Process Skills? If you were looking at a skill development? Or do you have to have an Advancement?" – Marie, Cycle 4

Wording within the framework could also be designed to give different options:

"…possibly that last section of the *Integration* criterion could be broadened to say, 'Disciplines, or aspects of disciplines' because then you could ask, have they chosen the right tool to use? So, for example, if we're teaching the unit that [Marie] suggested and I'm teaching report writing and [Marie] is teaching the scientific elements, are [the students] choosing the right elements from the report writing? Maybe I've taught them about using statistics and I've taught them about using graphs and I've taught them about using sub-headings and so on – are they then picking up the right elements to use for their particular report or for their particular product that they're making?" – Mel, Cycle 4

During the early meetings in this cycle, the assessment rubrics had not yet been updated. The feedback at this point reinforced the feedback on accessibility from Cycle 3, that there needed to be more elaboration on how the descriptors might be reflected in a piece of student work. There were some suggestions on ways to do that, for example, as a task-specific elaboration or similar:

"I marked them on two English criteria and to two of the interdisciplinary skills … I didn't find the criteria particularly easy to mark to, but then no criteria are easy to mark to the first time you use them. – Mel, Cycle 4

"I think [the descriptors are] very abstract, very vague and I think that if you're trying to write criteria from junior primary to senior high school then that's going to be the case. So, one way or the other I would say that they need to be – not as part of the criteria perhaps but as an appendix that states what is expected for the students to meet because otherwise [the descriptors] are in danger of being meaningless. My marking was very cursory in terms of that." – Mel, Cycle 4

In the later meetings of the cycle, when the assessment rubrics had been updated, comments indicated that the wording in the assessment rubrics had enabled a clearer understanding of what was expected. There were still some elements that were unclear, however, these would perhaps be better clarified through examples of assessed student work.

> "…some of the language, like 'innovative' or 'substantial' – how do you decide what's innovative, how do you decide what counts as a 'substantial' learning thing, so I had trouble with those words." – Marie, Cycle 4

> "…when I first had a look at it, I was thinking, how do you differentiate between reflection and advancement for the students, because there is a little bit of crossover?" – Robin, Cycle 4

These comments indicated that a full suite of planning, teaching and learning resources would be even more beneficial to support interdisciplinary initiatives. In addition to the interdisciplinary framework being trialled, examples of teacher practice and student work would be useful.

Teachers reiterated during Cycle 4 that the framework would be more accessible if there were versions that were tailored to specific curriculums. This way, teachers would be able to immediately see how the framework would fit with their existing practice:

> "…if it allowed us to [see] how does this support the [Australian Curriculum] capabilities, that would be really handy." – Jamie, Cycle 4

Teachers in International Baccalaureate (IB) schools were particularly interested whether such a framework could help them fill in their IB interdisciplinary unit planner:

> "'…if you're in an IB school, here is where you put this', that would be really helpful" – Rohan, Cycle 4

> "Yes, and that's exactly how I could see a teacher using this, just like a checklist you can work down, making sure you've got all of those elements." – Riley, Cycle 4

Within the idea of accessibility, teachers also commented on the appearance and logical construction of the framework. Many of the comments showed that the framework was clear, however some of the questions that arose indicated that some areas might need redesign, due to unexpected interpretations.

> "I guess, by definition of being a core element, that everything you do would assume to have those three elements in them?" – Marie, Cycle 4

> "Is there a reason *advancement* is above *integration and process skills*?" – Riley, Cycle 4
>
> "I found it easier to go with [Enable] first, than [Inform]. And I know that's not the natural order of things …but in my planning, it was better to do yellow before pink. [Why – asks researcher] I found it easier to understand and I think I was trying to subconsciously justify the integrity of my interdisciplinary unit" – Martin, Cycle 4
>
> "…in the 'level/grade', where you go down and you've got a star by year 6 – I wasn't sure what you meant by having year 6 or year 7 in there?" – Marie, Cycle 4

These comments indicated a need for further explanation of certain elements in the draft framework and guidance on how to use them.

Enabling

When viewing the first full framework draft, the positive effects the research was having on enabling the planning and teaching processes were reinforced, and the prompts within the framework to ensure disciplinary grounding as well as integration was being reflected in the classroom.

> "And because there's [now] so much support around the text type or the genre that students produce, that's the interdisciplinary-ness, it's Science content but the format and the genre, the text features are very much English. So, the benefit to us as teachers is that we often get students who [have fixated on] getting the Science right and they concentrate so much on [Science] that the format falls over and they do a [poor] essay, or their prac-report is awful because it's not [the correct genre of] a prac-report…
>
> …
>
> … So, we spent two or three lessons on, 'this is what an argument is, this is how you structure an argument, is this a good argument, mark this argument'. Compared to previous years everyone went up by a grade-band because now we actually supported that skill whereas traditionally the Science just tells you to write an argument and there's no explicit teaching of it." – Jamie, Cycle 4

These comments further indicated the positive backwash effect that the draft framework was having on interdisciplinary classroom practice.

This was further reinforced through viewing the updated assessment rubrics. School B particularly talked about the need to make the advancement visible so that it can be assessed. This idea was then connected back to the planning and teaching processes necessary to make that advancement happen:

> "So, if [the students] are not going to show advancement, then perhaps there's something wrong with the task and how it's been constructed." – Martin, Cycle 4

> "I thought the same as you when I read through this, that there is the potential to limit the students' outcomes based on …[if] the task you design doesn't quite, well, it might not be that they don't go together but you just haven't planned it right to enable those connections to form. So, I guess any piece of assessment you can mess up for the students through [task] design." – Marie, Cycle 4

There was consensus among each of the three schools, however, that the framework would be very useful as a planning tool for teachers, regardless of whether they used the assessment rubrics formally or not. Indeed, the IBMYP schools would be unlikely to use the rubrics developed in this research for formal assessment, as they are required to use the published IB assessment criteria (IBO, 2017a). While the assessment rubrics developed were helpful in clarifying what quality interdisciplinary learning might look like, and this had influenced the rest of the planning and teaching framework, it was stated the planning-for-teaching elements would be the most useful.

> "I think that's where we've found this [framework] more useful is not necessarily to mark student work but in designing tasks. Or in assessing the task before it gets to the student." – Jamie, Cycle 4

> "For us, this would be a planning tool, an aid for teachers… now that we've got a framework here, if you went through this process, at the end of that meeting you're going to have something concrete and everyone's going to be on the same page. So that's how I see this being really good, that now when we do get that time we can actually have outcomes. Instead of good ideas that then aren't followed through." – Rohan, Cycle 4

> "This is pretty useful – so, go through this in your meeting, ask these questions and once you've gone through this process and written the unit plan, you're ready to go." – Riley, Cycle 4

These comments indicated that the inclusion of an assessment component at the planning stage added a quality-control indicator for the interdisciplinary endeavour.

Additional feedback

There were suggestions that tasks may need to be designed differently so that interdisciplinary process skills can be captured in a final product or performance. This was seen as a positive, given the need for these skills in multiple disciplines. For example, students could complete an exegesis or author's statement, or a journal for a creative piece to make the design process visible.

> "The author's statement is becoming more and more a part of English, so I think that your process journals are like authors' statements in intent, showing what students are thinking. And that's become a part of Personal Project, part of the Extended Essay at Diploma level, etc., so I think reflective thinking is something that we need to be teaching. And tell [the students] that it's something they're going to be doing all the time." – Mel, Cycle 4

The challenges with this approach were clear.

> "With assessment, I think I had to be quite generous with the interdisciplinary skills because I really only had that, well, the main thing that applies to it is the author's statement and that's only 150-200 words long, so how much depth can they actually put in within the realistic word count at year 8? – Mel, Cycle 4

Teachers also discussed the option of assessing integration skills when they were more naturally visible, often at the earlier stages of an interdisciplinary task. These comments supported the idea that the timing of assessment might be considered differently in an interdisciplinary learning context.

Most comments within the meetings focused on the three guiding themes of academic rigor, accessibility and potential for the framework to enable interdisciplinarity in a classroom. There were also discussions, however, on how the structures within a school could negate all of these through the restriction of choices. For example, if two teachers were designing an interdisciplinary unit, then the unit would generally use those teachers' disciplines rather than engaging with other disciplines that might better address the problem or challenge. One teacher of multiple disciplines reflected on whether this might have caused difficulties in previous units:

> "…I could contrive mine because I was the teacher for both subjects, so I didn't have to collaborate with a colleague… so, it was all very contrived and teacher-led, which is why I think it didn't work with *advancement* skills because it was all done by me and not naturally out of the learning process." – Martin, Cycle 4

During Cycle 4, with the introduction of the full planning, teaching, learning and assessment framework, an important element became apparent. The framework had become a long document (10 pages at this stage) and there was potential for it to become unwieldy when teachers used it, particularly for the first time. The researcher highlighted this issue for consideration at the time when the final framework would be developed, lest the length of the document present accessibility issues.

In addition, there were interesting discussions that centred around the context of one teacher in School B. This teacher worked solely with a class of recently-arrived international students and the class was designated as an intensive English-language class with the intent of helping the students access the mainstream school curriculum as quickly as possible. The curriculum for this class, however, was not based on English language acquisition alone, rather, learning how to access all school subjects in an Australian school environment. Nearly every lesson therefore was planned as interdisciplinary, given that the students were learning a second language as well as subject-based content and skills. It was noted that the purposes for interdisciplinarity, both in the framework and in the interdisciplinary literature, did not explicitly address this second-language purpose and this would need further investigation.

Analyse-Reflect

The *Analyse-Reflect* stage of Cycle 4 involved collating the feedback gathered from the teachers in the *Trial* stage and cross-referencing the feedback with the reviewed literature to ensure the assessment and broader-framework design remained aligned with the reviewed research in the field. At this stage, however, it was considered that the framework was now at its full expansion and that any data gathered would help to improve the framework content in the next phase rather than expand it further.

The feedback from teachers in Cycle 4, based on the first full draft of the interdisciplinary planning, teaching and learning framework and the updated assessment rubrics (Figures 4.8 and 4.9), was collated, analysed and reflected upon as shown in Table 5.7.

Table 5.7: Analysis of teacher feedback and decisions made, Cycle 4

Feedback code	Feedback overview	Decisions made by researcher
Rigorous	Although interview discussions produced some examples, some teachers were unsure about how to introduce the concept of integration to students. For example, should teachers identify the disciplines used? Should students select disciplines themselves? Would either of these strategies be better in certain contexts? This would need clarification.	The flexibility around subject integration needed to be emphasised. The reviewed literature specifies that disciplines should be integrated to serve an interdisciplinary purpose (Boix Mansilla & Gardner, 2003; Klein, 2012; Repko & Szostak, 2017): it does not dictate who selects the purpose, disciplines involved or integration style. This flexibility needed to be included.
	An example of integration that was not present in the literature was suggested: the idea of flitting between subject groups so quickly that the disciplines appear integrated.	The example of integration that suggests the idea of drawing together multiple subject groups in quick, cyclical succession would be included.
	The concept of advancement from the interdisciplinary literature was becoming clearer, however, it was still complex. Alternative terms were suggested, as well as the idea of a glossary to ensure clarity.	Alternative terms for advancement would be considered for the next draft framework. A glossary of terms would also be included in the final framework.
	Some concepts or outcomes suggested in the reviewed literature, for example, "innovation", might not be age- or context-appropriate in some cases. This would need revision to ensure clarity.	Some concepts or outcomes suggested in the reviewed literature, for example, "innovation", would need to be emphasised as *appropriate to students' age or school context*.
Accessible	Teachers desired flexibility to include or omit certain elements of interdisciplinary practice, assessment descriptors or part thereof, according to the needs of an interdisciplinary endeavour, differentiation for students, or school context (collaborative, timetable, assessment and reporting constraints).	The flexibility to include or omit, as appropriate, certain elements of interdisciplinary practice or assessment descriptors needed to be emphasised in the framework.
	Teachers desired examples of how the descriptors might be reflected or better clarified in student work. Tailoring the framework to specific curriculums would assist greatly with accessibility.	Two extensions to the framework could be provided: • Examples of student work that has been assessed with the rubrics could be provided to further exemplify the framework. • The framework could be tailored to specific curriculums, for example, Australian Curriculum, IBMYP.

	The core elements in the framework model were interpreted as hierarchical. This would need careful consideration.	The framework model needed to be revised to ensure that any implicit hierarchies are either supported by, or adjusted to better reflect, the analysed literature.
Enabling	The idea of a cyclical connection from assessment to teaching and learning was reinforced by the teachers.	While this idea would not impact on the development of the next draft, it was a significant finding from the interviews.
	Opportunities for quality planning and teaching offered through the framework continued to be identified. Comments indicated that the framework would be useful as a planning tool whether or not teachers used the assessment rubrics – it was the planning *for* teaching elements that were reported as the most useful.	Opportunities for quality interdisciplinary planning and teaching offered through the framework were reinforced. The influence of the assessment rubrics on planning, teaching and learning were accepted as a critical part of the framework cycle. This was noted as a significant finding from the interviews.
Additional feedback	Some task modifications required to make interdisciplinary learning more visible, for example, requiring journals, author's statements, reflections, were well received since these task-types are transferable to various disciplines. Some performance elements, for example, integration and process skills, are not always visible in a final task. Some skills may therefore need to be assessed at different times.	Interdisciplinary endeavours need careful consideration of how interdisciplinary learning is made visible. For example, • Some skills, especially integration and process skills, may need assessing in the early- or mid-stages of a task, rather than in a final product. • Students could show reflection, for example through journals, author's statements or similar, to show interdisciplinary advancement.
	Some school structures may restrict interdisciplinary endeavours. For example, timetabling and the disciplinary organisation of schools may cause teachers to create interdisciplinary endeavours that include certain disciplines and exclude others.	Flexibility in the framework would need to cater for existing school structures. For example, many schools are organised by discipline and therefore interdisciplinary endeavours might also be driven by discipline availability rather than interdisciplinary purpose.
	Interdisciplinary engagement through second-language acquisition is a common yet often unidentified category of interdisciplinary purpose.	Second-language acquisition needed to be investigated as a new category of interdisciplinary purpose.

Moving to the next Synthesise *stage*

The reflection stage of Cycle 4 involved the researcher reflecting on the complete cycle. This involved ensuring that the planned changes for the next prototype was justified and that the guiding questions for the development of the assessment tool, whether the draft assessment rubrics were rigorous, accessible and enabling, were being addressed.

The feedback in Cycle 4 focused more on the practical applications of the framework and less on its research base. Therefore, many of the decisions made by the researcher at the end of this cycle related to ensuring the accessibility of the framework and ease of use in a classroom context, and less related to aligning suggestions with the reviewed literature.

The reviewed literature has clear guidelines on what constitutes interdisciplinarity and what might assist with its assessment. Specifically, there must be conscious and deliberate integration of disciplines to enable transformation of understanding and skills. These indicators of quality (as detailed in Table 4.1) might help in evaluating interdisciplinary programs. There are diverse methods for enabling interdisciplinarity in the classroom, however. An interdisciplinary planning, teaching, learning and assessment framework, therefore, should accommodate this diversity. For this reason, questions within the framework needed to emphasise teachers' and students' freedom to include or omit a range of elements as appropriate to the interdisciplinary challenge, or their school context.

As an extension to this emphasis on inclusivity, examples of what the framework may look like when adapted to local curriculums were designated for development after the end of the research process. It was envisaged that this would increase accessibility of the framework and further exemplify how teachers can adapt the content for their own purposes.

While flexibility is critical in making the framework accessible, interdisciplinarity requires that there are necessary changes in teaching and learning practice that also need to be made clear within the framework. This clarity would help guide teachers and students in changing practice and ensuring that interdisciplinary teaching and learning is made visible. For example, assessment task types may need adjustment and certain skills may need assessment at early- or mid-stages of a task. This flexibility of thinking was to be inserted into the *Inform* and *Enable* components of the framework.

There are examples in the reviewed literature of interdisciplinary purpose and how integration of disciplines might occur, however, there was the possibility that the research might uncover more purposes and there might be further examples in the future. Three particular needs that were uncovered in this Cycle were designated for insertion into the framework: second-language

acquisition purpose (a new sub-purpose), rapid integration of multiple skills (a sub-category of cross-over tooling) and disciplinary availability (contextual flexibility).

Even though teachers did not comment on the length of the framework as an issue, its presentation would need to be carefully considered so that its guidance remained easily accessible, despite its length.

The findings in Cycle 4 reinforced and continued to expand upon findings from earlier cycles. By this stage it had become clear that some emergent findings, those indirectly related to the framework development, needed to be discussed further, particularly the cyclical nature of the curriculum – teachers were finding that teaching, learning and assessment were closely connected and had a strong influence on each other – and the impact of school structures on curriculum innovation. This latter finding specifically related to timetabling and disciplinary time allocation structures, as well as assessment and reporting structures that had created challenges to the implementation of innovative teaching ideas. These emergent findings were collated according to the context themes shown in Table 3.5 (Chapter Three) and retained for later discussion (Chapter Seven).

End of Phase 2, Cycles 2-4

Phase 2 was the *design, evaluation and re-development* phase of the research. The data presented so far in this chapter has provided an insight into the *Trial-Analyse-Reflect* stages of the design cycles that informed the synthesis of the interdisciplinary planning, teaching, learning and assessment frameworks. It has explained how the framework drafts were synthesised through drawing upon the research literature, feedback from volunteer classroom teachers and through analysis and reflection by the researcher.

Findings from the interviews indicated the draft framework was rigorous according to the reviewed literature and generally accessible and enabling at this stage of development, even though some further modifications were still needed. The framework, while initially driven by the creation of assessment rubrics, was receiving positive feedback on its ability to guide planning and teaching rather than assessment per se. Despite the lessened focus on assessment, however, this was still seen as a key element that supported the planning, teaching and learning cycle and was integral to framework quality.

In Phase 2, the interview data also began to show the complexity of the school context. While the development of the framework itself was explicitly addressed in the interviews, implicit feedback related to school contexts demonstrated the impact that school structures, for example, timetabling

and existing assessment processes, were having on teachers' ability to implement innovative curriculum.

In Phase 3 of the research, the penultimate draft of the framework was developed and subsequently reviewed by a volunteer teacher from a fourth school. The remainder of this chapter presents the *Trial-Analyse-Reflect* stages of Cycle 5. This includes the interview data from School D that contributed to the final analysis and development.

Cycle 5: Full framework independent review

Cycle 5 (Figure 5.4) of the research involved an independent review of the draft framework by a school that had not been involved in the extended development cycles. This method was primarily used to evaluate the immediate accessibility of the full framework. This was in addition to soliciting feedback on the framework's academic rigour, general accessibility and ability to enable interdisciplinary teaching and learning in a classroom, as per the previous development cycles.

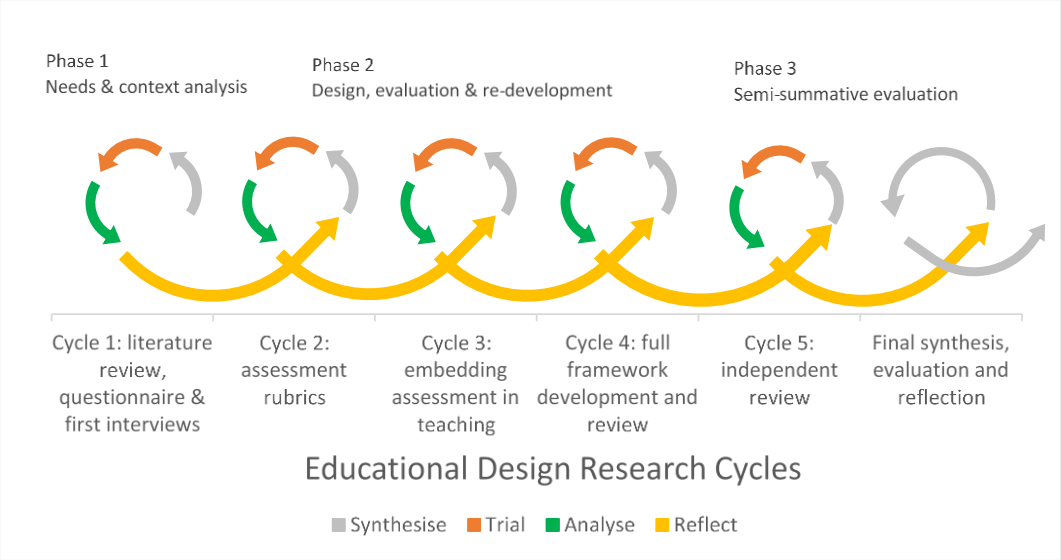

Figure 5.4: Trial, Analyse and Reflect stages that influenced each framework prototype

Trial

The trial stage for Cycle 5 of the research was aimed at evaluating the full draft framework as developed and reviewed by the volunteer teachers from Schools A, B and C. For this reason, a teacher who had identified themselves as an experienced interdisciplinary educator through the recruitment process and who had not participated in the ongoing development of the framework, was recruited to provide feedback on what was considered a final development draft. As the teacher had not previously seen the framework or been involved in development discussions, this was an ideal opportunity to gauge the immediate accessibility of the framework. The meeting would also give an opportunity to gain feedback on the qualities aimed for in the development stages, specifically, whether the framework was rigorous according to the reviewed literature, accessible and enabling. Feedback was sought to evaluate how feedback from School D might compare or contrast with that from Schools A, B and C. The framework draft presented in Figure 4.11 (Chapter Four) was sent to the teacher from School D in preparation for the interview meeting, though the progress of the meeting also involved a collaborative reading through of the framework.

Rigorous

The teacher supported the notion that the framework integrates interdisciplinary purpose in the interdisciplinary planning, teaching and learning cycle. This was contrasted with another curriculum, where disciplinary grounding and integration is assessed, but the interdisciplinary purpose, the transformation of understanding and abilities, is not:

> "Yes, the whole purpose for doing it. I guess that appears in the [alternate curriculum] unit planner but isn't necessarily explained to students and I think that's what's lacking." – Dale, Cycle 5

There was evidence that the purpose, as presented in the rubrics was better understood now, although the teacher also considered the issues inherent in the term *advancement* and had suggestions for improvement, which aligned with earlier comments from Schools A and B.

> "…maybe it's that the term advancement implies that they've got to be above and beyond the standard, but I guess what I'd be thinking about with interdisciplinary is not so much advancement per se, but what are you achieving by bringing these together that you could not have done as effectively [with one discipline]? So, that is a key thing for me, it's not necessarily above and beyond what the standard was, it's more a case of how do these two things come together to make it better?" – Dale, Cycle 5

> "I think for me, what [advancement is] about is, it's back to that transformation, it's got to be transformative. It's got to be where the two things come together to create something that is enhanced maybe. Maybe 'enhanced' is the word?... if you enhance something it means that there's an improvement to it and that there's another way of looking at it, but it doesn't necessarily mean it's an A [grade] or a B. It almost seems like levels with [advancement]. Interesting how one word can make such a difference." – Dale, Cycle 5

These comments confirmed the idea raised by schools A and B that "enhancement" was the term that was perhaps best suited to communicating the nature of an interdisciplinary transformation.

Accessible

Similar to the other schools, the interview with School D indicated that the planning and teaching affordances of the framework had the potential to be the most useful aspect.

> I guess I was thinking in terms of a planning tool… I really like, for example, that middle section where you have questions and things, I can see how we could tap into those because I think it's back to that planning stage. I can say to my teachers… 'here are some great

> questions to get you thinking about it, you don't have to wade through the whole [curriculum] manual for an IDU'… So, I can see how they can use this." – Dale, Cycle 5

This comment indicated that the questioning style of the framework was a helpful method of prompting teacher planning.

In addition to making the framework curriculum specific, this interview broached the topic of a different format that would make the framework more accessible. Specifically, it was suggested that an online, interactive version might better enable teacher collaboration and address the need to assess *integration and process skills* at early- and mid- stages of an interdisciplinary endeavour.

> "… are you thinking about creating an online tool that people can actually, so, if you're planning then I can put my stuff in and you can put your stuff in and when we're marking we can both put comments in? Because, to me, that's more of an online, interactive tool in which we can both be working, in my office, in your office, wherever and then somehow bringing it together. I can see that that could be a really good option without having to directly talk to each other all the time… I think the more online it is, the more user-friendly it will be. Because I think, as a platform, that's probably what people need." – Dale, Cycle 5

> "And I think that would be an opportunity where [teachers] can dialogue in this platform and to say, 'I can do this', or, 'I've just observed [student] doing blah-blah', so you could have that observational, anecdotal stuff that then helps to inform your synthesis results… something you can do even when you're in the lesson, like you can be wandering around with a tablet and making a comment and if the class list is available there and you've got some checklists, [teachers] could do stuff like that." – Dale, Cycle 5

These comments reinforced the idea that the framework would be most useful if it were available in a range of formats.

Enabling

There was further positive feedback on how the framework ensures that all indicators of interdisciplinary quality are evident throughout the planning, teaching and learning process and how this has much potential to enable quality planning overall:

> "I'd say it's much more of a planning tool for me rather than as a student assessment, because I think it goes back to the core of the interdisciplinary planning process, which is really asking, 'What's the purpose? Why are you doing this?' And perhaps as a reflection tool for [students] at the end… and it prompts you – I could really see this as a useful tool at the

start of an IDU unit planning. I think, particularly the inner circle of your model is a really good one, it really gets you thinking about all of that." – Dale, Cycle 5

"The core is probably the thing that, oh and I do like the [formative] feedback sheet as well, that's really cool, but I think, to me, that is the centre of what we have to think about before we go any further and I think [current curriculum] provides us with some of this sort of [planning] stuff, not all of it, but, I think, as a model to help teachers out, I think it will be very effective, it will be good to have a go with it." – Dale, Cycle 5

There was also positive feedback on the assessment criteria, however, it was noted that teachers would still need to convert the rubrics to be task specific so that students would understand the expectations.

"I still have to define what synthesis looks like to a student. For me, that is the big thing – what does this look like to a student – so that they can then go, 'oh, yes, I get it, that's what I'm doing' and I think, for me, that's the big thing. Because I myself can see that, 'you've obviously used some English skills here and some History skills here and some other skills here' and I can kind of see it, but could that child articulate it? I'm not so sure. And I feel like they should be able to… [we] at least want to be able to introduce the idea. Like, this is your English bit and this is your History bit, so at least [students] know what it is." – Dale, Cycle 5

These comments indicated that while the draft framework had the potential to be highly enabling for teachers in the planning, teaching and learning aspects, the assessment section could still benefit from additional clarity. In addition, it would need to be clear that the assessment rubrics would always require some level of adaptation to the classroom context, simply due to the natural diversity of interdisciplinary endeavours.

Additional feedback

There was some discussion around the challenge of being able to make interdisciplinary learning visible without requiring that students generate extra explanatory work to provide evidence of their interdisciplinary thinking. This idea had been discussed with the other schools, as they had also experimented with the idea of assigning authors' statements or process journals, or similar, to capture student thinking. This challenge impacts upon both teacher and student workloads, namely, if students produce more work, then teachers have more to assess. The teacher questioned whether interdisciplinary process skills could be made visible in a single piece of work.

"… it feels like they need a writer's statement to go with their product, but then they've got more work, which kind of annoys me… [description of History-English task] [students] had to

present their posters to us, showing what they'd brought in from English and what they'd brought in from History. But then they've got a product that's a poster *and* a product that's an oral to be able to do that. And then we're like, we've just made you do two lots of work anyway. How could we see the synthesis in that poster without [students] having to actually say it and state it? That, to me, is the challenge that I haven't worked out the answer to." – Dale, Cycle 5

"…one of the things that staff want to know is, how do we manage this marking so that it doesn't go above and beyond what we already have to do?" – Dale, Cycle 5

These comments emphasised the need for interdisciplinary assessment processes to introduce innovative methods for summative assessment. Teachers had noticed the assessment challenge that important interdisciplinary skills were being used during an interdisciplinary endeavour but that these skills were not necessarily evident in a final interdisciplinary product. A modification to the timing of assessment would need to be emphasised in the final version of the framework.

Analyse-Reflect

The *Analyse-Reflect* stage of Cycle 5 involved collating the feedback gathered from the teacher from School D in the *Trial* stage and using it to build upon the reviewed literature and teacher feedback captured in Phases 1 and 2, to further improve the interdisciplinary framework. This had been the last stage for feedback to be gathered from schools. From here, the data gathered would be used to improve and refine a framework that addressed the purpose of this developmental research.

The feedback from the teacher in Cycle 5, based on the second full draft of the interdisciplinary planning, teaching and learning framework, was collated, analysed and reflected upon as shown in Table 5.8.

Table 5.8: Analysis of teacher feedback and decisions made, Cycle 5

Feedback code	Feedback overview	Decisions made by researcher
Rigorous	The inclusion of the three indicators of quality from the analysed literature was well received, particularly that of interdisciplinary purpose. The interdisciplinary purpose, formerly presented as advancement, was better understood and there were suggestions for improvement to terminology.	The inclusion of the three indicators of quality from the analysed literature was well received. This would continue into the final version of the framework. Interdisciplinary purpose would keep its current assessment title, *transformation*, but *enhancement* would be used in preference to *advancement*.
Accessible	In addition to making the framework curriculum-specific, an online and interactive version of the framework was suggested. This would make the framework more easily accessible for teachers.	Extensions to the framework could be provided as a supplement to the final thesis-version: • The framework could be tailored to specific curriculums, for example, Australian Curriculum, IBMYP • An online, interactive version of the framework could be investigated to make the tool even more accessible.
Enabling	There was positive feedback on the assessment rubrics, but it was noted that teachers would still need to convert the rubrics to be task specific, so students would understand the expectations. An online and interactive version of the framework could make the framework more enabling for teachers: an online, interactive version would better enable teacher collaboration and more easily enable assessment of *integration and process skills* at early- and mid- stages of an interdisciplinary endeavour.	Extensions to the framework could be provided: to accompany the examples of assessed student work, task-specific rubric examples could also be provided. An online, interactive version of the framework needed to be investigated with a view to development, to more easily enable both teacher collaboration and assessment of *integration and process skills* at early- and mid- stages of an interdisciplinary endeavour.
Additional feedback	Task modifications required to make interdisciplinary learning visible were considered, as well as the challenge of creating more 'work' for students and teachers within this solution.	The solution of assessing *integration and process skills* during an interdisciplinary endeavour needed to be emphasised. Assessment of these skills through observation and interaction appears to be potentially more effective than requiring task modifications (for example, an exegesis or author's statement) to make interdisciplinary learning visible.

Moving to a final framework

The reflection stage of Cycle 5 involved the researcher reflecting on the complete independent review cycle and how it had built upon the development cycles from Phases 1 and 2. This reflection involved ensuring that quality feedback had been captured and that any planned changes for the final version of the framework were justified according to both teacher feedback and the reviewed literature.

The discussions on the final indicator of quality, *transformation*, suggested terminology that better reflected the nature of interdisciplinary advancement. An *enhancement*, as described by the teacher interviewed, implies an overall improvement in quality, depth or perspective, while not implying that there is a physical move from one "grade" to another.

As decided in Cycle 4 and reinforced here, examples of what the framework might look like when adapted to local curriculums can be developed after the framework is finalised. All schools suggested that tailoring the framework to specific curriculums would make the framework more immediately accessible. Examples of student work that have been assessed with the rubrics and task-specific rubrics could also be provided as part of this.

An online, interactive version of the framework would certainly make the tool more accessible, as well as enabling key elements of the planning and assessment cycle, for example, enabling teacher collaboration and the assessment of *integration and process skills*. This further development is outside the scope of this research; however, it is a natural progression of the project and can be investigated further post-thesis.

The timing of assessment of *integration and process skills* needed to be more clearly articulated within the framework. These skills can be assessed at the end of an interdisciplinary endeavour, but only if they have been made visible somehow, which likely involves the production of explanatory pieces, for example, authors' statements or process journals. It may be more efficient, therefore, to assess these skills at the early- or mid-stages of an interdisciplinary task, at a time when students are integrating disciplines and demonstrating their academic process skills in the classroom. Both these options are valid methods for interdisciplinary assessment and the framework needs to clearly offer teachers and students the choice.

The findings in Cycle 5 reinforced and continued to expand upon findings from earlier cycles. At this final interview stage, there was one more significant finding for discussion, the idea of using an online application that could enable both collaborative and time-dependent assessment practices. It

is interesting that Schools A, B and C had not broached this idea, despite the technology being available in their schools. This proposition is further discussed in Chapter Eight.

End of Phase 3, Cycle 5

Phase 3 was the *semi-summative evaluation* phase of the research and its presentation is spread across the findings and discussion chapters of this thesis. Phase 3, Cycle 5 was the first evaluative cycle of the research and involved the presentation of the penultimate draft of the interdisciplinary planning, teaching, learning and assessment framework to a school that had not been involved in any of the previous development cycles. This was both to gain independent feedback on the framework draft, as well as to better gauge the immediate accessibility of the framework with a new school.

The findings in this cycle indicated that the draft framework was rigorous according to the reviewed and analysed literature and was generally accessible and enabling, though there were still suggestions for improvement. The framework continued to receive positive feedback on its potential to guide planning and teaching.

The interview data continued to show the complexity of the school context. Feedback on the challenges teachers face when attempting to implement innovative curriculum, particularly when it impacts timetabling or existing assessment processes, was useful, as were the suggestions for addressing these challenges.

Chapter Five: Summary

While qualitative research is unique to each context in which it is situated and may not be suitable for repeat studies, Cobb and Gravemeijer (2008) reinforce the requirement for Educational Design Research to be presented as replicable. This does not imply that the research should be replicated, only that others be informed so they can see the pivotal components of the design, including the culminating forms of reasoning, and subsequently customise the design to their own context (Cobb & Gravemeijer, 2008, pp. 88-89).

Chapters Three, Four and Five are the key chapters in which this research is described in a manner that enables its replicability. Chapter Three described the Educational Design Research methodology that guided the research, including methodological choices as appropriate to the research context, and described the research contexts in detail. Chapter Four described the product outcomes – the framework prototypes – from each of the *Synthesise* stages of the research cycles. Chapter Five described the data gathered from the teacher participants and their school contexts and the analyses and decisions that contributed to the evolving prototypes.

Chapter 6 – Research Outcome

Chapter Six describes the *Synthesise* stage of the second half of the *semi-summative evaluation* phase of the research that brought the development of the framework to a close. This was followed by a final *Evaluation and Reflection* stage (Figure 6.1). Both these stages were completed by the researcher based on the data collected in all previous phases and cycles.

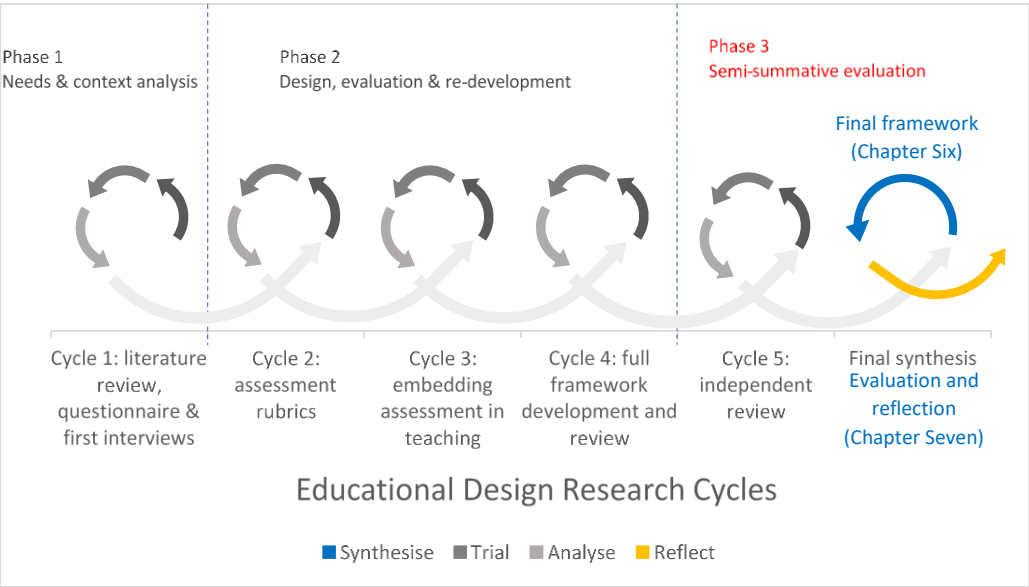

Figure 6.1: Final synthesis stage of the final research cycle, presented in this chapter

Chapter Six presents the original contribution to knowledge of this thesis, namely, a framework that provides support for classroom teachers in implementing interdisciplinary planning, teaching, learning and assessment, and that addresses the resource gap identified in the interdisciplinary conceptual and guidance literature. In doing so, it directly addresses the research question:

How can interdisciplinary planning, teaching and learning be enhanced through assessment design?

The short answer to this question is, *by (1) identifying indicators of quality interdisciplinary learning, (2) describing them in detail and (3) embedding these indicators throughout the planning, teaching and learning cycle.*

This chapter proposes that a new framework for interdisciplinary planning, teaching and learning, one that incorporates assessment at every stage, might be useful for teachers in a middle-school context. The full framework itself is presented first (Figure 6.2), followed by the final analyses and decisions that led to the alignment of the framework with the reviewed literature and teacher feedback.

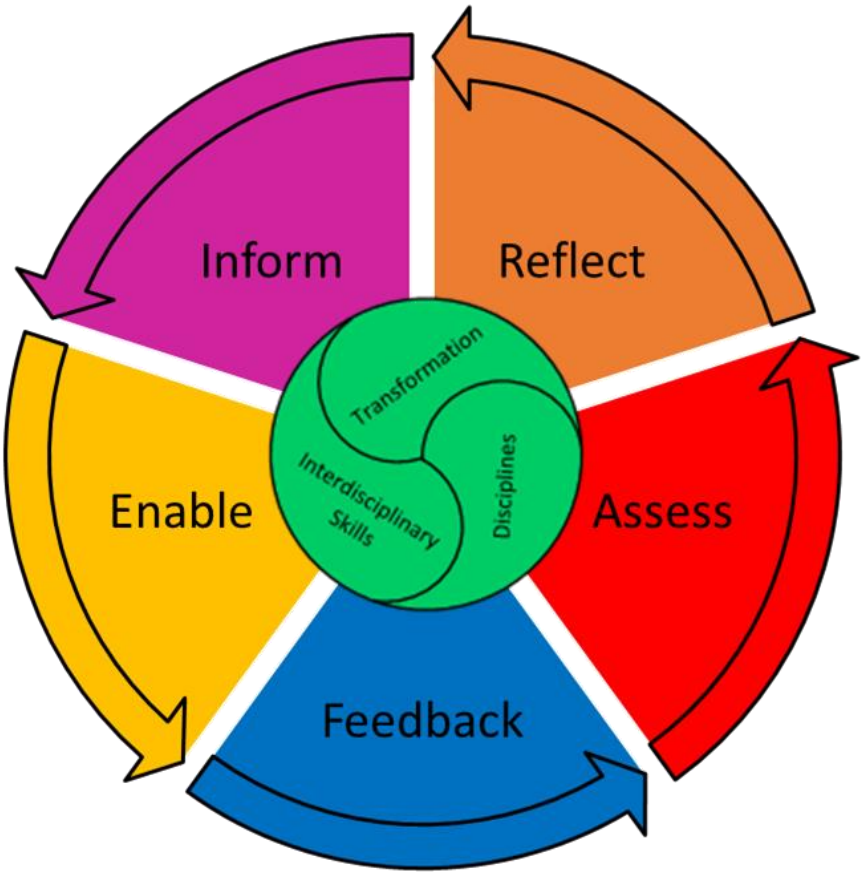

Figure 6.2: Interdisciplinary framework model (1 of 13)

The model shows indicators of interdisciplinary quality (green) embedded in the planning, teaching, learning and assessment cycle

Core Elements

Disciplines

Identifying and addressing disciplinary objectives within an interdisciplinary endeavour ensures that student work is rigorously grounded in the disciplines. Students can then use the disciplines as building blocks for interdisciplinary transformation.

Disciplines, and their corresponding objectives, will likely be defined by a school's existing disciplinary curriculum (e.g.: national/state curriculum, IB programme, school-based discipline). Teachers and students should choose the objectives that are most relevant to the interdisciplinary endeavour. Further prompts that help align the disciplines with the interdisciplinary purpose are contained within the framework.

Interdisciplinary skills

Students show the ability to integrate relevant disciplinary knowledge, concepts and skills in innovative ways to address the situation presented. At various times throughout the interdisciplinary endeavour, students might show:

- understanding of the relationship between disciplines. How do the disciplines support or contrast each other? Do they interlock, intertwine, blend, build upon, borrow, adapt, exapt, reframe?
- an ability to communicate across and between disciplines that generates mutual understanding of the situation presented and that enables a solution, product or more-complex understanding. This may include the development or use of an interdisciplinary vocabulary.
- an ability to reflect upon and analyse the disciplinary combination, particularly if disciplines are contrasting: how does the combination of disciplines illuminate the issue, problem or challenge?
- creativity in choosing and combining disciplines, when appropriate.

Transformation

Students show an enhancement of knowledge, understanding, skills or attitudes that could not have been achieved through a single discipline. At the end of the interdisciplinary endeavour, students may show:

- a quantitative or qualitative enhancement of knowledge, concepts, skills or attitudes in an integrated context. Enhancement may be reflected in innovation, creativity and/or complex analysis.
- elements of synergy, emergent complexity or serendipity: deliberate or unexpected enhancements that arise from skilful integration of disciplines.
- the ability to reflect upon and evaluate their own enhancement of knowledge, concepts, skills or attitudes in an integrated context.

Figure 6.2a: Core Elements

Inform Interdisciplinary Design

What is the purpose for interdisciplinarity? How do the core elements influence unit or task design?

Who will find, generate and drive the interdisciplinary endeavour?

Purpose of the interdisciplinary effort	**Questions that guide planning of the unit or task**
Instrumental interdisciplinarity: Task-, Outcome- or Problem-focused • Will it be an aesthetic or literary synthesis: a symbolic work that can help viewers make sense of complex ideas that span disciplines? (Boix Mansilla, 2010; IBO, 2017a; Klein, 2012) • Will it be personal expression: a song, poem, artwork, performance or similar that expresses a concept? (Boix Mansilla, 2010; IBO, 2017a) • Will it be a practical solution: multiple disciplines combine to address a problem and create a product, find a solution, develop an intervention? (Boix Mansilla, 2010; IBO, 2017a; Nikitina, 2006)	Will the interdisciplinary endeavour be: • Teacher-selected? (due to school constraints?) • Student-driven? (will students find an interdisciplinary challenge themselves?) • A combination of teacher- and student-driven? What is the purpose of this interdisciplinary unit/task? (Choose one from the column at left) **Core elements** With the purpose in mind:  What disciplinary objectives will be met? What existing disciplinary assessment will this involve?  What interdisciplinary skills* do students need?  What transformation* might happen? *Check the *Core Elements* and *Assess Interdisciplinary Achievement* for ideas
Methodological interdisciplinarity: Skill-focused • Will it involve cross-over tooling: use of a skill or concept in multiple disciplines to understand a new issue? (Boix Mansilla, 2010; IBO, 2017a; Klein, 2012) • Will it involve communication through a first or second language that integrates linguistic objectives into the process or outcome?	
Theoretical interdisciplinarity: Knowledge- or Concept-focused • Will it be a complex explanation: combining expertise from multiple disciplines to develop a more complete/complex understanding? (IBO, 2017a; Nikitina, 2006) • Will it be a contextualisation: embedding ideas from one discipline into another disciplinary context or into a larger philosophical framework? (IBO, 2017a; Nikitina, 2006)	
Critical interdisciplinarity: Philosophical focus • Will the interdisciplinary endeavour critique the structure of knowledge and education? Will philosophy be used as an integrating lens through which one or more disciplines will question what is known and how we know it? (Frodeman, 2013; IBO, 2013; Klein, 2012; Nikitina, 2006)	

Figure 6.2b: Inform Interdisciplinary Design

Enable Interdisciplinarity

How do the core elements enable the interdisciplinary unit or task?

Core Elements	Questioning	Enabling
Disciplines 	• What do students need to know from the disciplines? • How will we learn this?	• What are the disciplinary objectives? • Where do they come from? • How will the objectives be assessed? And ***when***? • Could teachers and students design the task-specific rubric together? • How can the disciplinary objectives be taught/learned? • What activities will the students need in order to develop expertise in the disciplinary building blocks? • Is the interdisciplinary endeavour centred through one discipline (for example: arts-based learning), or are they relatively equal?
Interdisciplinary Skills 	• How will the students (or teachers) combine the disciplinary knowledge, concepts, skills or attitudes? Will the integration interlock, intertwine, blend, build upon, borrow, adapt, exapt, reframe?	• What are the integration skills needed in this unit or task? • How will students combine disciplines? • What skills do students need to think about disciplinary combination? • How can students act upon their integrative thinking? • How can students show their integrative thinking? • How and ***when*** will these skills be assessed? Interdisciplinary skills are often best assessed ***as they occur***, rather than as part of a final product.
Transformation 	• What will students produce? • How will students show their learning? • How will students recognise and show their transformed awareness?	• What do we imagine will be the outcome of this unit or task? A product, solution, explanation? Will students choose? • How will the outcome show the disciplines? • How will the outcome show the integration? • Within the above, is the unit or task open enough to allow a transformation to occur? • How will students recognise the transformation? (By using multiple disciplines, do you think you have a better understanding?) • How will students talk about the transformation?

Figure 6.2c: Enable Interdisciplinarity

Formative Feedback

How do the core elements and the planning, teaching and assessment sections enable formative feedback?

How will students bridge the gap from where they are to where they wish to be?

Core Elements	**Scaffolding to enable interdisciplinarity (what did we plan to do? Refer to previous sections, *Inform* and *Enable*)**	**Formative feedback – example guiding questions How will students bridge the gap to achieve an outcome that reflects 'quality'? How will teachers see what is needed?**	**Targeted performance descriptors (where are we heading? Refer to next section, *Assess* for more detail)**
Disciplines 	What did we plan to do? What could the outcome be? What are students aiming for? **This will reflect information from the previous *Inform* and *Enable* sections.**	• How can the student improve the disciplinary building blocks – knowledge, concepts, skills or attitudes – required? • What does disciplinary quality look like? • How can the student bridge the gap between current and targeted disciplinary performance?	Where are we heading? What is considered 'quality' in this interdisciplinary endeavour? **This will reflect information from the next section, *Assess*.**
Interdisciplinary Skills 		• How can the student improve their demonstration of disciplinary interplay? • How can the student improve their communication between disciplines? • How can the student improve their analysis of the disciplinary combination? • Does the student need to experiment with more disciplinary combinations, ratios or integration methods?	
Transformation 		• How can the advancement – over and above the disciplinary standard – of knowledge, concepts, skills or attitudes be made clearer? Will it be part of the outcome or reflection? • Have there been elements of synergy or serendipity? How can the students highlight these? • Can students recognise and reflect upon their transformation? How can the student improve their reflection on the task?	

Figure 6.2d: Formative Feedback

Assess Interdisciplinary Achievement

Disciplines

Students show achievement of the disciplinary objectives as defined by their local curriculum (national/state curriculum, IB programme, school-based disciplinary assessment). Teachers (and students, where appropriate) will have selected the disciplinary objectives at the *Inform* and *Enable* stages.

It is recommended that, where possible, disciplinary assessment follows the pattern used in the *Interdisciplinary skills* and *Transformation* rubrics, so that all indicators of interdisciplinary quality are assessed in the same manner. These rubrics have been designed as follows:

1. Attribute is chosen – for disciplinary assessment, this attribute will come from the disciplinary objectives. These attributes can be listed above the rubric table.
2. Attribute is given four *holistic* level descriptions (Jonsson & Svingby, 2007; Tierney & Simon, 2004; Wiggins, 1998) that align with the SOLO taxonomy levels of "uni-structural", "multi-structural", "relational" and "extended abstract" (Biggs & Collis, 1982, pp. 24-25).
3. Each of these general descriptions is supported by *analytic* dot-points (Jonsson & Svingby, 2007; Tierney & Simon, 2004; Wiggins, 1998) dot-points that describe in detail what that attribute might look like in a classroom setting.
4. Multiple attributes may be combined into one indicator-of-quality rubric, as long as each attribute addresses the overarching objective.

Disciplinary objective 1

Attribute(s)	Level
Holistic description • analytic • analytic	Uni-structural
Holistic description • analytic • analytic	Multi-structural
Holistic description • analytic • analytic	Relational
Holistic description • analytic • analytic	Extended abstract

Disciplinary objective 2

Attribute(s)	Level
Holistic description • analytic • analytic	Uni-structural
Holistic description • analytic • analytic	Multi-structural
Holistic description • analytic • analytic	Relational
Holistic description • analytic • analytic	Extended abstract

Disciplinary objective 3

Attribute(s)	Level
Holistic description • analytic • analytic	Uni-structural
Holistic description • analytic • analytic	Multi-structural
Holistic description • analytic • analytic	Relational
Holistic description • analytic • analytic	Extended abstract

Figure 6.2e: Assess Interdisciplinary Achievement (1 of 5)

Interdisciplinary skills

Students show the ability to integrate relevant disciplinary knowledge, concepts and skills in innovative ways to address the situation presented. At various times throughout the interdisciplinary endeavour, students may show:

- understanding of the relationship between disciplines - how disciplines support or contrast each other? Do they interlock, intertwine, blend, build upon, borrow, adapt, exapt, reframe?
- an ability to communicate across and between disciplines that generates mutual understanding of the situation presented and that enables a solution, product, or more-complex understanding. This may include the development or use of an interdisciplinary vocabulary.
- an ability to reflect upon and analyse the disciplinary combination, particularly if disciplines are contrasting: how does the combination of disciplines illuminate the issue, problem, or challenge?
- creativity in choosing and combining the disciplines, when appropriate.

Description The student shows:	**Level** (align with disciplinary style)	**When assessed?** (start, mid, end, *in tempore*?)
Limited understanding of the interplay between disciplines • can identify the disciplines involved • struggles to describe the connections between disciplines **Limited** ability to communicate across and between disciplines • uses discipline-specific vocabulary • shows little or no awareness of the interdisciplinary audience **Limited** reflection on and analysis of the disciplinary combination and how it illuminates the issue/problem/challenge • can identify the disciplines involved, but shows little or no awareness of how multiple disciplines can help address the issue/problem/challenge • reasoning for disciplinary combination may be shallow or show disciplinary bias **Shows limited** creativity in choosing and combining disciplines • needs assistance to identify which disciplines could help address the issue/problem/challenge • can choose and combine disciplines with assistance	Uni-structural	
Some understanding of the interplay between disciplines • can describe how the disciplines connect, combine, intertwine or otherwise integrate **Some** ability to communicate across and between disciplines • uses discipline-specific vocabulary • shows some awareness of the interdisciplinary audience **Some** reflection on and analysis of the disciplinary combination and how it illuminates the issue/problem/challenge • can explain simply how multiple disciplines help address the issue/problem/challenge • reasoning for the disciplinary combination is sound **Shows some** creativity in choosing and combining disciplines, **with minimal support** • can identify disciplines that might help address the issue/problem/challenge, with minimal assistance • can choose and combine disciplines with minimal assistance	Multi-structural	

Figure 6.2e (continued): Assess Interdisciplinary Achievement (2 of 5)

Good understanding of the interplay between disciplines • can explain how the disciplines connect, combine, intertwine or otherwise integrate • can explain how and why the disciplines support each other **Requisite** ability to communicate across and between disciplines • uses discipline-specific vocabulary • shows an awareness of the interdisciplinary audience through clarifications and explanations across disciplines **Adequate** reflection on and analysis of the disciplinary combination and how it illuminates the issue/problem/challenge • explains in detail how multiple disciplines contribute to addressing the issue/problem/challenge • gives sound reasoning for the disciplinary combination and makes some suggestions to improve the combination **Shows some** creativity or divergent thinking in choosing and combining disciplines • proposes and explains their choice of multiple disciplines that might address the issue/problem/challenge • chooses and combines disciplines independently and critically	Relational	
Thorough, detailed understanding of the interplay between disciplines • can explain how the disciplines connect, combine, intertwine or otherwise integrate, showing awareness that the interplay may be invisible at times • explains in detail how and why the disciplines support each other **Sophisticated** ability to communicate across and between disciplines • uses discipline-specific vocabulary • communicates seamlessly to an interdisciplinary audience through clarifications, explanations and disciplinary translations where needed **Deep** reflection on and **thorough** analysis of the disciplinary combination and how it illuminates the issue/problem/challenge • evaluates how multiple disciplines contribute to addressing the issue/problem/challenge, describing the strengths and weaknesses of the combination • gives thoughtful reasons for the disciplinary combination and makes suggestions to counter any disciplinary- or combination-related challenges **Shows** creativity or divergent thinking in choosing and combining disciplines • proposes and justifies their choice of a range of disciplines that might address the issue/problem/challenge: justifications may be insightful • chooses and combines disciplines independently and creatively	Extended abstract	

Figure 6.2e (continued): Assess Interdisciplinary Achievement (3 of 5)

Transformation

Students show an enhancement of knowledge, understanding, skills or attitudes that could *not* have been achieved through a single discipline. Students may show:

- a quantitative or qualitative enhancement of knowledge, concepts, skills or attitudes in an integrated context. Enhancement may be reflected in innovation, creativity and/or complex analysis.
- elements of synergy, emergent complexity or serendipity: deliberate or unexpected enhancements that arise from skilful integration of disciplines.
- the ability to reflect upon and evaluate their own enhancement of knowledge, concepts, skills, or attitudes in the integrated context.

Description The student shows:	**Level** (align with disciplinary style)	**When assessed?** (start, mid, end, *in tempore*?)
Limited or no enhancement of knowledge, concepts, skills or attitudes in an integrated context • shows disciplinary knowledge, concepts, skills or attitudes but these are not integrated and limit any transformation • little or no awareness shown of the value of integrating disciplines **Limited or no** elements of synergy, emergent complexity or serendipity • difficulty using disciplinary grounding and interdisciplinary skills in combination, even with support, has limited the transformation • consideration of only one potential integration, solution or way of knowing before choosing a course of action, even with support, has hindered enhancement **Limited** ability to reflect upon their own cognitive advancement • has difficulty considering how the integration of disciplines might help in enhancing their own knowledge, concepts, skills or attitudes	Uni-structural	
Supported enhancement of knowledge, concepts, skills or attitudes in an integrated context • has used support structures (scaffolding) to enable creativity, analysis or transformation **Some** elements of synergy, emergent complexity or serendipity achieved **with support** • has used the disciplinary grounding and interdisciplinary skills in combination, **with support**, to enable some transformation • consideration, **with support**, of more than one potential integration, solution or way of knowing has helped enable an enhancement **Some** ability to reflect upon their own cognitive advancement • considers, **with support**, how the integration of disciplines has enabled enhancement of their own knowledge, concepts, skills or attitudes (continued next page)	Multi-structural	

Figure 6.2e (continued): Assess Interdisciplinary Achievement (4 of 5)

Some enhancement of knowledge, concepts, skills or attitudes in an integrated context • shows the beginnings of innovation, creativity and/or perceptive analysis, with little or no support **Some** elements of synergy, emergent complexity or serendipity • has used the disciplinary grounding and interdisciplinary skills in combination to enable some transformation • consideration of multiple potential integrations, solutions or ways of knowing has helped enable an enhancement **Requisite** ability to reflect upon their own cognitive advancement • considers how the integration of disciplines has enabled enhancement of their own knowledge, concepts, skills or attitudes	Relational	
Clear enhancement of knowledge, concepts, skills or attitudes in an integrated context • innovation, creativity and/or perceptive analysis is shown **Clear** elements of synergy, emergent complexity or serendipity • has used the disciplinary grounding and interdisciplinary skills to leverage an enhancement • thoughtful consideration of multiple potential integrations, solutions or ways of knowing has helped enable an enhancement **Sophisticated** ability to reflect upon their own cognitive advancement • thoughtfully considers how the integration of disciplines has enabled enhancement of their own knowledge, concepts, skills or attitudes	Extended abstract	

Figure 6.2e (continued): Assess Interdisciplinary Achievement (5 of 5)

Reflect – Evaluate – Reconnect

How do the core elements enable reflection for future interdisciplinary endeavours?

Core Elements	Reflection on performance	Reflection leading forward
Disciplines 	• Were the disciplinary objectives fit for purpose? Do we need to modify/add to/swap them? • Were the objectives assessable? Do we need to modify disciplinary assessment? • Do we need to change the timing of disciplinary assessment? • Could there be other ways for students to develop knowledge/concepts/skills/ attitudes to address the disciplinary objectives?	Where will we go next time? Will the interdisciplinary effort be: • Instrumental: Task/outcome/problem focused? • Methodological: Skill focused? • Theoretical: Knowledge- or concept-focused? • Critical: Philosophical focus? With the above purpose in mind (see reflections from column at left): • What disciplinary objectives will be met? What existing disciplinary assessment will this involve? • What interdisciplinary skills will students need? ▪ Integration skills? (connect, combine, intertwine, blend) ▪ Communication skills? ▪ Reflection skills? ▪ Thinking skills? ▪ Creativity? • What transformation might happen? ▪ Knowledge? ▪ Concepts? ▪ Skills? ▪ Attitudes?
Interdisciplinary Skills 	• Did students understand the need to integrate disciplines? How can this be improved? • Were the integration skills fit for purpose? Did students need more skills, more practice, or both? • Were the disciplinary combinations effective? How can we further enable this step? • Were students able to show their integrative thinking? How can this be enabled further? • Do we need to change the timing of interdisciplinary skills assessment?	
Transformation 	• What were the various outcomes of this interdisciplinary endeavour? As predicted? Were there any unpredicted outcomes? • How did the outcomes show the disciplines? How did the outcomes show the integration? Were they appropriate to the unit or task or does this need modifying? • Was the unit or task open enough to allow synergy? Serendipity? Unpredictability? Could it be modified to do so? • Did students recognise the transformation? Do we need to enable this further? • Were students able to talk about the transformation? Do we need to enable this further?	

Figure 6.2f: Reflect – Evaluate – Reconnect

Framework Glossary

Term	Definition in the interdisciplinary education context
Adapt	A form of integration. Students might borrow knowledge, concepts and/or skills from one discipline and modify them for use in another discipline.
Blend	A form of integration. Similar to intertwining, students draw multiple subject group attributes together in rapid, iterative succession.
Borrow	A form of integration. Students might use knowledge, concepts and/or skills from one discipline to enhance knowledge, concepts and/or skills in another discipline.
Build upon	A form of integration. Students alternate between disciplinary insights, but each addition enhances the understanding or solution. Insights are not discarded after use.
Complex analysis	Students collate ideas into patterns or relationships that demonstrate and explain how multiple, integrated disciplines contribute to a more-complex understanding of an interdisciplinary phenomenon. Complex analysis may involve sub-skills such as deduction, induction and restructuring of ideas.
Creativity	Attribute where students draw upon their knowledge, concepts, skills and/or attitudes to develop an outcome that is innovative and may not follow linear expectations. Creativity may show elements of divergent thinking. Robinson (2015) simplifies the idea as *creativity = imagination + action*.
Discipline	"Academic studies that focus on a self-imposed limited field of knowledge" (Cohen & Lloyd, 2014, p. 189). In the Australian Curriculum (ACARA, 2017a) the *Learning Areas* equate to disciplines; in the International Baccalaureate (IBO, 2017c) disciplines are called *subject groups*. In the interdisciplinary framework, disciplines are used as the building blocks for interdisciplinary endeavours.
Emergent complexity	A more-complex representation of, or solution to, a problem, challenge or issue that has resulted from the integration of disciplines
Exapt	A form of integration. To co-opt knowledge or skills for a use other than that for which they were originally designed or developed. Students might borrow and/or modify knowledge, concepts and/or skills from a discipline that is conceptually or methodologically distant (Nissani, 1995) from another discipline.
Illuminate	Used in the context of multiple disciplines illuminating an issue, problem or challenge. How is an issue/problem/challenge seen differently when students view it through different disciplinary lenses?
Innovation	One possible representation of the transformation that may have occurred through an interdisciplinary endeavour. Students may have generated an idea or solution that is new and useful through their skilful integration of disciplines.
Integrate, Integration	A combination or combining of disciplines. This may take various forms, for example, disciplines may interlock, intertwine, blend, build upon, borrow, adapt, exapt or reframe. Each of these examples is defined in this glossary.

Figure 6.2g: Framework Glossary (1 of 2)

Interlock	A form of integration. Disciplines are used in tandem to generate a more-complex understanding or solution. This reflects Martin's (2009) idea of the opposable mind, where students hold two different ideas in their head in order to begin to resolve the issue, challenge or problem at hand. Disciplines are not separated at the end of the interdisciplinary endeavour.
Interplay	How the disciplines integrate with each other.
Intertwine	A form of integration. The drawing together of multiple subject groups in rapid, cyclical succession.
Reframe	A form of integration. Students view multiple disciplines through the lens of a different discipline, for example, arts-based learning. Even though one discipline provides the lens for the interdisciplinary endeavour, disciplinary objectives from all disciplines involved are clearly addressed and integrated.
Serendipity	In everyday parlance, this refers to unintentional good fortune. In the context of interdisciplinary education, *serendipity* is the idea that students may transform their understanding or abilities in unexpected or surprising but beneficial ways, as a result of integrating disciplines.
Synergy	The concept that *the whole is greater than the sum of its parts*. In interdisciplinary education, students achieve synergy when their knowledge, conceptual understanding, skills or attitudes are enhanced or improved to an extent greater than the sum of the contributing disciplinary knowledge, concepts, skills or attitudes.
Transformation (interdisciplinary)	Students show an emergence or enhancement of knowledge, understanding, skills or attitudes that could not have been achieved through mono-disciplinary study.

Figure 6.2g (continued): Framework Glossary (2 of 2)

The *Final synthesis, evaluation and reflection* stage of the Educational Design Cycle provided an opportunity to review each of the design cycles both individually and as a whole in order to synthesise the final version of the interdisciplinary framework. Over the 14 months of data collection and the subsequent 12 months of evaluation and reflection, further literature on interdisciplinarity, assessment and interdisciplinary assessment was reviewed as it became published. This new literature required integration into the existing literature review to inform the framework. Feedback from the volunteer teachers from across Cycles 1-5 also needed a comprehensive review to ensure that comments and ideas informed the framework in a coherent manner and that the framework truly responded to teachers' contextual challenges. The following is an explanation of the analyses and decisions made that led to the alignment of the framework with the reviewed and analysed literature and teacher feedback. Note that Figure 6.2 contains sub-labels which are used throughout this chapter to enable easy reference.

Interdisciplinary Framework Model

The interdisciplinary planning, teaching and learning framework is conceptualised as a cycle, that progresses through five stages of informing planning, enabling teaching, providing formative feedback, assessing learning and reflecting on the process (Figure 6.2: Interdisciplinary framework model). The indicators of quality from the analysed interdisciplinary teaching literature (see Tables 4.1 and 4.3) are depicted in the middle of the cycle, representing the key idea that these indicators are relevant to and embedded in every stage of interdisciplinary planning, teaching and learning.

The framework model is depicted as a cycle and it is intended that teachers and students would normally transition through the stages one after the other. The sections have been deliberately designed to align with their adjacent sections, for example, *Formative Feedback* is designed to build upon *Inform Interdisciplinary Design* and lead to *Assess Interdisciplinary Achievement*. However, this general intent should not restrict planning, teaching and learning processes. Teachers and students can use the cycle stages as best fits their needs, moving back and forth through the stages as is useful. Some stages may even be omitted. For example, schools following the International Baccalaureate Middle Years Programme (IBMYP) are required to use the IB's prescribed criteria to assess student work. Even though these schools might use details within the *Assess* stage for extra support, they are unlikely to use this stage for summative assessment purposes.

The framework model is expanded section by section, in order to support teachers' conceptual understanding of interdisciplinary teaching and learning and to provide practical assistance for each stage of the model. As a paper version, the model is represented in a linear fashion, however the expanded sections can be accessed in any order. Figure 6.2 uses the linear layout.

Core Elements and Glossary

The aims of both the *Core Elements* (Figure 6.2a: Core Elements) and *Framework Glossary* (Figure 6.2g: Framework Glossary) are to:

- Define terms specific to interdisciplinary curriculum design that are used within the framework
- Clarify the nature of each of the Core Elements – disciplines, interdisciplinary skills and transformation
- Bridge the gap identified between the interdisciplinary conceptual literature and classroom practice.

The Core Elements represent the indicators of quality identified in the analysed literature on interdisciplinary planning, teaching and learning (Tables 4.1 and 4.3). As highlighted in the Findings chapters (Chapters Four and Five), and as discussed in Chapter Seven, the volunteer teachers' conceptual understanding of interdisciplinary teaching and learning varied. One teacher (from School A) had accessed some of the academic literature on interdisciplinarity, however, most teachers in the volunteer cohort were relying on the International Baccalaureate's (IBO, 2017a) interpretation of interdisciplinarity (Schools B, C and D), or attempting to make sense of the concept as it applied to their own context (one teacher from School A, all teachers from School B). In the context of this research, all volunteer teachers accepted the researcher's collation, analysis and simplification of the reviewed literature (Table 4.2) as a valid base from which to proceed with the research. Their acceptance in itself raises questions for further investigation and this is discussed in Chapter Seven. For the purpose of this chapter, it is sufficient to note that teacher acceptance of the indicators of quality may demonstrate that the indicators seemed reasonable to the volunteer teachers in their contexts and, at the very least, teachers had little inclination to challenge them.

The framework therefore includes a section that briefly explains the Core Elements (Figure 6.2a: Core Elements), based on the understanding that teachers who access the framework will have a range of experience in interdisciplinary teaching. The explanation of Core Elements is designed to help teachers who have little experience in interdisciplinarity to access the new ideas and to show teachers with significant experience how ideas from the interdisciplinary assessment literature are transferred to the framework.

The interdisciplinary concepts that needed most explanation during the teacher interviews were those included within *Interdisciplinary skills* and *Transformation*. In the context of this research this makes sense, since all teachers were experienced and confident teachers of their own disciplines. In

the final version of the framework some guidance is still offered towards selection of *disciplinary* objectives, however. This was included to direct teachers toward their existing disciplinary expertise for this Core Element and to confirm the importance of single disciplines as the building blocks for interdisciplinarity.

The Core Element *Interdisciplinary skills* was called "Integration and process skills" throughout the research stages. At the time it was felt that this nomenclature more directly aligned with the Core Element's nature in describing to teachers and students how they might integrate the disciplines. On reflection however, it seemed unhelpful to separate these as two capacities and it was considered that *Interdisciplinary skills* might better describe this Core Element, given that integration *is* an academic processing skill and each of the skills described within the framework incorporate both integration and academic processes with no clear line of division. The title *Interdisciplinary skills* also has potential to give teachers and students a clear indication of transition to an interdisciplinary context and reinforces the meta-disciplinary, practical nature of this Core Element.

The title of the Core Element *Transformation* was changed from the independent review stage (School D), though at that time, numerous references were still made within this Core Element to *advancement* of student knowledge, concepts, skills or attitudes. The term *advancement* had been problematic throughout all research stages as it was often interpreted as a quantitatively measurable attribute when this was not the intent (see Table 4.1). Based on feedback from the final meetings with Schools B and D, the term *advancement* was changed to *enhancement*, as teachers felt this implied student progression or transformation without this progression or transformation necessarily being quantitatively measurable.

All other terminology that had been queried during the interviews with teachers was inserted and defined within a glossary. This glossary is an *addendum* to the framework (Figure 6.2g: Framework Glossary) and is not discussed further here since the definitions simply relate to use of terms in context rather than inherent issues of clarity. Definitions are cited from the literature where appropriate or adapted from the discussions with teachers.

Inform and Enable

The aims of both the *Inform Interdisciplinary Design* (Figure 6.2b: Inform Interdisciplinary Design) and *Enable Interdisciplinarity* (Figure 6.2c: Enable Interdisciplinarity) sections are to assist teachers in:

- Determining the purpose for an interdisciplinary endeavour
- Navigating contextual barriers to enabling an interdisciplinary endeavour

- Identifying disciplinary and interdisciplinary outcomes and requirements

The *Inform interdisciplinary design* and *Enable interdisciplinarity* sections of the framework are designed to assist teachers, and students where appropriate, in the planning and teaching stages of an interdisciplinary endeavour. As already discussed in Chapter Two, guidance for planning an interdisciplinary unit or task is available in the interdisciplinary teaching literature (Figure 2.2 and Tables 2.3 and 2.4). Most of the guidance contained within these sections of the framework was therefore not created during the research but synthesised from the reviewed literature and cited as appropriate. This synthesis was ongoing throughout the research period, with revisions being made to ensure accessibility.

The premise for creating a complete framework, however, was so that teachers and students could see how the new assessment components influenced and guided decisions and actions during an entire planning, teaching and learning cycle. So, while the *Inform interdisciplinary design* and *Enable interdisciplinarity* sections are largely guided by the existing literature on interdisciplinary teaching and learning, there are some key additions that arose during the interviews with volunteer teachers and these are described below. These additions include: (1) threading the *Core Elements* through each section of the framework, (2) the style of using questions to prompt curriculum design, (3) reaffirming disciplinary language input and (4) determining how an interdisciplinary endeavour will be initiated and directed.

Threading the core Elements

The *Core Elements* are the indicators of interdisciplinary quality. It is these elements that direct interdisciplinary assessment and, therefore, need to be a continuous thread throughout the planning, teaching and learning cycle. The *Core Elements* are highlighted by their green icons in every section of the framework and use questions to prompt teachers to consider the indicators of quality as they plan and teach.

Questioning

The use of questions throughout the framework provides flexibility for teachers and students. This style was introduced when the full framework was drafted during Cycle 4 and consciously reinforced throughout the final version (Figure 6.2). Since a key purpose of interdisciplinary teaching and learning is to generate innovative solutions or new understandings, it was reasonable to conclude that the framework could not be designed to 'give answers' or explicitly direct teaching and learning. In this light, a questioning style was used in order to accommodate a variety of classroom contexts and interdisciplinary endeavours.

In the final reflection stage, the questioning style was reinforced throughout the framework with the intent that the style not only enable the framework to accommodate a range of contexts, but also to enable discussion among teachers. This style leverages the idea of questioning for thoughtful discussion (Dillon, 1988, refined by Walsh & Sattes, 2015) and follow-up questioning that solicits further information (Brooks & John, 2018) to enable further planning, expanding these authors' notions of questioning for teacher-student interaction to include a teacher-teacher context. Through enabling contextual adaptability and teacher discussion, the questioning style further enables the framework's accessibility.

Reaffirming languages

The conversations with Teacher B[19] were particularly informative for the *Inform interdisciplinary design* and *Enable interdisciplinarity* sections of the framework. Teacher B was responsible for curriculum for students who were in an intensive English-acquisition program that also inducted the students into the Australian school environment. This consistent integration of English disciplinary objectives with disciplinary objectives from other subjects gave rise to an interdisciplinary curriculum:

> "I realised early on that it was not just going to be ESL in terms of English grammar, vocabulary, structures, etc., it was also going to be equipping [students] with the ability to deal with other classes and other subject areas: maths, science, humanities subjects and so on." – Teacher B

Teacher B recognised the interdisciplinary nature of the ESL curriculum, with the need to consciously integrate English plus at least one other discipline, however, it was noted that student output may not appear interdisciplinary to other teachers in what was a largely monolingual English-speaking school. Teachers would see a 'science assignment' or a 'maths investigation' in English and not see the language objectives that had been integrated into the tasks. It therefore seemed appropriate to emphasise the language option within the *Inform interdisciplinary design* section of the framework, under the category of *skill-focused*, to reaffirm that deliberately addressing language objectives does lead to interdisciplinary learning.

Who directs the interdisciplinary endeavour?

The final modification to the planning and teaching sections, over and above what was already recommended in the interdisciplinary teaching and learning literature, was the question prompting

[19] This teacher is re-coded in this section to further ensure confidentiality and is one of the teachers from School B.

who would initiate the interdisciplinary endeavour. Teachers agreed that the ideal way to initiate an interdisciplinary unit was through identifying the purpose for integration, as recommended by Boix Mansilla and Gardner (2003), Klein (2012), Nissani (1995) and Repko and Szostak (2017). The disciplines that naturally contributed to this purpose would then be used in the unit.

Even though teachers agreed that using the interdisciplinary purpose to direct an endeavour was the ideal, some teachers pointed out that there were school structures that hampered the use of disciplines that had a natural affiliation with the interdisciplinary purpose. For example, timetabling and resourcing restrictions, grading and reporting demands and managerial decisions that restricted interdisciplinary collaboration. These barriers are discussed at length in Chapter Seven. Here, it is sufficient to say that the identification of these barriers inspired the options in the *Inform interdisciplinary design* section of the framework, where a decision must be made whether teachers, students or a combination of teachers and students will plan and direct the interdisciplinary endeavour. This gives teachers the option to modify the interdisciplinary purpose to suit the available disciplines and teachers, and to circumnavigate resourcing, reporting or restrictive administrative decisions.

Feedback and Assess

The aims of both the *Formative Feedback* (Figure 6.2d: Formative Feedback) and *Assess Interdisciplinary Achievement* (Figure 6.2e: Assess Interdisciplinary Achievement) sections are to:

- Identify quality in interdisciplinary teaching and learning
- Assist in identifying the gap between what students know and can do and the learning goal(s)
- Indicate the time-dependence of some assessment practices

The *Formative Feedback* and *Assess Interdisciplinary Achievement* sections of the framework are closely related, not only because they are the original components of this research but also because they identify quality in interdisciplinary teaching and learning. The primary goal of this research was to create a resource for assessment of interdisciplinary learning that included the assessment of interdisciplinary purpose and this has been achieved through the creation of these two sections.

The assessment rubrics were created to align with the indicators of quality. Through a process of *Synthesise-Trial-Analyse-Reflect*, as described in Chapters Three, Four and Five, the final version of the assessment rubrics was produced. While these rubrics were being created the volunteer teachers commented on how their use would need to be linked with planning and teaching processes. This link could only be made through conscious application of the assessment rubrics in a

classroom setting: if the planning sections set the interdisciplinary purpose, the assessment section would judge where students' learning appears in relation to that purpose.

The *Formative Feedback* section was the critical link between assessment and teaching and learning. This outcome reflects and supports the literature on formative assessment practices in two ways. Firstly, it shows the interrelationship between teaching, learning and assessment and that teaching and learning can be more easily designed if an outcome is clearly identified (Wiggins & McTighe, 2005). Secondly, the formative feedback section of the framework helps teachers and students identify the gap between what students know and can do and the learning goal(s) so that teaching and further learning can be tailored to lessen the gap (Black et al., 2003; Black & Wiliam, 2010; Hattie, 2012; Hattie & Timperley, 2007; Sadler, 1989). The *Formative Feedback* section was specifically designed to prompt this connection by positioning the feedback column between the simplified *Enable* and *Assess* columns (Figure 6.2d: Formative Feedback). It was also designed to be accessible to both teachers and students so that a full range of formative assessment practices, assessment *for* and *as* learning (Earl, 2006), could be enabled.

Timing of assessment

A key assessment challenge that came from the discussions with the volunteer teachers was that of *timing* of assessment. It was agreed that disciplinary and interdisciplinary outcomes were generally visible in an end-product or -performance or in interim disciplinary products and could be assessed through these items. However, interdisciplinary process skills were often not visible in these products or performances. The assessment rubrics were therefore given an extra column to prompt thinking about the timing of assessment practices. Teachers need to consider when students are using interdisciplinary skills, often at the beginning and middle of interdisciplinary endeavours when they are consciously bringing disciplines together, and how these skills are made visible in a classroom context so that they can be highlighted for assessment and ongoing formative feedback. Otherwise, as the teacher in School D suggested, teachers might revert to creating more assessment tasks to compensate for non-visibility of *Interdisciplinary Skills* in culminating tasks.

A final element that was included in the *Assess* section after the teacher interviews was brief guidance for disciplinary assessment. Even though disciplinary assessment was discussed in the interview meetings, it generally related to the existing demands on teachers and students rather than the mechanics of how to develop a quality, disciplinary assessment rubric. This is unsurprising, since many teachers involved in the research were teaching in IBMYP schools where assessment rubrics are both provided and controlled by the IBMYP curriculum (IBO, 2014b, 2017c). The interdisciplinary planning, teaching, learning and assessment framework, however, is intended to be

useful for as broad an audience as possible and therefore it was considered that brief guidance towards disciplinary rubric design might be useful in achieving this aim. The assessment rubrics for *Interdisciplinary skills* and *Transformation* were based on principles gleaned from the literature on quality assessment design (Andrade, 2000; Biggs & Collis, 1982; Jonsson & Svingby, 2007; Popham, 1997; Tierney & Simon, 2004; Wenzlaff et al., 1999). Guidance has therefore been provided in the final framework version to assist teachers in aligning disciplinary rubric design with that of the *Interdisciplinary skills* and *Transformation* rubrics.

Building upon this decision to provide disciplinary assessment guidance, the final significant change that was made to the rubrics at this stage of the research was the replacement of grading examples (letters, numbers, adjectives) in each rubric with Biggs' and Collis' (1982) SOLO taxonomy indicators of "uni-structural", "multi-structural", "relational" and "extended abstract" (Biggs & Collis, 1982, pp. 24-25). The main reasoning here was that the four achievement levels within the created rubrics had been influenced by the SOLO taxonomy levels. By converting these SOLO taxonomy levels to grading examples the researcher was concerned that the framework might unintentionally promote grading over assessment-for-learning considerations. Mel and Marie, for example, had specifically asked for guidance on how to apply the example grading system in the earlier drafts. In accordance with the ideas from the assessment literature, it was intended that the rubrics should be viewed as highly detailed indicators of quality, even though in practice many teachers might also use them as a resource with which to determine grades. In addition, it was felt that by providing the same taxonomy indicators across all three interdisciplinary indicators of quality, this would further assist teachers in aligning disciplinary assessment with assessment of *Interdisciplinary skills* and *Transformation*. The grading examples were therefore removed and the primary influence, the SOLO taxonomy levels, were inserted. The "pre-structural" level (Biggs & Collis, 1982) was not included as rubric development had focused on student achievement rather than pre-achievement, however, a "pre-structural" level could also be included if schools prefer.

Reflect

The aims of the *Reflect* section (Figure 6.2f: Reflect – Evaluate – Reconnect) are to:

- Prompt reflection on current interdisciplinary endeavours for evaluation purposes
- Assist teachers in using reflections and evaluations to help plan future interdisciplinary endeavours

While much of day-to-day teaching and learning in a classroom will focus on the *Enable, Feedback* and *Assess* sections of the framework, there are occasions when reflection on the teaching, learning

and assessment process will expand into reflection and re-planning activities to improve the interdisciplinary endeavour for future use. The *Reflect* section of the framework deliberately prompts reflection and re-planning. The section draws upon the indicators of quality interdisciplinary learning and the previous and subsequent sections in the framework (*Assess* and *Inform*) to prompt questioning by teachers and students. Additionally, the *Reflect* section ensures that Rowntree's five dimensions of assessment (Rowntree, 1987) are accounted for within the framework, particularly those that consider *how to respond* to assessment data, to further ensure quality assessment practice.

The reflection stage of a unit of work may be interpreted as an end-point for teaching and learning. While this is partly the case, as all interdisciplinary endeavours need a point of closure, the *Reflect-Evaluate-Reconnect* section also prompts teachers to think about using the reflections to inform the next iteration of interdisciplinary learning, whether for the same or for a new unit of work. This concept influenced the structure of the *Reflect* section of the framework (Figure 6.2f: Reflect – Evaluate – Reconnect), which prompts reflection on the interdisciplinary endeavour already engaged with, as well as prompting modifications and improvements for the future. The latter set of questions, those leading forward, align with the *Inform* section of the framework (Figure 6.2b: Inform Interdisciplinary Design) to further prompt a continuous planning, teaching, learning and assessment cycle.

Extensions of the new framework

The final version of the interdisciplinary teaching and learning framework (Figure 6.2) has been presented in this chapter, with explanations and justifications for the final changes and decisions made to ensure quality and accessibility for teachers. There were some suggested extensions to the framework that need discussion, however, and that can be resolved at this point.

Adaptability to local contexts

As reported in Chapter Five, the volunteer teachers considered that the most useful and enabling version of the framework would be one that met their personalised curriculum needs, specifically highlighting the requirements of the Australian Curriculum or the International Baccalaureate (IB). The challenge here, however, is somewhat circular. The framework was designed as a *general* interdisciplinary teaching and learning framework that could be adapted to any school context. As soon as the framework is personalised for one context, however, it would be less useful for other contexts. As the framework design was intended to be *adaptable* to individual school contexts, however, conducting a trial of this adaptability would be useful, even if a modified, curriculum-specific version was not useful for all schools.

Ultimately, the research goal was to enhance interdisciplinary planning, teaching and learning through assessment design and this was achieved with the general framework presented in this chapter. Individualised adaptations of this framework seem outside the scope of the research and are therefore not presented or discussed here. The question of adaptability is a pressing one however and to address this challenge, an Australian Curriculum-specific and an IBMYP-specific version of the framework have been created by the researcher. These are included as Appendices F and G and are discussed in Chapter Eight in the context of highlighting potential future development and research opportunities.

Accessibility

During the interviews, data was collected on the accessibility of the draft frameworks in terms of educational concepts and language used as well as the structure and layout of the framework. There was one further suggestion in Cycle 5, however, that warrants further investigation, the transfer of the framework into an electronic application. While the current framework has been produced in Microsoft Word and is also available in a portable document format (pdf) file, the teacher from School D particularly emphasised that an electronic application version would be useful, particularly as many schools in the Australian context are using portable tablet technology in the classroom. An application version of the framework would also have the benefit of better enabling time-critical assessment practices, like the assessment of interdisciplinary skills, as teachers could input data as they observe students demonstrating these skills during classroom time. This suggestion is also discussed in Chapter Eight in the context of future development opportunities.

Chapter 7 – Discussion, Evaluation and Reflection

Chapter Seven of this thesis provides an interpretation of the research findings and framework development presented in Chapters Four through Six. Chapter Seven first discusses the implications of the final developed framework and how the framework supports and will feed back to the literature on interdisciplinarity, assessment and interdisciplinary assessment. It draws particularly from the feedback that addressed whether the framework was *rigorous*. Chapter Seven then discusses the enablers and barriers to interdisciplinarity in the school context, particularly those related to conceptual understanding and organisational challenges, which draw from the feedback that addressed whether the framework was *accessible* and *enabling*. The chapter concludes by discussing the interpretation of the findings in the context of the volunteer schools.

The discussion, evaluation and reflection presented in Chapter Seven complete the *Semi-summative evaluation phase* of the Educational Design Research cycle. These evaluations and reflections are aligned to the second *Reflect* stage of Phase 3 of the research process (Figure 7.1).

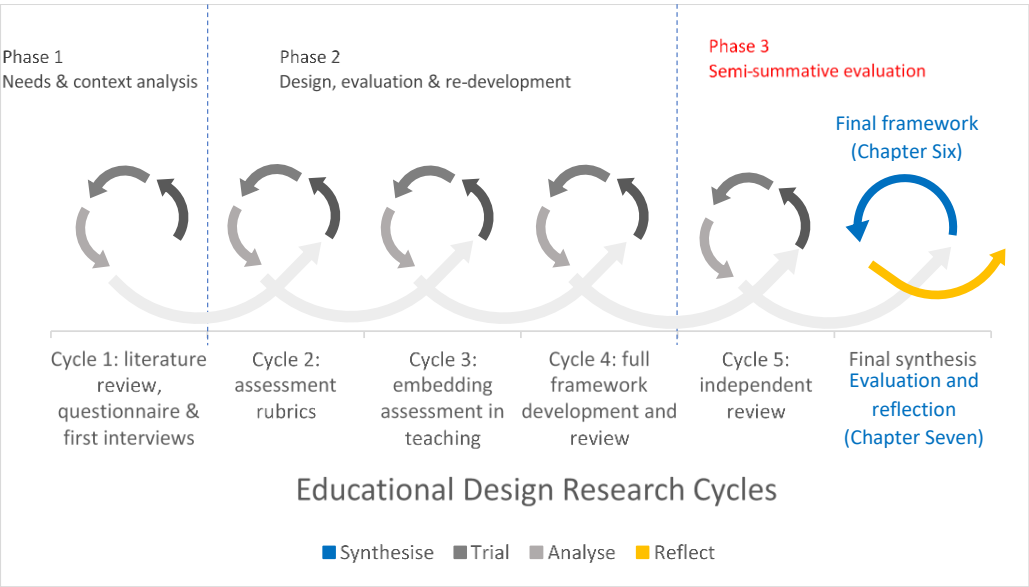

Figure 7.1: Final synthesis, evaluation and reflection stage, highlighted in colour

Implications of the framework

The intent of this research was to develop an assessment resource for interdisciplinary teaching and learning that would help teachers implement interdisciplinary curriculum in their schools. It was initially envisaged that the proposed assessment resource would provide a goal towards which interdisciplinary endeavours could aim, thus enabling teachers to backward-design their classroom initiatives. The research method involved analysing and synthesising existing literature on interdisciplinary teaching and learning to illuminate what was considered quality practice. These

ideas were then immersed in the school context to develop the tool and ensure that it was helpful for both teachers and students in the classroom.

During the research process, the focus was firstly upon the development of interdisciplinary assessment rubrics, which subsequently developed into a complete interdisciplinary planning, teaching and learning framework. This shift during the research process reinforced the transition from the notion of assessment as a summative process to assessment as an integral part of the teaching and learning process. This positioning of assessment is discussed first in this chapter and includes that it is possible to enhance interdisciplinary teaching and learning through the use of assessment, that assessment is an indispensable element of interdisciplinary endeavours as it provides a quality goal, and that assessment needs to be embedded throughout planning, teaching and learning processes.

Assessment *can* be used to enhance interdisciplinarity

The most significant implication from the development of the framework was that the volunteer teachers found that the act of considering and discussing interdisciplinary assessment directly improved their planning and teaching practices. These examples began to emerge in Cycle 2, when Jamie commented that the assessment rubrics had assisted in explaining integration skills to students, and continued throughout the development Cycles 3 and 4, when multiple teachers commented on the usefulness of the assessment rubrics to guide planning. This improvement occurred despite the differences in school contexts, teachers' experience with interdisciplinarity and even when teachers did not use the assessment rubrics to directly assess student work. The act of thinking about assessment purpose and practice directly influenced planning and teaching. This finding presents one answer to the research question:

How can interdisciplinary planning, teaching and learning be enhanced through assessment design?

An answer is, *by ensuring that assessment design is integrated throughout all stages of interdisciplinary planning, teaching and learning, as shown through the synthesised framework.*

The natural conclusion from this finding is that, if the act of more deliberateness in thinking and discussing assessment practice improves planning and teaching, then prompting teachers to think about assessment practice during the planning, teaching and learning stages of a unit could enhance or better enable an interdisciplinary endeavour. It was for this specific reason that the interdisciplinary indicators of quality that drive interdisciplinary assessment were embedded throughout the framework.

This was an interesting outcome, given that the initial aim of the research was only to create a stand-alone tool to assess interdisciplinary student work. The aim of the research evolved into the creation of a resource that covered every category in the analysis table (Table 2.4) and produced a resource that collated existing guidance on quality interdisciplinary planning, teaching and learning practices *and* included a new assessment tool that was both directly aligned with this guidance and included example rubrics. The creation process did begin with a stand-alone tool that highlighted links to quality classroom practice, however, the teachers in this study indicated that such a tool would not be enough. To ensure that any interdisciplinary endeavour was imbued with quality practice, assessment needed to be embedded throughout all stages of planning, teaching and learning.

The final framework (Figure 6.2) provides such a resource. This can be interpreted as a successful outcome, given that the framework produced during this research covers all the categories in the update of the analysis table (Table 7.1), and addresses each of the reasons for which other models have been critiqued in this thesis, as shown in Table 2.4 in the Literature Review chapter. Table 7.1 expands on Table 2.4 and illustrates how the new interdisciplinary framework includes:

- both disciplinary and interdisciplinary assessment practices,
- assessment that addresses the interdisciplinary purpose (transformation of student learning),
- assessment rubrics that are detailed with both holistic and analytic descriptors,
- assessment categories that can be transferred into practice,
- assessment that is aligned with the literature on quality interdisciplinary teaching and learning practice, and
- a framework that is specifically tailored for the interdisciplinary, middle- and high-school context.

Table 7.1: Updated overview of guidance towards interdisciplinary practice in middle and secondary school

	Krovetz et al., 1993	Martin-Kniep et al., 1995	Clarke and Agne, 1997	Boix Mansilla, Miller and Gardner, 2000	Wolfe and Haynes, 2003	Boix Mansilla and Gardner, 2003; Boix Mansilla, 2005	Drake, 2007	Boix Mansilla, Duraisingh, Wolfe and Haynes, 2009	Fogarty and Pete, 2009	SACE Board of SA, 2011a, 2011b	Boix Mansilla, 2012b	Huutoniemi, 2012	Lattuca, Knight and Bergom, 2013	Vasquez, Sneider and Comer, 2013	IBO, 2014a, 2016a, 2017a	Drake and Reid, 2017	Repko and Szostak, 2017	This research, 2018
Pedagogical guidance for the Planning-Teaching-Learning cycle, incl. 'why assess'	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓
Performance indicators, 'what to assess'	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Examples of assessment tasks, 'how to assess'	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓
Assessment rubrics, 'how to interpret'	×	×	✓	×	✓	×	✓	✓	✓	✓	×	×	×	✓	✓	×	×	✓
Examples of 'how to interpret' applied to student work	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	✓	×	×	✓
'How to assess, interpret, respond' aligned with 'why and what to assess'	×	×	×	✓	✓	✓	×	✓	×	×	✓	✓	✓	×	×	×	✓	✓
Critique – is it useful for the school classroom? (see *Note* for codes)	5	4, 5	1, 2, 5	4	4, 6	4	1, 3	4, 8	1, 2, 3	2, 5, 7	4	3, 4	6	2, 4	2, 3	1, 2	4	9

Note. Critique reasons are: 1 – Assessment is de-integrated; 2 – Assessment does not address the interdisciplinary purpose; 3 – Rubrics are simple (one-line performance descriptors) or not self-explanatory (too general); 4 – Performance indicators too broad for practical transfer; 5 – Assessment is not drawn from the literature, or it pre-dates the seminal literature; 6 – Self-assessment survey; 7 – Local curriculum that is integrated but not interdisciplinary; 8 – Assessed student work not actually provided to exemplify 'how to interpret'; 9 – Extended descriptions of teaching ideas and exemplars of assessed student work collected but not presented as part of this thesis due to length restrictions

Each of these elements contribute to the premise that a deliberate and integrated approach to assessment *can* be used to enhance interdisciplinarity. Quality assessment practice, specifically tailored to interdisciplinary teaching and learning in a middle- and high-school context, was carefully threaded throughout the developed framework. As a result, teachers found that even if they did not use the assessment rubrics, the quality of their planning and teaching improved and student achievement in the interdisciplinary context improved as a result.

Assessment is a critical component of a teaching and learning cycle

Following on from this premise that interdisciplinary assessment needs to be embedded within the planning, teaching and learning cycle to function effectively, it was interesting to note that most of the volunteer teachers *did not intend to use* the assessment rubrics at the time of the research. This was because schools were already either required to use existing assessment practices (IBMYP schools) or teachers were not required to assess or report upon the interdisciplinary components of teaching and learning. For example, School A required disciplinary grades, while Schools B, C and D were required to use the International Baccalaureate Middle Years Programme interdisciplinary criteria for any official interdisciplinary units.

Even though most volunteer teachers did not *intend* to use the assessment rubrics, the comments on how the rubrics enhanced teachers' planning and teaching practices implied that the act of creating the rubrics was an indispensable part of enhancing interdisciplinary practice. It appears, therefore, that while the primary motivator for the research, the creation of interdisciplinary assessment rubrics, was necessary for enhancing interdisciplinary planning, teaching and learning, ironically, the assessment rubrics are the one part of the framework less likely to be used in schools. This is due to existing assessment and reporting requirements rather than any identified deficiencies in the rubrics themselves and findings show that the volunteer teachers were still interested in using the assessment rubrics to provide significant support to their existing assessment practice.

This finding implies that assessment is an essential component in planning, teaching and learning activities during an interdisciplinary endeavour, even if it is not intended for summative purposes. This reflects the literature on educational assessment regarding instructional design and formative feedback. Wiggins and McTighe (2005) advocate that assessment should be included at the early planning stages to identify the learning goal(s) and enable teachers to plan teaching and learning according to those goal(s). Black and Wiliam (2010) and Sadler (1989) note that formative assessment is about identifying the gap between the learning goal and a student's current state so that feedback can aim to narrow the gap. If indicators of quality, as guidelines for assessment, are missing then teachers have no recourse to planning and teaching or defining a learning gap.

This prompts the question, if assessment is this important in teaching and learning design, why has there been a significant gap in the examples of interdisciplinary assessment tools and practices in the related literature? One proposition may be that interdisciplinary teaching and learning is highly context-specific. An interdisciplinary challenge can be met in multiple unpredictable ways, thus providing an outcome-specific assessment tool may, therefore, be unhelpful (Boix Mansilla, 2012b; Klein, 2002a). Given the stated importance of assessment as part of the teaching and learning cycle (Black & Wiliam, 2010; Earl, 2014; Graves, 2008; Hattie & Timperley, 2007; Rowntree, 1987; Wilson & Murdoch, 2006) however, and since the findings from this research show that descriptions of quality are a critical part of interdisciplinary planning, teaching and learning, even when they are not intended for direct use, the premise holds that assessment needs to be a distinct component integrated throughout any teaching and learning endeavour.

This is the second significant implication from the development of the framework, that even if teachers do not intend to use an assessment tool for direct assessment of student work, a clear identification of what represents 'quality' in planning, teaching and learning still needs to be incorporated into the educational endeavour. Without this identification of quality, teachers and students lack an intended goal or outcome for their learning, and planning and teaching may subsequently be less effective.

In the narrower context of this research, this means that if teachers and students use the created framework to guide their planning, teaching and learning, it does not matter if they exclude the *Assess* section in favour of other assessment models or eschew summative interdisciplinary assessment completely. However, the *Assess* section is a critical element in enabling the framework to provide a comprehensive planning, teaching and learning tool and even if it is not directly used, it should not be separated from its framework context. This leads to the final implication of the framework.

Interdisciplinary assessment must be embedded in a teaching cycle

The third significant implication from the development of the framework is the idea that the interdisciplinary assessment tool only functions well *when* it is embedded in the broader planning, teaching and learning context. This was shown in both the construction of the framework itself and in the feedback from volunteer teachers. This implication also reflects the assessment literature that notes the interrelationship between assessment and the planning, teaching and learning process (Black & Wiliam, 2010; Earl, 2014; Hattie & Timperley, 2007; Ridden & Heldsinger, 2014; Rowntree, 1987; Sharratt & Fullan, 2012) and asserts that assessment should inform planning and teaching and enhance and support the learning process. Therefore, rather than seeing assessment as a separate

entity, a new model that depicts assessment as embedded throughout the planning, teaching and learning cycle might be more helpful (Figure 7.2).

Figure 7.2: The cycle of planning, teaching and learning, with assessment embedded

An extension of this idea is the application of Rowntree's (1987) five dimensions of assessment to the interdisciplinary framework model. This framework overlay (Figure 7.3) further exemplifies the embedded nature of assessment.

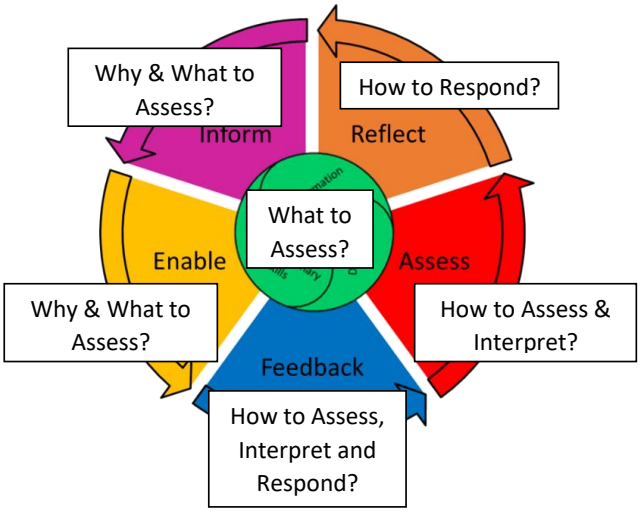

Figure 7.3: Rowntree's (1987) five dimensions of assessment as they relate to the interdisciplinary framework model

The need to define and provide precise, detailed descriptions of indicators of quality is essential, not just in interdisciplinary but in any educational endeavour. By emphasising embedded assessment, detailed indicators of quality can assist in:

- the judgement of teachers' own planning and teaching practice, so they can make immediate and future changes to practice (teacher self-assessment)
- judgement of student learning progress (diagnostic and summative assessment)

- showing students what quality looks like and describe how students can get there (formative assessment, or assessment *for* learning)
- showing students what quality looks like, so they can judge for themselves how to get there (formative assessment, or assessment *as* learning)
- making overall judgements of teaching and learning quality at the end of a unit or course (summative assessment, or assessment *of* learning
- showing others what is considered important to learn (definitional purpose of assessment)

The act of identifying assessment as an indicator of quality and embedding it throughout planning, teaching and learning activities transforms our understanding of assessment from the popular notion of its summative purpose, to its more helpful role as a quality indicator that helps improve all planning, teaching and learning.

Position of assessment

The three main implications that directly arose from the development of the framework are discussed above, including:

- It is possible to enhance interdisciplinary teaching and learning practice through using assessment processes, or precise descriptions of quality, as a focusing element
- Assessment is an indispensable component in interdisciplinary planning, teaching and learning, as it provides a quality goal
- Interdisciplinary assessment needs to be embedded throughout planning, teaching and learning processes rather than being represented as a separate entity

While the first implication is specific to this research, the latter two implications reflect and support existing literature on educational assessment practice, albeit from an interdisciplinary perspective. These implications have potential to contribute to the literature on interdisciplinary assessment and to the general educational assessment literature from an interdisciplinary viewpoint.

This research used principles gleaned from the reviewed literature to construct an interdisciplinary planning, teaching, learning and assessment framework that could be useful for classroom teachers in the middle- and high-school context. The findings show that the creation of such a framework, which can be viewed as a translation of research into practice, is possible. However, as a first attempt, it is unlikely that the framework is comprehensively ready for use in schools. It may serve, however, as a framework that supports first forays into interdisciplinarity. Further research would then be required to determine *to what extent* the framework supports and enables interdisciplinarity. This idea of a subsequent validation study is addressed in Chapter Eight.

Challenges

As discussed above, the initial focus of this research was the development of an assessment tool, which was elaborated over the course of the research. The school contexts in which the developing resource was trialled, however, provided emergent findings and, while contextual influences were expected, the extent of these influences was unexpected.

The challenges that arose via the volunteer teachers and their school contexts that influenced the implementation of interdisciplinary teaching and learning included:

- teachers' conceptual understandings of interdisciplinarity
- challenges related to how the schools organised themselves, and
- institutionalised assessment and grading practices.

These challenges were briefly reported in Chapters Four and Five in relation to how they influenced the interdisciplinary planning, teaching and learning framework. Here, these challenges are discussed in further depth, as they are likely to be common challenges that arise in schools when an innovative curriculum is introduced. Teacher comments, those specifically relevant to conceptual and contextual challenges, are also included to exemplify the challenges and justify the discussion.

The conceptual and contextual challenges were complex, were a constant presence in the schools, and often overlapped and interacted with each other. The complex nature of the challenges, therefore, must be emphasised. It is into this complex school environment that curriculum innovations, like the interdisciplinary framework, are implemented, so challenges need to be illuminated and understood in order to move forward.

Conceptual challenges

The gap between theory and practice

One driving factor that initiated this research was the perception that teachers are being asked to implement interdisciplinary or similar integrated curriculum (ACARA, 2017a; IBO, 2017a, 2017c; SACE Board of South Australia, 2011a, 2011b) with little grounding in or advice towards interdisciplinary assessment practice. This factor was reconfirmed through findings in both the questionnaire and comments from the schools that participated in the framework trial, showing that there is indeed a gap between what is highlighted as best practice in the academic literature (collated in Table 2.3) and what is presented to teachers in schools.

For example, according to the questionnaire results, two-thirds of respondent schools use the International Baccalaureate Middle Years Programme (IBMYP) interdisciplinary criteria (IBO, 2017a),

which do not include the concept of an interdisciplinary enhancement or transformation within their assessment practice. The remaining one-third of schools that responded to the survey indicated that they separate their interdisciplinary student work into single disciplines for assessment, which is, by definition, unlikely to include concepts and skills relevant to interdisciplinary processes and practices, nor the idea of interdisciplinary transformation. Of the schools that participated in the extended framework trial, three out of the four use the IBMYP and so have been restricted by the incomplete nature of the IBMYP assessment criteria. The one school that uses its own interdisciplinary curriculum, School A, aligns its assessment practices in all year levels with what they are held accountable to: disciplinary assessment.

Despite these limitations in their own contexts, the teachers who participated in the framework trial stages were open to questioning the draft interdisciplinary framework as it developed. It is important to note however, that teachers' underlying conceptual understanding of interdisciplinary curriculum was at times unclear, thus they seemed hesitant to question the conceptual literature that was provided in the research process.

To explain further, the volunteer teachers' conceptual understanding of interdisciplinary teaching and learning, as reported in the data from the first meetings was varied. Some teachers had been involved with interdisciplinary curriculum for more than five years, while other teachers were new to the concept. Within these experiences, one teacher from School A had accessed some of the academic literature on interdisciplinarity. Most teachers in the volunteer cohort, however, were relying on the International Baccalaureate's (IBO, 2017a) interpretation of interdisciplinarity (teachers from Schools C and D), attempting to make sense of interdisciplinarity as it applied to their own context (a second teacher from School A), or a combination of both (teachers from School B).

In the first meetings with schools, the background to the research was presented, including a preliminary representation of the analysed literature (Table 4.2). In these first meetings, all teachers accepted the researcher's presentation of the research problem and analysed literature as a valid conceptual base from which to proceed with the research. This unquestioned acceptance of the research conceptual premises raises concerns around the discerning criticality of teachers' conceptual understanding of interdisciplinarity. These were not explored in-depth within the research project as the main focus for the teachers was on validation of the framework within a classroom context but could be addressed within future research. For example,

- What are teachers' existing perceptions of interdisciplinary curriculum? Have they interrogated it for themselves, or do they align (or resign) themselves with a commercial style (for example, IBO, 2017a)?

- What do teachers think is expected of them in delivering an interdisciplinary curriculum? Does this perception align with the expectations of their school's principal or head(s) of curriculum? Does it align with the documentation they are working with, if any?
- Are teachers aware of the discourse within integrated curriculum design (multi-, inter-, transdisciplinary) and whether any of the issues apply to their context?
- Do teachers feel able to question the interdisciplinary curriculum they are being asked to deliver?
- Do teachers feel able to question the researcher or the research process?
- To what extent is there a conceptual dissonance between disciplinary and interdisciplinary curriculum demands?

Some of these questions were explored briefly with the volunteer teachers at the classroom level, but not at a broader or higher-conceptual level.

While complete acceptance of the researcher's preliminary literature analysis may highlight challenges in teacher literacy and critical engagement with interdisciplinarity, there may be other reasons for this acceptance. For example, it might have been understood that the research intended to explore a new method for interdisciplinary curriculum design (which it did) and therefore new interpretations of the interdisciplinary literature, or of the concept of interdisciplinarity, were going to be necessary. Some teachers may have participated because they wished to learn more about interdisciplinary curriculum and had not previously had a chance due to other pressing teaching responsibilities. Perhaps the research presented a low-stakes opportunity (for example, teachers at School B) to try a different style of teaching. Teachers' existing perceptions of interdisciplinarity and the potential to challenge the accepted paradigm of interdisciplinary teaching and learning within schools could therefore be directly explored within future research.

Lack of a baseline

One of the clearest instances of a conceptual gap was with the interdisciplinary concept of *Advancement*. This concept was quite abstract and its inherent difficulty appeared to be related to both the terminology used and existing assessment practices within schools. That is, teachers are accustomed to measuring student achievement that is clearly visible and measurable according to stated criteria in a disciplinary context. This was exemplified by one teacher in particular, who saw the need for an existing baseline measurement of student proficiency to be able to measure advancement.

> "I think your huge challenge is going to be assessing the students' advancement of understanding because you would have to do something beforehand to know what their starting point is." – Marie

The concept of *Advancement* in interdisciplinary curriculum is not, however, an additive progression, rather, it is notional that through integrating disciplines, students' achievement will be enhanced in comparison to what they would have achieved in a non-integrated context. For example, the interdisciplinary proposition is that student achievement is enhanced through studying a history topic that integrates both historical and literary perspectives than studying that same topic through separate history and literature classes.

The conundrum here is that teachers do not have a baseline, or control, with which they can compare student achievement. What a student would have achieved through single disciplinary study remains unobserved. The new concept is that in an interdisciplinary (ID) endeavour that integrates disciplines (D) A and B, we are asserting that an outcome from ID(A+B) is greater than D(A)+D(B), where comparative outcomes from disciplines A and B might be unobserved. This is both the premise and purpose of interdisciplinarity, that through integrating disciplines an enhanced outcome is enabled.

$$\text{Outcome ID(A+B)} > \text{Outcome D(A)+D(B)}$$

This premise can be measured to an extent through a controlled intervention study of students separated into disciplinary or interdisciplinary cohorts. There are existing studies that do so, for example, Spintzyk, Strehlke, Ohlberger, Gröben and Wegner (2016). Within an interdisciplinary classroom, however, teachers do not have this luxury of comparison. Even when disciplinary objectives are identified and observed, as exemplified in the created framework in this research, a student's transformative experience is assessed without comparison against a mono-disciplinary or multidisciplinary outcome. It is this lack of opportunity for comparison that requires a conceptual leap for teachers when assessing interdisciplinary endeavours.

Timing of assessment

In addition to the conceptual leap required to assess an interdisciplinary transformation, the assessment of interdisciplinary skills also requires a conceptual change. All of the volunteer teachers were familiar with assessing disciplinary work through end-of-unit, complex, performance-based assessment tasks. It was proposed, however, that students' use of interdisciplinary skills would be better assessed *during* a unit of work when these skills were visible, rather than in an end-product where application of interdisciplinary skills were usually not evident. By assessing interdisciplinary

skills when they are naturally demonstrated in the classroom, teachers would also avoid any process that tried to make the skills artificially visible in an end-product.

For some teachers, this change in timing and nature of assessment also required a significant change in mindset from their usual assessment practice. While most teachers were used to providing formative assessment and feedback during a unit, the idea of highlighting interdisciplinary skills for summative assessment at different times was a new concept.

Conceptual solutions

While some teachers in the volunteer cohort were familiar with the academic literature on interdisciplinary teaching and learning, most teachers were not. All teachers were familiar with their school requirements for interdisciplinarity, however, which gave them some grounding in the academic concepts. For example, the IBMYP interdisciplinary guide (IBO, 2017a) is directly based on some of the interdisciplinary literature, so many of the teachers were *in*directly familiar with the work of Boix Mansilla (2010) in particular. The idea that interdisciplinary transformation was assessable, however, was new to all schools and, for some teachers, this required a conceptual leap. The idea that interdisciplinary skills might need assessing *during* a unit rather than at the end was also a new concept that emerged as a question during the Cycle 2 interviews and was further discussed during the Cycle 4 and 5 interviews.

This conceptual gap between theory and practice narrowed as the research progressed. Each interview with volunteer teachers involved in-depth conversations about the nature of interdisciplinary purpose and practice and teachers kept these practices and purpose in mind when giving feedback to the developing framework. However, the conceptual gap is a challenge that needs to be acknowledged and addressed by any school wishing to implement interdisciplinary teaching and learning. Interdisciplinary purpose and practice and the assessment thereof contain new educational concepts and teachers and students need to be provided with time and other resources to engage with this change.

The conceptual challenges that arose in this research have been addressed as far as possible within the interdisciplinary framework. The framework aims to transfer best practice from the interdisciplinary literature into a tool that explains best practice at the same time as enabling it in a classroom context. There was, perhaps, one more option that might assist with this issue, although this was not discussed with the teachers: redefining interdisciplinarity for the middle- and high-school context. By bringing an overarching definition of interdisciplinarity for the school context to the fore, the macro-process of conceptual change could be identified and addressed before teachers

launch into the micro-details of interdisciplinary curriculum planning. This proposition is addressed in greater detail at the end of this chapter.

Contextual challenges

The interdisciplinary teaching and learning framework was designed to be used in middle and high school environments. It was developed with teachers who work within the Australian educational system, but it is envisaged that the framework would be adaptable to multiple school environments. The most significant finding to emerge from this research that was not related directly to framework development, however, was that existing school structures can act as barriers to innovation. Liddicoat, Scarino and Kohler (2017) describe how school structures, specifically, "timetabling, the organisation of curriculum, the planning and enactment of teaching, learning and assessment and the approach to staffing" influence what is possible in terms of change within schools (p. 1). These influences were evident in each of the volunteer schools and their internal organisation and accountability structures – timetables and reporting practices – had the most impact. These findings are also reflective of existing findings in the university context, as reviewed by Chettiparamb (2007).

This research did not aim to encourage change in schools. It was a developmental study, designed to create a framework that would assist implementation of interdisciplinary teaching and learning. When implemented in the future, however, the framework's task *will* be to enable classroom-based change. In this context, the framework needed to incorporate considerations towards any perceived implementation barriers. Timetables and reporting structures were significant challenges for which the interdisciplinary framework would need to make allowances.

Timetables

On the surface, timetables allocate students to class times and groups and assign teachers to classes. The timetable also allocates classrooms and other resources. However, the influence of the timetable runs deeper than these surface responsibilities. When timetabling, schools attempt to minimise inefficiencies like empty rooms or underutilised teachers. The effect of this is that resources within a school, for example, personnel and other capital, are very tightly managed, leaving little room for flexibility or innovative curriculum that is outside the monodisciplinary structure of the timetable.

Timetables also illuminate a hierarchy within the curriculum, based upon which subjects are allocated the most time. For example, in School B, English, Mathematics and Science subjects were allocated four or five lessons per week, while Health was allocated one lesson per week. The subjects, in turn, concentrate primarily on their own disciplinary objectives, filling their allocated

time as efficiently as possible with the content and skills required by the school's designated curriculum. Even though schools have differing reasons for time allocation to a particular subject, this has repercussions on what sort of curriculum innovation(s) can be implemented and whether innovations can be implemented at all.

For example, if a teacher wishes to implement an interdisciplinary initiative, they will need to negotiate with other disciplinary teachers to find time within the school day to collaborate and classrooms within which to engage with the interdisciplinary endeavour. For some interdisciplinary initiatives, this may not involve much extra time and effort, for example, the teachers involved might already communicate and collaborate in other forums and perhaps the initiative can be run within existing classrooms. Two examples from School B did reflect this ease of organisation. Both Mel and Max had organised interdisciplinary units that integrated English (four lessons per week) and Health (one lesson per week), had spoken to the Health teachers in their own time, in the staffroom at break times or in the common teacher planning areas, and both interdisciplinary units were conducted within the existing classroom allocations. The English teachers involved in these collaborations, Mel and Max, both indicated that they had willingly given up what would normally have been designated "English time" to the interdisciplinary collaboration for a number of reasons. Firstly, they understood the restrictions on the Health subject in that it only had one lesson per week to cover required content. Secondly, they believed that by integrating English and Health the students would gain a transformative interdisciplinary experience that outweighed any English-time loss. And thirdly, as the English teachers had proposed the collaboration to the Health teachers, they felt a responsibility to make the collaboration easier where possible. For example,

> "My intention is not necessarily to require any time in HPD[20] because the HPD curriculum runs for one lesson a week. The year 8s are working through what's called *Healthy Minds* that's had a lot of content [description of interdisciplinary task] … So [Teacher], who is their HPD teacher, should be able to mark that to the *Healthy Minds*, well, the HPD criteria without any extra class time, she said they can have some of a lesson to discuss it with her, but they shouldn't really need it." – Mel

This example is reflective of many interdisciplinary initiatives. It is teacher-driven and occurs because one or more teachers see the value in an interdisciplinary collaboration and are willing to invest the extra time and effort required to make the collaboration happen. These teachers are clearly Dinham's (2016) *enthusiasts* for interdisciplinarity. Teachers see, as in the above example, how

[20] Health and Personal Development (HPD). In this school, HPD is the theoretical component in the practical Physical and Health Education curriculum. HPD is allocated one lesson per week in School B.

content that is being covered in a Health subject can be used to leverage concepts and skills that students are learning in the English class. The individual teachers then take the time to propose the collaboration to the Health teachers and devote time from their own English lessons to enable the interdisciplinary collaboration.

To propose such an initiative in the first place also presumes a certain level of knowledge of the school structure within which the interdisciplinarity will occur. For example, Mel knew which teacher the year 8 class had for Health lessons, knew that they had been doing the Healthy Minds unit and had the inspiration that the English and Health curriculums might provide a good interdisciplinary opportunity. Without this background knowledge, inspiration for the collaboration might not have happened.

For some teachers, the idea of engaging with the timetable challenge is daunting. There were examples where teachers were interested in enabling interdisciplinary units, but their position outside the mainstream timetable restricted collaboration. For example, Teacher B[21] was responsible for the intensive English program at School B, where students were placed in this class for up to six months. Teacher B had created an interdisciplinary curriculum where English language learning objectives were integrated with another subject, one at a time, to better enhance the students' English language acquisition. While Teacher B consulted with other teachers to ensure disciplinary rigor in the curriculum, there was no collaborative teaching involved. Another example was Martin, who empathised with the workload of other teachers and felt that one's own individual timetable could be manipulated to enable interdisciplinarity. Martin taught both English and Music to one year 8 class and saw this as an opportunity to integrate these two subjects without the need to involve other teachers.

While these latter initiatives circumnavigated the challenges of crossing timetable borders and the reluctance to take time from other teachers' lessons, they did highlight the importance of keeping interdisciplinary purpose as a primary consideration for the development of an interdisciplinary unit. Martin commented on this often, feeling that a previous attempt at interdisciplinarity had been less than successful, perhaps due to English and Music being forcefully integrated before considering the purpose for integration.

> "I was thinking about the semi-disaster I had in semester 1 where everything that I tried to get the kids to join together was contrived by me and I expected that all this 'flowering' would happen naturally and it wasn't and now I think that the task and how I did it was at

[21] Teacher B is the re-code, first seen in Chapter Six, to further ensure confidentiality.

> fault… I could contrive mine because I was the teacher for both subjects, so I didn't have to collaborate with a colleague, unlike [Max] and I thought, 'what can I do that could be done in English and in Music?'. So, it was all very contrived and teacher-led, which I why I think it didn't work with *Advancement* skills because it was all done by me and not naturally out of the learning process [purpose]" – Martin

These examples illuminate the effect that timetabling has on the introduction of an interdisciplinary curriculum. Teachers and students are organised within disciplinary 'boxes' and curriculum requirements (disciplinary content and skills, for example) are set within these boxes. To venture outside such disciplinary organisation necessitates time and effort above what, for example the Australian Curriculum, requires. It is worth noting also that the examples of interdisciplinarity described here were attempted only through the persistent efforts of the volunteer teachers involved in the research. There were further examples of proposed interdisciplinary collaborations that did not eventuate because of timetable and disciplinary content restrictions. For example,

> "…I would have liked to have done something very different as an interdisciplinary unit… I came away from the MYP conference at PAC thinking, 'oh yeah, there's stuff we've done with that zoo thing, that would be ideal in week 9 [comments on administrative reactions] … I was still keen to do it with [2 classes] … but the two Science teachers weren't too keen on doing it because it didn't fit in with the Science program." – Max

The interdisciplinary planning, teaching and learning framework, therefore, needed to accommodate the potential restrictions and influences of a school timetable. These accommodations were inserted into the *Inform* section of the framework. This was an appropriate location for questioning how the interdisciplinary endeavour might be generated, since the focus of the *Inform* section is on determining the *purpose* of an interdisciplinary endeavour. Interdisciplinary purpose gives meaning to an interdisciplinary endeavour. If there is no interdisciplinary purpose, then there is no need for interdisciplinarity. This concept is proposed in the interdisciplinary teaching and learning literature (Boix Mansilla, 2010; Jacobs, 2013; Repko et al., 2014) and reinforced in the research findings, for example, Martin's comments above.

The restrictions of a disciplinary timetable need to be considered alongside the need for interdisciplinary purpose. While the interdisciplinary purpose will still generate and drive the interdisciplinary endeavour, teachers are prompted by the *Inform* section of the framework to consider how the endeavour will be planned within school constraints to address that purpose. Specifically, 'will the interdisciplinary endeavour be teacher-selected *(due to school constraints),* student-driven, or a combination of teacher- and student-driven?' Teachers are aware of the

constraints related to school organisation, particularly timetable constraints. If teachers can see that an interdisciplinary endeavour will not fit with the timetable, due to lesson scheduling, subject curriculum demands, time available, or resource availability, the interdisciplinary framework allows them to search for a different interdisciplinary purpose that may fit better within organisational constraints. And while student-driven interdisciplinarity, for example, the IBMYP Personal Project (IBO, 2017b), is often less constrained by the timetable, there will be occasions where student-driven initiatives may still need to be negotiated according to discipline or resource availability. The intent, therefore, of questioning how the interdisciplinary purpose will be selected, is to allow teachers and students flexibility to change the interdisciplinary purpose so that it can be addressed according to the time and resource constraints of the school.

The interdisciplinary purpose gives meaning to the interdisciplinary endeavour. It must be adaptable, however, to the time and resources that teachers and students have, and it is for this reason that interdisciplinary purpose within the framework can be adapted to accommodate specific school contexts.

Broader organisational challenges

In addition to the timetable challenge, other challenges to the implementation of interdisciplinarity arise within a context largely dictated by a disciplines-based organisational structure. These include the macro-organisation of disciplines as decided by schools, as well as the resulting collaborations needed between teachers themselves and between teachers and curriculum structures. These organisational challenges occur at an administrative level where teacher-managers may be overseeing a single discipline across multiple year levels (vertical management), overseeing all disciplines across one year level (horizontal management), or a combination of these. Challenges also occur at the classroom level where individual teachers need to manage the coherence of their own disciplinary curriculum, as well as interacting with the larger horizontal and vertical curriculums to ensure a coherent student experience.

The volunteer teachers involved in this research had attitudes that were clearly biased towards the implementation of interdisciplinary initiatives. If they had not had this bias, it is unlikely that they would have volunteered for the research at all. This gave a unique insight, however, into the problems faced by teachers who wish to implement an interdisciplinary initiative yet are hampered by administrative or collaborative challenges.

For School B, the implementation of interdisciplinary teaching and learning was a relatively new challenge. Although they had been an IBMYP school for a long time, the IBMYP requirement for schools to have an interdisciplinary unit in each year of the programme (years 6-10) from the 2015

school year onward (IBO, 2017a) was something the school was still implementing. The school had designated a small number of interdisciplinary units to be implemented as their 'official' IBMYP units and these involved a relatively small number of staff. The volunteer teachers in the research from School B were not part of these official units, though were permitted to experiment with interdisciplinarity if it fitted with their disciplinary curriculum. This situation, however, resulted in some difficulties for the School B volunteer teachers with their own interdisciplinary efforts. Two teachers particularly commented on the administrative barriers that had frustrated some interdisciplinary efforts.

> "…I would have liked to have done something very different as an interdisciplinary unit… use something like the Personal Project criteria and get the kids used to that Personal Project model. And then I came back at the start of the year and was told we're doing Personal Project very different this year and we're not going to do it that way. I made a suggestion to [teacher-manager], 'why don't we do it like this?' but no, they had it sorted to do it a different way"– Max

> "…part of our context is feeling like if you've got an idea and the idea is around interdisciplinary units there's got to be a forum where you can present that idea and have it *really* heard, not just [brushed aside] because it's not fitting with what I've already got planned, there's got to be that opportunity for, you know, trying…" – Marie

In addition to the challenges linked to administrative decisions, collaborative challenges were faced at the planning stage by the volunteer teachers. Collaboration itself is an integral part of interdisciplinary teaching and learning. Unless a teacher is responsible for multiple disciplines with the same class and unless an interdisciplinary purpose needs input from those very disciplines, collaboration between teachers will be necessary to bridge the timetable barrier and enable disciplinary integration.

This need for collaboration has its own challenges, though many of the collaborative challenges did not appear to result from interpersonal negativity. Rather, some teachers felt constrained by the organisation of the school and the existing disciplinary demands. The example described earlier by Max indicated that other teachers could not collaborate as their disciplinary curriculum would not allow the extra time.

> "…the two Science teachers weren't too keen on doing it because it didn't fit in with the Science program." – Max

Another teacher met resistance when other teachers declined to collaborate because the interdisciplinary idea did not fit with the way curriculum was organised by year level.

> "[comments on planning the ID unit] And we were looking at, there's basically a unit or an idea of a unit there that they already have on the website from the zoo that is about zoo enclosures. And you hear those two words together and say, "well, that's a Maths-Science unit just there together". Can we get them to look at the space the zoo has? Then look at the space that each animal would typically have in the wild, how do we create this space and create the habitat? And all of that. I came back [to school] and talked about it and got the same reaction – nope. "No, we go to the zoo in year 7, we don't go to the zoo in year 6." And [I was] like, well, why not?" – Marie

While these types of challenges can appear to be non-collaborative, the other teachers that Max and Marie invited to collaborate did not seem opposed to the idea of the interdisciplinary initiative itself. They did, however, appear to feel constrained by the existing organisational demands, namely, disciplinary content that needed to be covered or particular topics being assigned to certain year levels. From an objective view, these are elements within a curriculum that could certainly be changed or modified to allow interdisciplinarity into the curriculum. The fact that some teachers felt that these obstacles were too great provides an opportunity for further research and this is further addressed in Chapter Eight.

Dominance of summative assessment

As discussed in Chapter Two, assessment has a range of purposes in education, including formative, summative and diagnostic (Black et al., 2003; Earl, 2006, 2014; Hattie, 2012; Sharratt & Fullan, 2012; Wilson & Murdoch, 2006). Assessment also has a definitional function, indicating what is valued in a curriculum (Orrell, 2010; Rowntree, 1987). Current thinking about educational assessment is that formative forms of assessment best enable student learning and should take precedence in the classroom (Earl, 2014; Hattie, 2012). What was found during the meetings with the volunteer teachers, however, was that teachers' attention was overwhelmingly drawn towards the summative forms of assessment and the reporting thereof. Teachers acknowledged the importance of both diagnostic and formative assessment in improving their own teaching and better enabling student learning. Despite this understanding, teachers commented that summative forms of assessment had greater influence and impact within their schools. Summative assessment practice was used to determine teacher and student accountability and was therefore high profile and needed extra careful planning and consideration. Interdisciplinary initiatives could be compromised or cancelled if they did not fit into existing summative assessment practices.

> "…for example, a *Science* magazine article where there's quite clearly a massive science component there is equally an English component: what it comes down to is we can't assess that task – we can't assess the same thing twice. So, what we can assess is, is the science correct? But we can't assess the Science Communication and the English Communication, we can't double-credit things. So, I guess we're at the tricky point now where we need to decide, is it a Science task or is it an English task as far as the assessment framework is concerned?" – Jamie

> "And certainly, from teaching it that year there were certainly areas where you think, "oh, why can't we be doing this together?" But for me, trying to understand then how [the interdisciplinary idea] impacted the assessment because there were differing opinions on how the assessment would work, what subject it would count for…" – Marie

> "The extra issue with the IB is that they want us to report on [interdisciplinary learning]. And they need a consistent reporting format with the four criteria and so on…" – Rohan

This focus on summative assessment has had an impact on teacher mindset when planning interdisciplinary curriculum. Martin commented on how the focus on assessment accountabilities had perhaps compromised earlier attempts at interdisciplinarity.

> "And when I think back to the beginning of it, I think I was too devising in the way I planned it, like *that part* is going to be assessed in Music and *that part* is going to be assessed in English – already I was splitting it apart rather than thinking of them as together… And I have to admit that I was grateful that there was no [interdisciplinary] rubric – I had *this* for Music, *this* for English, it was done, reports were due and pfft, get it out there." – Martin

It was therefore found that existing summative assessment practice can indeed be a barrier to curriculum innovation. Schools understand the importance of the social uses of summative assessment (Black et al., 2003; Earl, 2014), that student reports must be rigorous and accurate and that students must be prepared for external exams or other forms of testing. Schools therefore make summative assessment a priority within the curriculum and teachers plan curriculum to give students the best opportunities to perform well.

The interdisciplinary teaching and learning framework therefore needed to provide an opportunity for students to be summatively assessed, so that interdisciplinarity can be aligned with schools' assessment priorities. The form of interdisciplinary summative assessment created needed to be flexible enough that it would fit with schools' current assessment and reporting practices, while remaining aligned with quality interdisciplinary teaching and learning practice. Based on these

considerations, the assessment rubrics in the *Assess* section of the framework that can be used for summative assessment address the assessment challenges of *disciplinary assessment demands* and *accountability*, as described below.

Addressing disciplinary assessment demands

The rubrics in the *Assess* section clarify what quality interdisciplinary assessment practice looks like. Each rubric is individually aligned to one of the quality indicators from the interdisciplinary teaching and learning literature (Tables 4.1 and 4.3), disciplinary grounding, interdisciplinary skills or transformation. The rubrics themselves are aligned with quality rubric construction principles (Biggs & Collis, 1982; Jonsson & Svingby, 2007; Krathwohl, 2002; Popham, 1997; Tierney & Simon, 2004).

Assessment of disciplinary grounding is particularly important, as it bridges the gap between existing disciplinary assessment and the interdisciplinary initiative. The assessment process emphasises the importance of the contribution of individual disciplines and allows for assessment of these disciplines to be used as part of the existing and ongoing disciplinary curriculum and organisation of the school. This would save time for teachers involved in an interdisciplinary endeavour. Instead of needing to agree on a single grade for disciplinary grounding, like in the IBMYP (IBO, 2017a), teachers would assess disciplinary concepts and skills against as many existing disciplinary requirements as needed, without the need to reduce a disciplinary grade any further. The only assessment collaboration needed would be for *Interdisciplinary Skills* and *Transformation,* which are specific to the interdisciplinary components of the student work, not the disciplinary components.

Enabling accountability

For a curriculum initiative to continue within a school, there needs to be some form of assessment to measure whether the initiative is enabling and enhancing student learning. This assessment needs to be objective: it needs to be aligned to external benchmarks and free from individual subjectivity (Black & Wiliam, 2004). In this research, the literature on quality interdisciplinary teaching and learning (Table 2.3) was analysed to provide organising categories for this objectivity, namely, disciplinary grounding, interdisciplinary skills and transformation (Tables 4.1 and 4.3). The extended consultation with the volunteer teachers provided intersubjectivity.

The *Assess* section of the interdisciplinary teaching and learning framework is used to show student achievement of the interdisciplinary quality indicators. Assessed student data can then be used to determine to what extent an interdisciplinary endeavour has been successful and to what extent it could be improved.

The interdisciplinary assessment process could also contribute to an increased status of interdisciplinary teaching and learning in a school, since it provides a form of quality control and a way to provide feedback on the initiative to teachers, students and parents through existing reporting systems. This process could also assist with the status of interdisciplinarity in schools, as the very provision of summative assessment appears to be correlated with subject status. This hypothesis could be designated for future research, using the rubrics in the *Assess* section as an enabling tool.

These allowances within the interdisciplinary teaching and learning framework for existing school-based assessment practices and priorities were not intended to be a defining attribute of the framework. The emphasis was intended to be on the formative function of assessment and how this can assist in enhancing planning, teaching and learning. The *Inform*, *Enable*, *Formative Feedback* and *Reflect* sections were developed as part of the framework to emphasise this. However, it is acknowledged that there are current assessment realities within schools. Assessment is organised by discipline and it is used for accountability purposes for both teachers and students (Black et al., 2003; Earl, 2014). It was therefore important that these realities were accommodated within the framework, to assist interdisciplinarity in gaining a foothold within schools.

Circumnavigating the challenges

Despite these challenges, many of the volunteer teachers in the research spoke about ways that they had circumnavigated the school structural challenges in order to bring interdisciplinarity into their classrooms, reflecting Lindvig, Lyall and Meagher's (2017) finding that human agency can enable interdisciplinary initiatives. For example, two of the School B teachers looked within their own timetables to find solutions, two other School B teachers gave time from their own disciplines to enable the collaboration, and teachers from School C were experimenting with new ways to represent interdisciplinarity in their reporting system. The framework was synthesised by drawing upon this innovative mindset.

Integrating research with practice

This research intended to create an assessment tool that would be useful in enabling interdisciplinarity in schools. This aim, and more, was achieved with the creation of the interdisciplinary planning, teaching, learning and assessment framework, presented in Chapter Six. Chapter Seven, to this point, has discussed the implications of the framework and the conceptual and contextual challenges in educational environments that emerged during the research.

The framework was designed to accommodate the conceptual and contextual challenges as much as possible, even as far as the draft development of bespoke versions that incorporated specific needs of local curriculums (Appendices F and G). The detail within the framework and the local-curriculum extensions take interdisciplinarity further towards micro-level considerations. To achieve a balance, it is important to also consider the macro-level of interdisciplinarity, clarifying what is meant and what is intended by an 'interdisciplinary approach' in the context of the middle- and high-school environment. By bringing an overarching definition of interdisciplinarity for the school context to the fore, the macro-challenges of conceptual change and contextual reality could be identified and addressed before teachers launch into the micro-details of interdisciplinary curriculum planning.

This concluding stage of the research is an ideal place to reflect on the beginning of the research process and to compare ideas of how interdisciplinarity might be represented in the classroom, both from the reviewed literature and from the research data.

As concluded in the literature review, the term *interdisciplinary* is used in different ways, from the general, descriptive idea of disciplines brought together for a purpose through to precisely defined ideas that specify the need for *integration* (Boix Mansilla & Gardner, 2003; Repko & Szostak, 2017) in the educational context, or *effective team working* (Grant et al., 2016; Neumann et al., 2010) in the medical context, for a collaboration to be termed as interdisciplinary. This was with the understanding that the tertiary education context uses both definitions. As this research was grounded in the middle- and secondary- educational context, however, the general definition from the educational literature was used, that interdisciplinary teaching and learning occurs when disciplinary knowledge, concepts and skills are integrated to solve a problem, create a solution, explain phenomena or generate further questions (Boix Mansilla & Gardner, 2003; Repko & Szostak, 2017).

These concepts of interdisciplinarity were represented differently at each school. The difference in representations was due to the complex school environments and curriculums run therein, rather than any misinterpretation of interdisciplinarity on the part of the schools or teachers themselves.

IBMYP perspective

The International Baccalaureate Middle Years Programme (IBMYP) is the only curriculum body that has addressed interdisciplinarity at middle- and secondary-level in detail. Because the IBMYP requires one interdisciplinary unit per year, per year level (IBO, 2017a), it has also accepted the challenge of describing and exemplifying the manner in which schools should implement interdisciplinary teaching and learning. The IBMYP has internal requirements, however, particularly around assessment, that impact the flexibility of curriculum delivery. For example, each of the

IBMYP subject groups, including interdisciplinary learning, have “four assessment criteria divided into four bands” (IBO, 2017c, p. 82).

The impact of assessment on planning, teaching and learning has been discussed at length in this research. This research has also shown that assessment needs to be guided by indicators of quality that are directly linked to best practices in that domain (interdisciplinary teaching and learning, in this context). The IBMYP practice of tying interdisciplinary assessment to a specific number of criteria and examinable content and skills is therefore questionable. By assigning four assessment criteria that address disciplinary grounding and interdisciplinary skills, the IBMYP *defines* (Orrell, 2010; Rowntree, 1987) these attributes as what is important in interdisciplinary teaching and learning. Unfortunately, these attributes only partly address what is considered important in the interdisciplinary teaching and learning research (Boix Mansilla, 2005, 2012a; Boix Mansilla et al., 2009; Repko & Szostak, 2017).

The internal restrictions faced by the IBMYP, as described above, have impacted their provision of interdisciplinary guidance to IBMYP schools. The result has been that interdisciplinary teaching and learning in IBMYP schools is treated as an extra subject. It has a standalone subject guide, a separate exam and teachers are expected to report on interdisciplinary learning separately from the disciplinary subject groups (IBO, 2017a). This in turn has resulted in interdisciplinarity being represented in IBMYP schools as an extra imposition on top of existing curriculum (School B), or schools assessing existing work twice for two separate purposes (School C), with resulting confusion between schools as to which representation is ‘correct’. Despite these challenges, the IBMYP curriculum has been highly useful in providing this research with an exemplar curriculum to critique and has certainly provided substantial insight into the result of interdisciplinarity being subject to external assessment pressures, as well as being presented as an individual ‘subject’.

School A perspective

The situation of School A was significantly different to that of the IBMYP schools. School A is a government school and implements interdisciplinary curriculum across middle and high school year levels. It adheres to the Australian Curriculum in pre-senior school years and the South Australian Certificate of Education (SACE) in years 11 and 12, which means while interdisciplinary teaching and learning is encouraged, the school is not provided with a specific interdisciplinary teaching method or any interdisciplinary assessment requirements. It must be noted that there are local subject guides that provide some guidance towards cross-disciplinary and integrated assessment (SACE

Board of South Australia, 2011a, 2011b)[22], though School A did not identify that they were using these at the time. The school reported that it had devised its own method for delivering and assessing interdisciplinary learning, ensuring that they were meeting the disciplinary requirements for the Australian Curriculum (ACARA, 2017a) and SACE (SACE Board of South Australia, 2017).

School A implemented interdisciplinary teaching and learning by creating an interdisciplinary program of study that was inserted into a 'collapsed' timetable. The school did not organise their timetable around the eight learning areas of the Australian Curriculum (or fewer in SACE), rather, they assigned large blocks of the timetable to interdisciplinary studies. These interdisciplinary blocks were team-taught by disciplinary specialists who had constructed the curriculum to address interdisciplinary challenges while still meeting disciplinary curriculum requirements.

The case of School A was particularly interesting in that they had made the decision to significantly redesign the timetable in order to deliver an interdisciplinary curriculum effectively. While this form of organisation did indeed seem effective (based on the conversations with the School A teachers) and gave teachers and students clear opportunity to engage in interdisciplinary units, there was one drawback. It was an unusual way to organise school curriculum. This, of course, is not an issue for School A. However, other teachers commented on this school (not knowing that they were part of the research) and admired the method of collapsing the timetable while lamenting that this was not something that was transferable to their own context.

From the school examples in this research, it became clear that the practice of interdisciplinarity needs to be carefully considered at the middle- and high-school level, particularly with regard to how disciplines are organised and how interdisciplinarity is represented at the macro-level. Schools need to clarify what they mean by an 'interdisciplinary approach'.

Redefining interdisciplinarity for schools

There are two contexts to consider when defining interdisciplinary practice in schools: the theoretical literature and the school reality.

An overview of the theoretical literature defined interdisciplinarity as the use of individual disciplines that are consciously and deliberately integrated to address a complex purpose. These three components, disciplines, integration and purpose, align with the indicators of quality

[22] The SACE *Cross-disciplinary Studies* subject draws upon more than one discipline to address modern-day complexities (SACE Board of South Australia, 2011a, p. 1). The SACE Integrated Learning subject is "a focused study that has a purpose, product or outcome"(SACE Board of South Australia, 2011b, p. 8). These subjects do not mandate how disciplines should be integrated and could therefore be delivered in multidisciplinary, transdisciplinary or interdisciplinary ways.

interdisciplinarity that were a key element in developing the interdisciplinary planning, teaching, learning and assessment framework in this research.

It is understood, however, that interdisciplinarity is often attempted in an environment that is organised around single disciplines and this affects the perspective through which interdisciplinary teaching and learning is viewed in a middle- or high-school environment. It is from the connection of the reviewed literature with the school environments involved in this research that the following three *definitional understandings* were reached.

1. Single disciplines are building blocks for interdisciplinarity integration,
2. Interdisciplinary integration skills and interdisciplinary purpose are meta-disciplinary objectives of interdisciplinarity
3. Interdisciplinary purpose is the driving force of interdisciplinarity

Firstly, there is already alignment between the fact that disciplines exist in schools and the idea that quality interdisciplinary teaching and learning needs to build upon a selection of these disciplines. So, while collapsing a timetable is certainly effective, it is not necessary for schools to change their structures to this extent. Rather, the disciplines that exist need to be understood as interdisciplinary *building blocks* that can contribute directly to interdisciplinary endeavours.

Secondly, interdisciplinary skills, including the conscious and deliberate integration of disciplines, and interdisciplinary purpose need to be understood as *meta-disciplinary objectives* that students can address through multiple disciplinary combinations. These meta-disciplinary objectives should not be seen as an add-on to curriculum, but can be understood as overlaying the curriculum, filling the interstitial spaces in a timetable, or as complementary capstone objectives (Strober, 2011) to which students can bring their disciplinary concepts and skills.

Thirdly, interdisciplinary purpose needs to be understood as the *primary driving force* behind interdisciplinary teaching and learning. If the purpose does not exist, there is no cause to integrate disciplines.

Adhering to these three understandings would mean that schools could incorporate interdisciplinarity into existing curriculum structures with minimal change. This means that:

- Collapsed timetable methods (full or part) would still enable interdisciplinarity effectively
- Disciplinary timetables could be used to leverage interdisciplinarity without the need to 'double up' on disciplinary time or bring in interdisciplinarity as an extra subject
- Teachers could still develop curriculum units according to disciplinary responsibility or availability, as long as the interdisciplinary purpose is the primary driving force. This would

also apply to a number of popular initiatives that need conscious integration and interdisciplinary purpose, for example, interdisciplinary STEM[23] initiatives, or arts- or design-based learning.

There are existing interdisciplinary endeavours that would need to be modified to align with this new definition, however, assuming a school wishes to implement interdisciplinary teaching and learning.

- Interdisciplinary curriculum(s) that are driven by external assessment considerations (for example, examinations) rather than interdisciplinary purpose
- Transdisciplinary or multidisciplinary combinations that lack disciplinary depth or are not consciously or deliberately integrated, for example, non-integrated STEM or HASS[24].

A new definition of interdisciplinarity that includes all three propositions may imply the need for change in some schools. This definition would enhance interdisciplinary curriculum provision, however, given that it aligns with both the research on quality interdisciplinary practice (see Table 2.3) and allows for school structure-related challenges.

Chapter Seven: Summary

Even though this research did not set out to specifically identify challenges to the implementation of interdisciplinary curriculum, it was found that appreciating the teaching and learning context was key to building a quality interdisciplinary teaching and learning framework. This was reflected in two ways.

Firstly, after developing the first drafts of the interdisciplinary assessment tool, what became the *Core Elements* and the *Assess* rubrics, it was clear that these rubrics needed both contextual and conceptual information so that teachers could apply them effectively. From this feedback, the full framework was developed that embedded the Core Elements throughout the cycle of *Inform*, *Enable*, *Feedback*, *Assess* and *Reflect*. The introduction of the preliminary drafts and the subsequent full framework revealed how quality assessment practice can influence teaching and learning and that assessment is a critical component of, and must be embedded in, the teaching and learning cycle.

Secondly, the challenges to implementation needed to be addressed within the framework so that teachers could more easily circumnavigate the conceptual and contextual barriers within their

[23] Science, Technology, Engineering, Maths
[24] Humanities and Social Sciences

school. These challenges included the required change in teachers' conceptual understanding of interdisciplinarity and disciplinary assessment practices, and the challenges caused by curriculum that is focused on and organised around single disciplines. These challenges have been discussed in this chapter and, while presented here as individual challenges, in practice they overlap and influence each other. Examples of this can be seen in the comments from teachers: when a teacher declines an invitation to collaborate, multiple factors contribute to the non-collaboration, including the demands placed upon teachers from the disciplinary curriculum, the school timetable and existing disciplinary assessment requirements.

The challenges presented in this chapter perhaps give a better indication of the context within which the interdisciplinary planning, teaching and learning framework was developed and an indication of the contexts in which it will be used in the future. As a further response to the challenges, this thesis proposes that they should not only be met at the micro-scale, with extensions and adaptations to the framework, but also at the macro-scale in the form of a revised definition of interdisciplinarity for the middle- and high-school sector.

The challenges highlighted in this chapter also illuminate the difficulty of embedding educational theory into practice. This conflict, however, is one that was purposely addressed through the Educational Design Research methodology used in this research. The goal of Educational Design Research is to bridge the gap between educational research and classroom practice by developing solutions for problems in the context of the problems themselves (Plomp, 2007; Reimann, 2011). Through using this methodology, this research aimed to find a way to enable interdisciplinary teaching and learning in an ordinary Australian classroom context. Finding the conceptual and contextual challenges described and discussed in this chapter was a critical element in developing the interdisciplinary planning, teaching and learning framework.

There is also the requirement within Educational Design Research that practice will feed back to theory (Plomp, 2007; Reimann, 2011) and it is important to find balance within this goal of bridging the gap between theory and practice. As such, this research cannot be viewed as one-way implementation of educational theory into practice, it must also be viewed from the perspective of educational practice providing influence on theory. In this light, the contextual challenges in schools have much to contribute back to the literature on interdisciplinary teaching and learning. It seems reasonable that the complexity of the educational environment, particularly that of middle- and high-schools, is returned to the interdisciplinary and assessment literature so that a more-complex understanding can be achieved.

Chapter 8 – Conclusions and Recommendations

The aim of this research was to develop an effective assessment resource that would assist classroom teachers with the implementation of interdisciplinary approaches to the curriculum. The research asked the question,

'*How can interdisciplinary planning, teaching and learning be enhanced through assessment design?*'

The nature of the research question prompted the research aim to be clarified as, 'the development of a theoretically defensible resource that was both theoretically and practicably accessible for teachers in schools and would enable the implementation of interdisciplinary approaches in the classroom'.

Based upon this aim, the research involved collaboration with volunteer teachers, key stakeholders in the research outcomes, to initiate, develop and redevelop a tool that would be considered rigorous according to the theoretical literature, accessible for teachers and enabling of an interdisciplinary classroom approach. These three elements, *rigorous*, *accessible* and *enabling* became the key themes throughout the research and acted as checkpoints to continually align the research with its stated goal. The research methodology used, Educational Design Research, provided a series of design cycles to enable the design and development of the tool, which over the course of the research, became the broader interdisciplinary planning, teaching, learning and assessment framework.

The development of an isolated interdisciplinary assessment tool was achieved mid-research. This achievement was followed by the development of the broader framework that situates the interdisciplinary tool in context and provides guidance towards interdisciplinary planning, teaching and learning that was achieved through the final research cycles.

The interdisciplinary planning, teaching, learning and assessment framework is the centrepiece and the original contribution to knowledge of the research. The framework synthesises the theoretical literature on what constitutes quality in interdisciplinarity, assessment and interdisciplinary assessment and transforms this information into a format that is accessible and enabling for classroom teachers.

Significance

This thesis describes in detail the data gathered and processes used in generating an interdisciplinary planning, teaching, learning and assessment framework. The research process analysed and synthesised existing theoretical and practical knowledge and gathered data from a

variety of researchers and teachers, in fields related to interdisciplinarity, assessment, interdisciplinary assessment and Educational Design Research. This thesis makes a contribution back to these fields.

The centrepiece of the research is the final version of the interdisciplinary planning, teaching, learning and assessment framework described in Chapter Six. It is a unique outcome and will contribute to enabling interdisciplinary teaching and learning in middle- and secondary-school classrooms. This framework will enable assessment of interdisciplinary planning, teaching and learning, which will add to the quality of interdisciplinary approaches.

Key outcomes and recommendations

Chapter Seven discussed the curriculum implications of the interdisciplinary planning, teaching and learning framework developed in this research, as well as the conceptual and contextual challenges that arose within the volunteer schools and the further implications of these challenges. The implications discussed in this chapter include:

1. The framework created in this research is a useful interdisciplinary planning, teaching and learning tool, that can now contribute to subsequent validation studies.
2. The research findings support the idea that assessment is an integral component in interdisciplinary planning, teaching and learning and should be embedded throughout the process.
3. Further research into the conceptual challenges related to interdisciplinarity could assist with clearly identifying this challenge and developing or supporting measures that help further teachers' conceptual understanding.
4. There are a variety of potential barriers to the implementation of interdisciplinarity, related to internal school organisation. These barriers could be investigated through further research, with the aim of clearly identifying the barriers and devising ways to circumnavigate them.
5. A new definition of interdisciplinarity that caters specifically to the school sector and to students who are beginning to understand and develop interdisciplinary skills would be useful.

The recommendations in this thesis centre on these five key findings and inspire plans for future research.

1 Framework for interdisciplinary planning, teaching and learning

The interdisciplinary planning, teaching, learning and assessment framework developed in this research received feedback from the volunteer teachers that it is a useful tool. This does not mean that it is a perfect tool and there is still some ground to cover regarding the framework's implementation and validation. This research was an Educational Design Research *development* study that aimed to develop a research-based solution for a complex problem (Plomp, 2007). It is recommended that the framework now be considered an intervention for use in schools that wish to implement an interdisciplinary approach to the curriculum.

If this recommendation is followed, there are clear ways forward for future research. Firstly, the natural progression from an Educational Design Research *development* study is a *validation* study. A validation study would aim to validate theories (Plomp, 2007) about the interdisciplinary framework. By putting the framework into practice, a study that is similar to this research could be conducted, determining to what extent the framework is rigorous, accessible and enabling for schools implementing an interdisciplinary approach. The framework could be modified or developed further as a result of findings from this type of study.

Any extension of the framework, for example, the Australian Curriculum- or IBMYP-specific versions of the framework (Appendices F and G) or an electronic application version of the framework, could be trialled as part of or in addition to this type of validation study.

2 Assessment as an integral component of curriculum planning

The research findings supported the idea that assessment is an integral component in interdisciplinary planning, teaching and learning and should be embedded throughout the process. This supports the existing literature that explains the interrelationship between assessment and the planning, teaching and learning process (Black & Wiliam, 2010; Earl, 2014; Graves, 2008; Hattie & Timperley, 2007; Ridden & Heldsinger, 2014; Rowntree, 1987; Sharratt & Fullan, 2012) and asserts that assessment should inform planning and teaching and enhance and support learning. It is therefore proposed that a new model that depicts assessment as embedded throughout the planning, teaching and learning cycle might be helpful. A proposed model is shown in Figure 7.2 and is repeated here (Figure 8.1).

Figure 8.1: The cycle of planning, teaching and learning, with assessment embedded

This is the second recommendation from this research. Even if teachers do not intend to use a specific assessment tool for direct assessment of student work, the identification of what represents 'quality' in planning, teaching and learning still needs to be identified. Without this identification of quality, teachers and students will lack an intended goal or outcome for learning, and planning and teaching may be less effective as a result.

In addition to the proposed validation studies for the whole framework, it is possible that individual sections of the framework could also be targeted for research. For example, versions of the framework with and without the assessment component could be trialled, with variables identified for comparison. This type of research could determine the extent to which assessment impacts planning, teaching and learning.

In addition, a notion exists that the provision of summative assessment is correlated with subject status, leading to the position that perhaps interdisciplinary learning has not been an educational priority in the past because it has not had a rigorous assessment component. This hypothesis could also be a focus for future study, using the rubrics in the *Assess* section of the framework as an enabling tool.

3 Conceptual understandings

As discussed in Chapter Seven, the volunteer teachers' pre-existing conceptual understandings of interdisciplinarity were less than clear in the research findings. While this was not an element that was identified as part of the research, the broad acceptance of the researcher's summary of the interdisciplinary teaching and learning literature prompted some questions. For example,

- What are teachers' existing perceptions of interdisciplinary curriculum? Have teachers interrogated interdisciplinarity for themselves? Do teachers simply align themselves with a published style, for example, the International Baccalaureate style (IBO, 2017a)?
- What do teachers think is expected of them in delivering an interdisciplinary curriculum? Does this perception align with the expectations of their school's principal or head(s) of curriculum? Does it align with the documentation they are working with, if any?
- Are teachers aware of the discourse within integrated curriculum design (multi-, inter-, transdisciplinary) and whether any of the issues apply to their context?
- Do teachers feel able to question the interdisciplinary curriculum they are being asked to deliver?
- To what extent is there a conceptual dissonance between disciplinary and interdisciplinary curriculum demands?

Conceptual gaps arise with the introduction of any innovative curriculum. This is a challenge that must be acknowledged and addressed by any school wishing to implement interdisciplinary teaching and learning. Teachers' existing perceptions of interdisciplinarity and the potential for teachers to challenge the accepted paradigm of interdisciplinary teaching and learning within their school could be directly explored within future research. Research into the conceptual gap related to interdisciplinarity would assist with identifying this gap and developing or supporting measures that help further conceptual understanding.

4 Contextual barriers to innovative curriculum

The contextual barriers related to schools' internal organisation and structure were a key finding. There are two recommendations related to these barriers, the first related to a validation study of the framework and the second as a general study of contextual barriers to curriculum innovation.

A validation study has already been identified in the first recommendation above. When planning a validation study, however, the complexity of the educational environment needs to be embraced, with potential contextual enablers and barriers identified at the outset. Contextual barriers identified in this research were categorised under timetabling, curriculum priorities at both macro- and micro-levels and assessment demands.

A school's timetable may give indications towards how easily interdisciplinary teaching and learning can be enabled in a school. Questions related to how disciplines and school resources are organised through the timetable and how flexible the timetable is, will be useful information towards how well the interdisciplinary framework helps to overcome the timetable challenge.

Identification of the school's curriculum priorities related to vertical and horizontal curriculum organisation, time allocated to individual disciplines and content requirements within disciplines will also be useful information. These macro- and micro- considerations have the potential to impact on any interdisciplinary endeavour, especially if interdisciplinarity has not been identified as a curriculum priority.

Both internal and external assessment demands and the use of summative assessment for accountability purposes will also provide useful information for a framework validation study. As the framework provides two sections on interdisciplinary assessment (formative feedback and assessment rubrics), as well as drawing the interdisciplinary quality indicators through the entire framework, it would be informative to compare how the interdisciplinary assessment sections support or contrast with schools' existing assessment processes.

The second recommendation here is related to each of these contextual barriers: the timetable and a school's own curriculum and assessment priorities. These contextual challenges each had an impact on the development of the interdisciplinary teaching and learning framework. Building upon other research (for example, Liddicoat et al., 2017) that has equally found that contextual elements pose barriers to curriculum innovation, these barriers could be used as the focus of a research investigation. Instead of recognising the barriers as findings related to context when curriculum innovation is introduced, perhaps timetables and curriculum and assessment priorities could be key elements that are monitored when differing curriculum innovations are introduced. This pathway for research might consider the resistance factor involved when introducing curriculum innovations and could be partly grounded in the organisational change literature (for example, Fullan, 1993).

The contextual challenges that arose during this research are a rich source of potential future research. There are multiple perspectives from which research could focus, including from teachers' perspectives of implementing an innovative curriculum idea, or from the perspective of the challenges themselves, for example, from a timetable, curriculum organisation, or assessment perspective. A multi-modelling tool may be useful in these types of research to show impact of various factors, reflecting the need to view the educational environment as a complex system (Levin & Jacobson, 2017; Snyder, 2013).

5 Redefining interdisciplinarity in schools

The discussion chapter concluded with a reflection on the goals of this research. The research question was,

How can interdisciplinary planning, teaching and learning be enhanced through assessment design?

The brief answer to this question is, by *(1) identifying indicators of quality interdisciplinary learning, (2) describing them in detail and (3) embedding these indicators throughout the planning, teaching and learning cycle.*

The answer to the research question resides in the micro-domain of curriculum development. The solution has been in the form of a curriculum innovation that works within the existing educational system to help enable an interdisciplinary approach. It is important to balance this detailed approach however, by revisiting the macro-domain of interdisciplinary curriculum and the definition and purpose of interdisciplinarity. At the conclusion of the research, it was proposed that a new definition of interdisciplinarity, one that was developed specifically for the school sector, would be useful. This new definition recommends that schools not only refer to the accepted scholarly definition of interdisciplinarity, but also use the three understandings that emerged from this research. The new definition recommended is:

> *Interdisciplinary teaching and learning occurs when disciplinary knowledge, concepts and skills are integrated to solve a problem, create a solution, explain phenomena or generate further questions* (Boix Mansilla & Gardner, 2003; Repko & Szostak, 2017)*. The goal of interdisciplinarity is that the learning outcome shows enhancement when compared to disciplinary learning approaches. That is, Outcome ID(A+B) > Outcome D(A)+D(B).*
>
> *Interdisciplinary teaching and learning occur with the understanding that:*
>
> 1. *Single disciplines are building blocks for interdisciplinary integration,*
> 2. *Interdisciplinary integration skills and interdisciplinary purpose are meta-disciplinary objectives of interdisciplinarity*
> 3. *Interdisciplinary purpose is the driving force of interdisciplinarity*

This research cannot be viewed as one-way implementation of educational theory into practice, it must also be viewed from the perspective of educational practice providing influence on theory. The response from the school context to the recommended definition must therefore be addressed in future research. It is only from the complexity of the educational environment that it can be understood whether this new definition is appropriate for and helpful to interdisciplinary teaching and learning.

Further research and dissemination

The five recommendations propose five avenues for further research, including research that targets:

- validation of the whole, or individual components of, the framework,
- the hypothesis that interdisciplinary approaches may receive more status if they are evaluated with a rigorous assessment tool
- the conceptual gap that arises with the introduction of interdisciplinary curriculum
- the contextual challenges that arise with curriculum change. This could involve research from a stakeholder perspective, or from the perspective of the challenges themselves, for example, from a timetabling or assessment perspective
- responses to the proposed definition of interdisciplinarity for a middle- and high-school context.

One of the aims of Educational Design Research is to contribute to the advancement of knowledge in the fields in which the research is undertaken (McKenney & Reeves, 2012; Plomp, 2007; Reimann, 2011). Regardless of whether the proposed further research uses Educational Design Research or other methodologies, an important outcome for educational settings is that research should aim to bridge the perceived gap between theory and practice. Research cannot be viewed as one-way implementation of educational theory into practice, it must also be viewed from the perspective of educational practice in a complex educational environment providing influence on theory. This ongoing feedback cycle of theory-into-practice-into-theory is a key element in conducting useful educational research and leads back to the notion that theory-is-practice and practice-is-theory.

There are various outcomes from this research that will be delivered to the theoretical field with the intent to contribute to this theory-practice-theory cycle. The interdisciplinary planning, teaching, learning and assessment framework is the key outcome from the research that can contribute to theory. The development of the framework, however, did not occur in a theoretical vacuum but was closely interwoven with existing theory on interdisciplinarity, assessment and interdisciplinary assessment. It is to these theoretical fields that the research will also contribute, providing research findings on how interdisciplinarity can be represented in the middle- and secondary-school setting, the integral nature of assessment in the planning, teaching and learning process and the influence of school context on curriculum innovation.

Limitations and benefits

It is perhaps regarding these interrelated fields that flaws in the research were to be found. The research focus was clearly on the development of an interdisciplinary assessment resource and it was within this narrow field of vision that the research was conducted. However, the act of focusing in on such a restricted field naturally excludes a focus on the extensions or alternative perspectives of this field. Richardson (in Richardson & St. Pierre, 2005) proposes the analogy of a multifaceted crystal that guides research, with the caveat that by looking through this crystal, other perspectives are limited. "The crystal combines … multi-dimensionalities and [multiple] angles of approach… What we see depends on our angle of repose … there is no single truth… [crystallisation gives us] a deepened, complex and thoroughly partial understanding of the topic" (Richardson & St. Pierre, 2005, p. 963). By looking through 15 perspectives, those of the researcher and volunteer teachers, this research developed a 'deepened and complex' view of interdisciplinarity in the middle- and secondary-school classroom context and this view may be transferable to other contexts. There are countless other views, classroom perspectives and contexts, however, that could have contributed alternative ideas, and this is an accepted limitation of the research.

Despite the limitations, informative and illuminating insights for other practitioners can still result from the outcomes of qualitative research (Crotty, 1998, p. 48; McKenney & Reeves, 2014, p. 138) and communication between educational theory and the classroom context is still possible (Walker, 2011). Findings from an un-controlled classroom practice environment are often more useful to schools than those findings that result from artificially controlled situations (Black et al., 2003, pp. 119-120). That is, seeing other teachers' ideas and practice can improve one's own.

In this light, despite the limitations of the research focus and size, this research is relevant for teachers wishing to implement an interdisciplinary approach to curriculum. Whether this arises from internal or external school requirements or professional interest, the framework will be useful as it is intended as a support tool. This means that teachers can use the framework as a complete planning, teaching, learning and assessment cycle or use selected components as suited to their needs. The recommendation from the research would be to use the complete cycle, as this would ensure maximum alignment with the literature on interdisciplinarity. It is recognised that this is not the reality in many schools, however, and teachers will need to select and omit certain components. The IBMYP schools that contributed to this research are a good example here in that the IB has its own, very specific interdisciplinary planning and assessment requirements that IB schools must adhere to (IBO, 2017a), therefore IBMYP teachers would likely use the framework as a detailed support tool for planning interdisciplinary units of work.

Epilogue – levels of complexity

There have been a variety of cycles looping throughout the research process and, to an extent, throughout this thesis. The most evident cycles are those shown in the Educational Design Research figures that represent the different stages of the research process. There were less evident cycles that contributed to research quality that are well suited to being mentioned in this chapter, however, in order to bring the thesis to a close.

Designing an intervention required a methodology that would enable drafting and redrafting of ideas to evolve a quality solution. Educational Design Research best matched this need due to its iterative purpose and iterative nature: the iterative purpose encompasses the idea of research-informing-practice-informing-research that gradually closes the research-practice gap (McKenney & Reeves, 2014; Plomp, 2007; Reimann, 2011); the iterative nature of the methodology is reflected in the repeating design cycle that is organised within a series of phases (McKenney & van den Akker, 2005; Plomp, 2007; Reeves, 2006). When iterative purpose and iterative nature are combined, the methodology is represented as a (design) cycle within a (phase) cycle following a cyclical purpose. Rather than the single purpose (research-practice-research) that has been used in this research, it is perhaps better to show the cycles in their continuing dimension, where the research Phases 1 and 3 join to enable ongoing cycles of research (Figure 8.2).

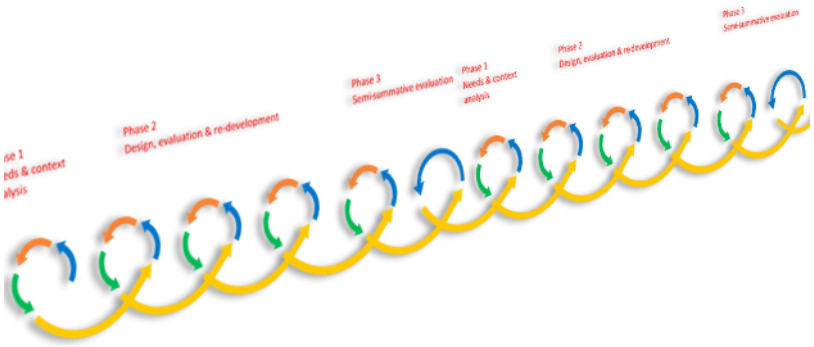

Figure 8.2: Ongoing Educational Design Research cycle

The ongoing, cyclical nature of Educational Design Research makes this methodology well suited to future validation studies of the interdisciplinary framework. The design cycles have the capacity to enable validation of the framework while continuing to apply modifications and further development where needed.

While it is useful to see the Educational Design Research cycles in extension (Figure 8.2), there are further cycles that were not followed in this research. There was potential for many cycles to emerge from each design cycle in an exponential stream of questions prompting further research

prompting further questions (Figure 8.3). These further questions needed to be placed to one side in order to contain the scope of this research and the resulting thesis, though they remain available for investigation. The most common questions are collated in this chapter.

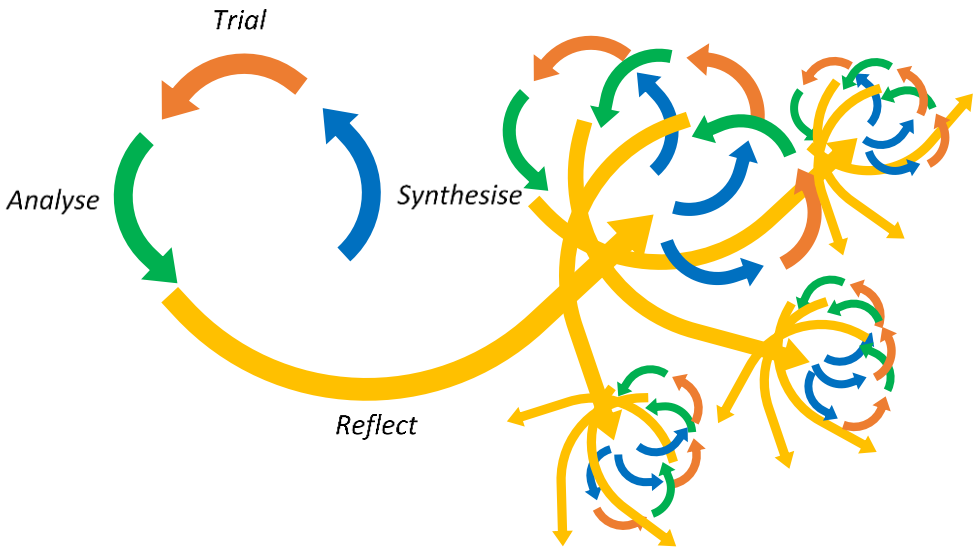

Figure 8.3: Further research potential arising from each design cycle

In addition to the levels of complexity within and arising from the research design cycles, there was also the theme of interdisciplinarity running through the research itself. The challenge in this research was to devise an intervention that would enable assessment of interdisciplinary approaches in the middle school classroom. The method needed to be *rigorous* according to the reviewed literature, *accessible* for teachers so that the tool could be used with little need for further access to literature or professional learning and *enabling* so that it would help teachers implement an interdisciplinary approach in the classroom. The intervention that was developed through this research, the interdisciplinary framework, was itself helpful in organising and reflecting upon the research as it progressed.

If the interdisciplinary framework is used to retrospectively describe the research, beginning at the *Inform* section, the interdisciplinary nature and flow of the research becomes apparent. *Figure 6.2b: Inform Interdisciplinary Design* asks for the identification of the interdisciplinary purpose and how the interdisciplinary Core Elements influence the unit or task design. The purpose of this research, designing a tool for interdisciplinary assessment, fits the first *Inform* category, 'problem-focused', even though there is potential overlap into the other purpose categories. To respond to the needs of the interdisciplinary Core Elements, two 'disciplines', interdisciplinary pedagogy and educational assessment were used as the building blocks for the research, as well as a third 'interdiscipline', existing attempts at interdisciplinary assessment. The interdisciplinary skills needed were

understanding of the relationship between disciplines, an ability to communicate between disciplines and to reflect upon and analyse the disciplinary combination. The transformation being aimed for was both a quantitative and qualitative enhancement. The aim was to create an additional tool that analysed and synthesised ideas of interdisciplinary quality from the literature and it was hoped that the inclusion of volunteer teachers would enable iterative enhancements of the tool.

Figure 6.2c: Enable Interdisciplinarity further scaffolds the research methodology. The *Disciplines* Core Element emphasises the need for a rigorous review of the literature on interdisciplinary pedagogy, educational assessment and interdisciplinary assessment so that these ideas can be built upon and threaded throughout the research. The *Interdisciplinary skills* Core Element emphasised the need to consider how the reviewed literature would be analysed and synthesised into a tool, in collaboration with the volunteer teachers. Ultimately this was enabled at a macro-level by the Educational Design Research methodology, though at the micro-level the blending of guidance from published research, feedback from teachers and school contexts was also clear. The *Transformation* Core Element emphasised the need to have a vision of what the outcome might be. This was originally conceived as an assessment resource, though rapidly became imagined as the broader interdisciplinary planning, teaching, learning and assessment framework.

Figure 6.2d: Formative Feedback was represented through the *Trial* stage of each design cycle. This was the stage where the draft assessment tool or framework was sent to the volunteer teachers with the specific intent to gain feedback on the drafts. At this point, the researcher and volunteers needed to be interdisciplinarians working as an interdisciplinary team. The Core Elements were addressed again here through the guiding interview themes that asked whether the framework was rigorous according to the reviewed literature, accessible for teachers and enabling of interdisciplinarity in the classroom. The interviews sought feedback related to whether the framework was drawing upon quality practice and then integrating and synthesising this practice into a useful tool.

Figure 6.2e: Assess Interdisciplinary Achievement was represented through each *Analyse* stage of each design cycle. This was the stage where the researcher would collate the feedback from the teachers, cross-reference the feedback with the reviewed literature and make judgements according to how the reviewed literature and teacher feedback were being integrated and synthesised into the tool or framework.

Figure 6.2f: Reflect-Evaluate-Reconnect was represented through the *Reflect* and *Synthesise* stages of each design cycle. This was the stage where the researcher reflected on the judgements from the previous stage, made decisions according to the reviewed literature, teacher feedback and the

perceived needs of the evolving interdisciplinary framework, then synthesised these decisions into the subsequent draft. From this point the cycle would repeat, reconfirming the research purpose, enabling the next design cycle, eliciting feedback, assessing the data, reflecting and re-synthesising.

There has been, therefore, cyclical complexity within the research process. The research used interdisciplinary methods to develop an interdisciplinary pedagogical resource: the research methods were reflected in the research outcome and the outcome in the methods. This research that aimed to develop an interdisciplinary teaching and learning resource has itself reflected interdisciplinarity in action.

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Appendix A: Questionnaire to schools

The questionnaire was enabled through Survey Monkey. It was created on 24 July 2015 and collected 33 responses between 21 September 2015 and 7 April 2016.

Introduction Page

The aim of this survey is to obtain a current picture of interdisciplinary teaching, learning and assessment in Adelaide schools. This will support the development of a new assessment method that supports interdisciplinary teaching and learning: if you would like to participate in the trial of this new method, please indicate so at the end of the survey. This research is being carried out by Shani Sniedze-Gregory, a PhD candidate at Flinders University, South Australia.

You are invited to participate in this research project because you are currently teaching, or planning to teach, an interdisciplinary unit of work to students in any year of middle school (years 6-10).

Your participation in this survey is voluntary. You may choose not to participate. If you decide to participate in this survey, you may withdraw at any time without penalty.

The procedure involves completing online survey that will take approximately 10 minutes. Your responses will be confidential and we do not collect identifying information, unless you volunteer for further research activity.

If you have any questions about the survey, please contact snie0002@flinders.edu.au.

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (project number 6930). For more information regarding ethical approval of the project, or for any concerns or complaints about this project, the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au. This project has also been approved by Catholic Education South Australia, and the Department for Education and Child Development (project number CS/15/00005-1.6).

Continuing with the survey indicates that:

- You are involved in teaching, or planning to teach, an interdisciplinary unit of work to students in any year of middle school (years 6-10)
- You have read the above information
- You voluntarily agree to participate
- You are at least 18 years of age

Contextual information

1. What curriculum and/or philosophy does your school follow (tick all that apply)?
    - Australian curriculum
    - International Baccalaureate (IB)
    - Steiner-Waldorf
    - Montessori
    - Other (please specify)

2. Which middle school year levels do you currently teach (tick all that apply)?
    - Year 6
    - Year 7
    - Year 8
    - Year 9
    - Year 10

3. In which subject areas do you teach (tick all that apply)?
    - The Arts
    - English
    - Health and Physical Education
    - Humanities and Social Sciences
    - Languages/language acquisition
    - Mathematics
    - Science
    - Technologies/Design
    - Work Studies
    - Other (please specify)

Interdisciplinary Curriculum

4. The IB Middle Years Programme requires that schools have at least one interdisciplinary unit per year, per year level. The Australian Curriculum has no such requirement but encourages interdisciplinary learning where possible. How is this reflected in your school?

5. Are there any professional learning opportunities offered by your school for interdisciplinary planning and teaching?
    - Yes:
        - external courses (please specify)
        - in-school program by own school staff
        - other (please specify)
    - No

6. Have you attended any professional learning opportunities offered for interdisciplinary planning and teaching?
    - Yes:
        - external courses (please specify)
        - in-school programs by own school staff
        - other (please specify)
    - No

7. How useful is your current planning process for interdisciplinary teaching?
    - Follow guidance from course attended (Likert scale 1-5, not useful at all – very useful)
    - Follow guidance from curriculum guide (IBMYP or other) (Likert scale 1-5, not useful at all – very useful)
    - Follow guidance from other texts/research (please identify) (Likert scale 1-5, not useful at all – very useful)
    - Collaboration with other teachers (Likert scale 1-5, not useful at all – very useful)
    - Other (please specify) (Likert scale 1-5, not useful at all – very useful)

8. How do you decide on the method for assessing the interdisciplinary work? How useful is this process?
    - Follow guidance from courses attended (Likert scale 1-5, not useful at all – very useful)
    - Follow guidance from curriculum guide (IBMYP guide or other) (Likert scale 1-5, not useful at all – very useful)
    - Follow guidance from other texts/research (please identify) (Likert scale 1-5, not useful at all – very useful)
    - Collaboration with other teachers (Likert scale 1-5, not useful at all – very useful)
    - Other (please specify) (Likert scale 1-5, not useful at all – very useful)

9. Who assesses a piece of interdisciplinary work at your school?
    - Teachers involved assess collaboratively
    - Teachers involved assess their own subject component
    - A combination of the two above
    - Other (please describe)

10. Do you use any specific criteria for assessing interdisciplinary work?
    - IBMYP criteria
    - We split the work back into disciplines for assessment
    - Other (please list)

11. How do you ensure quality control of interdisciplinary assessment?
    - Through use of standardised assessment criteria
    - Teachers collaborate to standardise their marking
    - Other (please specify)

<u>Evaluation</u>

(Likert dot point scales for questions 12-14)

12. How satisfied are you with the interdisciplinary *planning* process in your school? (Highly dissatisfied to highly satisfied)

13. How satisfied are you with the interdisciplinary *assessment* process in your school? (Highly dissatisfied to highly satisfied)

14. If you are less than highly satisfied with the above, please highlight the extent to which you would like to improve each category. (Needs much improvement to needs no improvement)
    - Management/coordination of ID units
    - Professional learning opportunities
    - Interdisciplinary planning processes
    - Interdisciplinary assessment methods

Planned trial of assessment method

In 2015/16, we are planning to trial an interdisciplinary assessment method that has been developed through an extensive review of current research and consultation with schools. We are looking for volunteer teachers who are already planning to implement an interdisciplinary unit within this timeframe to assist in the trial of the assessment method. This would involve 3-4 hours of your time, over and above what you would normally spend on an interdisciplinary unit, and would include face-to-face training in the trial assessment method as well as follow-up interviews to determine its effectiveness.

Are you willing to volunteer for this trial?

- Yes (please provide contact details below so we can contact you – your survey answers will still be de-identified as soon as practicable)
  Name:

  School email address:

- No

Thank you for your time and contribution to this survey. Your assistance is greatly appreciated.

Appendix B: Interview questions

The framing questions prepared for the interview meetings with volunteer teachers were designed to elicit specific feedback on the research direction and the draft interdisciplinary assessment tool and framework. The questions were based upon the plans for assessment framework analysis, addressing the extent to which the draft tool/framework was *rigorous*, *accessible* and *enabling*. Each interview included supporting material as a focus point, as described in Chapters Four and Five of the thesis, for example, the overview of the reviewed literature or the current draft framework.

Since specific feedback was being sought, the proposed interviews were *semi-structured*: this style utilised framing questions with the interviewees, as shown in the figure below, but also contained open-ended questions that gave interviewees the opportunity to describe their opinions and experiences in-depth. These open-ended questions are detailed below. The researcher added further questions or omitted questions at the time of the interview, as appropriate, to enable conversation. These further, informal questions stayed within the boundaries of the framing questions.

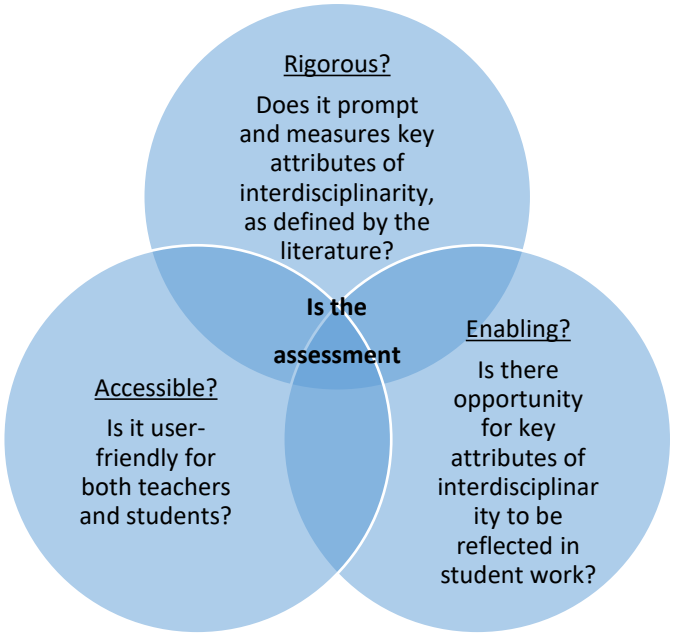

Figure B1: Framing questions for interviews

Accessibility

1. Can you describe how you used the assessment framework? Did you find the assessment framework user-friendly? Did you encounter any difficulties in applying the assessment framework to your interdisciplinary unit?
2. Is there anything about the framework that needs to be changed or could be better explained for teachers?

Rigour

3. Did the framework assist you to evaluate (measure) the learning outcomes that you were aiming for in the interdisciplinary unit? (learning outcomes may be, for example, disciplinary depth or conscious integration)
4. Did the framework fail to focus on any particular qualities or attributes that you think are important aspects of interdisciplinary learning?

Enabling

5. What interdisciplinary learning outcomes were you aiming for in the tasks you designed using the assessment framework?
6. Did the assessment framework assist you to design the task so that students had opportunities to demonstrate the intended interdisciplinary learning outcomes?
7. To what extent did the students (or student work) demonstrate the interdisciplinary learning outcomes you aimed for?

Note that the first interviews did not use the protocol above as these were introductory interviews. These initial interviews with volunteer teachers included self-introductions and conversations on the research goals, the contexts of the volunteer teachers, their schools and their expectations of participation in the research.

Appendix C: Consent form for volunteer teachers

CONSENT FORM FOR PARTICIPATION IN RESEARCH

I ….....

being over the age of 18 years hereby consent to participate as requested in the **trial of an interdisciplinary assessment method**, that includes interviews to provide feedback, as part of my planned interdisciplinary teaching schedule.

1. I have read the information sheet provided.
2. Details of procedures and any risks have been explained to my satisfaction.
3. I agree to **audio recording** of my information and participation.
4. I prefer to be interviewed:
   - ☐ individually
   - ☐ in a focus group
   - ☐ either individually or in a group, I don't mind
5. I am aware that I should retain a copy of the Information Sheet and Consent Form for future reference.
6. I understand that:
   - I am free to withdraw from the project at any time and am free to decline to answer particular questions.
   - While the information gained in this study will be published as explained, I will not be identified and individual information will remain confidential. Individual data will be stored on a secure university server.
   - I may ask that the recording/interviews be stopped at any time, and that I may withdraw at any time from the assessment method trial or the research without disadvantage.

Participant's signature……..…Date……...

I certify that I have explained the study to the volunteer and consider that she/he understands what is involved and freely consents to participation.

Researcher's name: Shani Sniedze-Gregory

Researcher's signature…….……..Date…….

NB: Two signed copies should be obtained. The copy retained by the researcher may then be used for authorisation of Item 7, as appropriate.

7. I, the participant whose signature appears below, have heard the audio recording and/or read a transcript of my participation *(delete as applicable)* and agree to its use by the researcher as explained.

Participant's signature……Date……...

Appendix D: Information sheet

Ms Shani Sniedze-Gregory
School of Education

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Adelaide SA 5001

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INFORMATION SHEET

Title: Interdisciplinary Assessment

Researcher:
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Description of the study:
This study is part of the project entitled 'Interdisciplinary Assessment' and is supported by Flinders University School of Education.

Purpose of the study:
The aim of this research is to deliberately include indicators of interdisciplinary effectiveness from current research on interdisciplinary teaching and learning into the assessment process, to see if these are useful in enabling both:

- the planning of interdisciplinary teaching and learning experiences, and
- assessment of the resulting student work.

The researcher aims to identify whether there are any indicators that emerge that enable teachers to adapt current interdisciplinary research to the classroom context, assisting them with both planning and assessment, and to see if there are any elements that hinder this process.

What will I be asked to do?
Teacher participants are asked to complete an electronic survey. This will take approximately 15 minutes. Completion of the survey will include consent to participate in the survey.

Subsequent to the survey, some teachers will agree to participate in a trial of an interdisciplinary assessment framework. This will take place between mid-2015 and mid-2016, to fit in as part of their normal interdisciplinary teaching schedule. Extra time needed to introduce the prototype assessment framework and engage in subsequent interviews (either individual or as a group) will

take approximately 3-4 hours, spread over the course of the interdisciplinary unit. Teacher participants may need to bring assessed student work to the interviews to exemplify their contributions.

The time and location of these sessions will be subject to the teachers' convenience, and teacher participants will have control over the data that they personally contribute to the study.

What benefit will be gained from being involved in this study?
It is hoped that the sharing of your experiences will improve the implementation of interdisciplinary teaching and learning programs in Australian schools. If desired, teachers may use any knowledge that they gain from their experience in their own continuing teaching practice. The researcher will share the outcomes of the project directly with all participants.

Will I be identifiable by being involved in this study?
If you only participate in the survey, we do not need your name and you will be anonymous.
If you volunteer for the assessment framework trial, we will need your name and contact details in order to work with you. However, after the collection of data is complete any identifying information will be removed, including the destruction of voice files. The re-identification key will be stored on a password-protected computer to which only the researcher (Ms Shani Sniedze-Gregory) will have access, and this will be stored separately to the research data.

Are there any risks or discomforts if I am involved?
Apart from the time imposition – 15 minutes for the survey, approximately 3 hours over a unit of work - the researcher anticipates few risks from your involvement in this study.

Participation is voluntary and you may withdraw yourself and any data you have contributed at any time. If you have any concerns regarding anticipated or actual risks or discomforts, please raise them with the researcher – the aim is to make the research beneficial to all parties involved.

How do I agree to participate?
Participation in both the survey and the assessment framework trial is voluntary.

- You can volunteer to participate in the survey by clicking on the survey link and consenting to participate as part of the first question.
- You can volunteer to participate in the assessment framework trial at the end of the survey by answering yes and providing your contact details so the researcher can get in touch with you. The researcher will then provide you with a consent form to participate in the assessment framework trial, along with further details of the trial.

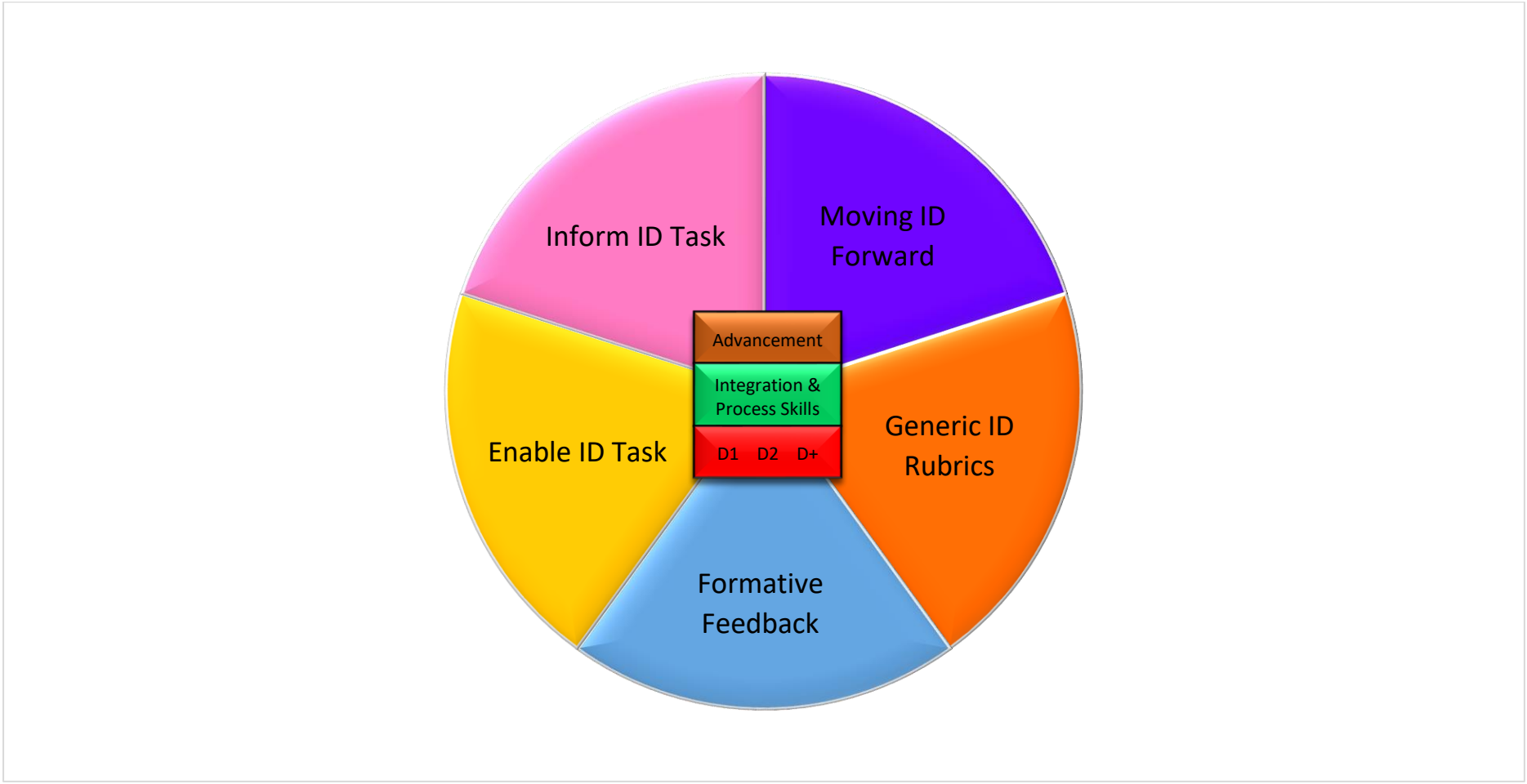
What will happen to the data after the project is complete?
Outcomes from the project will be summarised and given to you by the researcher at the end of the project. The primary use of the data will be to construct a thesis on interdisciplinary assessment; some data might be suitable to include in journal articles in the field of education. All data will have been de-identified before use in the thesis or any articles.

Thank you for taking the time to read this information sheet and we hope that you will accept our invitation to be involved.

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project Number 6930), the Department for Education and Child Development (Project number CS/15/00005-1.6) and Catholic Education South Australia. For more information regarding ethical approval of the project, or for any complaints, the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email <human.researchethics@flinders.edu.au>.

Appendix E: Second draft framework constructed during *Cycle 4* of the research

This draft framework includes the updated assessment rubrics shown in Figure 5.11 in the thesis and is an integration of Figures 5.10 and 5.11. This draft also includes a cosmetic overlay that refined the model into a circular diagram and highlighted the model colours throughout the framework. However, the content in this draft is largely the same as the first draft synthesised in *Cycle 4*, hence its presentation here as an appendix. This draft framework version was sent to volunteer teachers in preparation for the August-September 2016 meetings.



Core Elements – overview

D1 D2 D+ Disciplinary objectives

Students show achievement of the disciplinary objectives as defined by their local curriculum (Australian Curriculum, MYP, SACE, school-based disciplinary assessment)

Level	Description
X	
X	
X	
X	

Level	Description
X	
X	
X	
X	

Level	Description
X	
X	
X	
X	

I&PS Integration and process skills

Students show the ability to blend relevant disciplinary knowledge, concepts and skills in innovative ways to address the situation presented.

Description Students blend relevant disciplinary knowledge/concepts/skills in innovative ways. They show:	**When assessed?** (start, mid, end, throughout?)
• understanding of the interplay between disciplines - how disciplines integrate in order to support/contradict each other (do they interlock, intertwine, blend, build upon?)	
• an ability to communicate between disciplines to generate mutual understanding of the situation presented and enable a solution/product (including the use of an interdisciplinary vocabulary)	
• an ability to reflect upon and analyse the disciplinary combination (particularly if disciplines are contradictory in any sense): how do the disciplines illuminate the issue/problem/challenge?	
• creativity in choosing and combining the disciplines	

Adv Advancement

Students show an advancement of knowledge, understanding, skills or attitudes that could not have been achieved through a single discipline

Description Students demonstrate an advancement of knowledge/concepts/skills/attitudes that could not have been achieved through a single discipline. They show:	**When assessed?** (start, mid, end, throughout?)
• a quantitative or qualitative advancement of knowledge/concepts/skills/attitudes in an integrated context. Advancement may be reflected in innovation, creativity, and/or perceptive analysis.	
• elements of synergy or serendipity: deliberate or unexpected advancements that arise from skilful integration of disciplines	
• the ability to reflect upon and evaluate their own advancement of knowledge/concepts/skills from an integrated context	

Inform Interdisciplinary Task Design

How do the core elements influence task design?

What is the purpose for interdisciplinarity?

Purpose of the interdisciplinary effort	**Questions for Planning**
Task/Outcome-focused • Will it be an aesthetic or literary synthesis: a symbolic work that can help viewers make sense of complex ideas? (IBO, 2014) • Will it be personal expression: a song/performance or similar that expresses a concept? (IBO, 2014)	What is the purpose of this interdisciplinary unit/task? (Choose one from the column at left) **Core elements** With the purpose in mind: D1 D2 D+ What disciplinary objectives will be met? What existing disciplinary assessment will this involve? I&PS What integration and process skills* do students need? Adv What advancement* might happen? *Check the core elements/rubrics for tips
Skill-focused • Will it involve cross-over tooling: use of a skill or concept in multiple disciplines to understand a new issue? (IBO, 2014)	
Knowledge- or Concept-focused • Will it be a complex explanation: combining expertise from multiple disciplines to develop a more complete/complex understanding? (IBO, 2014; Nikitina, 2006) • Will it be a contextualisation: embedding ideas from one discipline into another disciplinary context or into a larger philosophical framework? (IBO, 2014; Nikitina, 2006)	
Problem-focused • Will it be a practical solution: multiple disciplines combine to address a problem and create a product, find a solution, develop an intervention? (IBO, 2014; Nikitina, 2006)	

Enable Interdisciplinary Task

How do the core elements enable the task?

Core Elements	Questioning	Scaffolding
Disciplinary Objectives D1 D2 D+	• What do students need to know from the disciplines? • How will we learn this?	• What are the disciplinary objectives? • Where do they come from? • How will the objectives be assessed? And when? • Could we design the task-specific rubric together? • How can the disciplinary objectives be taught/learned? • What activities will the students need to come to grips with these building blocks?
Integration and Process Skills I&PS	• How are will the students (or we) combine the disciplinary knowledge, concepts, skills or attitudes?	• What are the integration skills needed for this task? • How will students combine disciplines? • What skills do students need to think about disciplinary combination? • How can students act upon their integrative thinking? • How can students show their integrative thinking? • How and when will these skills be assessed?
Advancement Adv	• What will students produce? • How will students show their learning?	• What do we imagine will be the outcome of this task? A product, solution, explanation? Will students choose? • How will the outcome show the disciplines? • How will the outcome show the integration? • Within the above, is the task open enough to allow synergy or serendipity to happen? • How will students recognise the advancement? (By using multiple disciplines, do you think you have a better understanding?) • How will students talk about the advancement?

Formative Feedback

How do the core elements enable formative feedback?

Core Elements	Scaffolding to enable task (from previous, Enable Interdisciplinary Task)	Targeted performance descriptors (from next, Generic Interdisciplinary Rubrics)	Feedback – example guiding questions
Disciplinary Objectives D1 D2 D+	• What are the disciplinary objectives? • Where do they come from? • How will the objectives be assessed? And when? • Could we design the task-specific rubric together? • How can the disciplinary objectives be taught/learned? • What activities will the students need in order to come to grips with these building blocks?	**Sophisticated** performance of the objectives in each discipline	• How can the student improve the disciplinary building blocks – knowledge, concepts, skills or attitudes – required?
Integration and Process Skills I&PS	• What are the integration skills needed for this task? • How will students combine disciplines? • What skills do students need to think about disciplinary combination? • How can students act upon their integrative thinking? • How can students show their integrative thinking? • How and when will these skills be assessed?	**Thorough, detailed** understanding of the interplay between disciplines. **Sophisticated** ability to communicate between disciplines **Deep** reflection on, and **thorough** analysis of, the disciplinary combination, and how it illuminates the issue/problem/challenge **Shows** creativity in choosing and combining disciplines	• How can the student improve their demonstration of disciplinary interplay? • How can the student improve their communication between disciplines? • How can the student improve their analysis of the disciplinary combination? • Does the student need to experiment with more disciplinary combinations, ratios or integration methods?
Advancement Adv	• What do we imagine will be the outcome of this task? A product, solution, explanation? • How will the outcome show the disciplines? • How will the outcome show the integration? • Within the above, is the task open enough to allow synergy or serendipity to happen? • How will students recognise the advancement? (By using multiple disciplines, do you think you have a better understanding?) • How will students talk about the advancement?	**Clear** advancement of knowledge/ concepts/skills/attitudes in an integrated context **Clear** elements of synergy or serendipity **Sophisticated** ability to reflect upon their own advancement of knowledge/ concepts/skills/attitudes	• How can the advancement – over and above the disciplinary standard – of knowledge, concepts, skills or attitudes be made clearer? Will it be part of the outcome or reflection? • Have there been elements of synergy or serendipity? How can the students highlight these? • Can students recognise and reflect upon their advancement? How can the student improve their reflection on the task?

Generic Interdisciplinary Rubrics

Disciplinary objectives

D1 D2 D+

Students show achievement of the disciplinary objectives as defined by their local curriculum (Australian Curriculum, IBMYP or DP, SACE, school-based disciplinary assessment)

Description	Level
	X
	X
	X
	X

Description	Level
	X
	X
	X
	X

Description	Level
	X
	X
	X
	X

Integration and process skills

I&PS

Students show the ability to blend relevant disciplinary knowledge, concepts and skills in innovative ways to address the situation presented. They show:

- understanding of the interplay between disciplines - how disciplines integrate in order to support/contradict each other – do they interlock, intertwine, blend, build upon?
- an ability to communicate between disciplines to generate mutual understanding of the situation presented and enable a solution/product (including the use of an interdisciplinary vocabulary)
- an ability to reflect upon and analyse the disciplinary combination (particularly if disciplines are contradictory in any sense): how do the disciplines illuminate the issue/problem/challenge?
- creativity in choosing and combining the disciplines

Description The student shows:	Level, grade (align with disciplinary style)	When assessed?
Limited understanding of the interplay between disciplines • can identify the disciplines involved • struggles to describe the connections between disciplines Limited ability to communicate between disciplines • uses discipline-specific vocabulary • shows little or no awareness of the interdisciplinary audience Limited reflection on, and analysis of, the disciplinary combination, and how it illuminates the issue/problem/challenge • can identify the disciplines involved, but shows little or no awareness of how multiple disciplines can help address the issue/problem/challenge Shows limited creativity in choosing and combining disciplines • needs assistance to identify which disciplines could help address the issue/problem/challenge • can choose and combine disciplines with assistance	1-2 D ☹ Beginning *Year 6	(start, mid, end, throughout?)
Some understanding of the interplay between disciplines • can provide an explanation of how the disciplines connect, combine, intertwine or blend together Some ability to communicate between disciplines • uses discipline-specific vocabulary • shows some awareness of the interdisciplinary audience Some reflection on, and analysis of, the disciplinary combination, and how it illuminates the issue/problem/challenge • can explain simply how multiple disciplines help address the issue/problem/challenge	3-4 C 😐 Improving *Year 7	

With support, shows creativity in choosing and combining disciplines • can identify disciplines that might help address the issue/problem/challenge • can choose and combine disciplines with minimal assistance		
Good understanding of the interplay between disciplines • can explain how the disciplines connect, combine, intertwine or blend together • can explain how and why the disciplines support each other Requisite ability to communicate between disciplines • uses discipline-specific vocabulary • shows an awareness of the interdisciplinary audience through clarifications and explanations Adequate reflection on, and analysis of, the disciplinary combination, and how it illuminates the issue/problem/challenge • explains in detail how multiple disciplines contribute to addressing the issue/problem/challenge • makes some suggestions to improve the disciplinary combination Shows some creativity in choosing and combining disciplines • chooses and combines disciplines independently • proposes and explains their choice of multiple disciplines that might address the issue/problem/challenge	5-6 B ☺ Meeting *Year 8	
Thorough, detailed understanding of the interplay between disciplines • can explain how the disciplines connect, combine, intertwine or blend together, showing awareness that the interplay may be invisible at times • explains in detail how and why the disciplines support each other Sophisticated ability to communicate between disciplines • uses discipline-specific vocabulary • communicates seamlessly to an interdisciplinary audience through clarifications, explanations and disciplinary translations where needed Deep reflection on, and thorough analysis of, the disciplinary combination, and how it illuminates the issue/problem/challenge • evaluates how multiple disciplines contribute to addressing the issue/problem/challenge, describing the strengths and weaknesses of the combination • makes suggestions to counter the disciplinary- or combination-related challenges Shows creativity in choosing and combining disciplines • proposes and justifies their choice of a range of disciplines that might address the issue/problem/challenge: justifications may be insightful • chooses and combines disciplines independently	7-8 A ☺☺ Exceeding *Year 9/10	

Adv Advancement

Students show an advancement of knowledge, understanding, skills or attitudes that could not have been achieved through a single discipline. They show:

- a quantitative or qualitative advancement of knowledge/concepts/skills/attitudes in an integrated context. Advancement may be reflected in innovation, creativity and/or perceptive analysis
- elements of synergy or serendipity: deliberate or unexpected advancements that arise from skilful integration of disciplines
- the ability to reflect upon and evaluate their own advancement of knowledge/concepts/skills/ attitudes from an integrated context

Description The student shows:	Level, grade, etc (align with disciplinary style)	When assessed? (start, mid, end, throughout?)
Limited or no advancement of knowledge, concepts, skills or attitudes in an integrated context • shows disciplinary knowledge, concepts, skills or attitudes but these are not integrated • little or no awareness of the potential to integrate disciplines shown Limited or no elements of synergy or serendipity • has difficulty using disciplinary grounding, and integration and process skills in combination, even with support • considers only one integration, solution or way of knowing before choosing a course of action, even with support Limited ability to reflect upon their own advancement • has difficulty considering how the integration of disciplines might help in advancing their own knowledge, concepts, skills or attitudes	1-2 D Beginning ☹ *Year 6	
Supported advancement of knowledge, concepts, skills or attitudes in an integrated context • has heavily used support structures (scaffolding) to enable creativity and/or analysis Some elements of synergy or serendipity, achieved with support • has used the disciplinary grounding, and integration and process skills in combination, with support • consideration, with support, of more than one potential integration, solution or way of knowing has helped enable the advancement Some ability to reflect upon their own advancement • has heavily used support structures (scaffolding) to consider how the integration of disciplines has enabled their own advancement of knowledge, concepts, skills or attitudes	3-4 C Improving 😐 *Year 7	
Some advancement of knowledge, concepts, skills or attitudes in an integrated context • shows the beginnings of innovation, creativity and/or perceptive analysis Some elements of synergy or serendipity • has used the disciplinary grounding, and integration and process skills in combination • consideration of two or three potential integrations, solutions or ways of knowing has helped enable the advancement	5-6 B Meeting ☺ *Year 8	

Requisite ability to reflect upon their own advancement • considers how the integration of disciplines has enabled their own advancement of knowledge, concepts, skills or attitudes		
Clear advancement of knowledge, concepts, skills or attitudes in an integrated context • innovation, creativity and/or perceptive analysis is shown Clear elements of synergy or serendipity • student has used the disciplinary grounding, and integration and process skills to leverage an advancement • consideration of multiple potential integrations, solutions or ways of knowing has helped enable the advancement Sophisticated ability to reflect upon their own advancement • considers in detail how the integration of disciplines has enabled their own advancement of knowledge, concepts, skills or attitudes	7-8 A Exceeding ☺☺ *Year 9/10	Throughout End Throughout

Moving Interdisciplinary Planning Forward

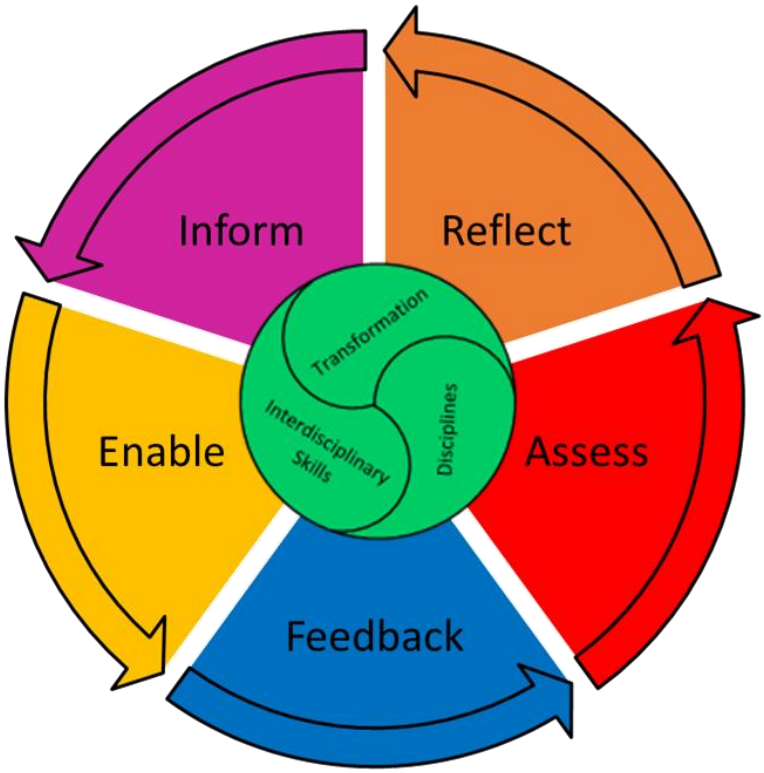
How do the core elements enable reflection for future tasks?

Core Elements	Reflection on performance	Reflection leading forward
Disciplinary Objectives D1 D2 D+	• Were the disciplinary objectives fit for purpose? Do we need to modify/add to/swap them? • Were the objectives assessable? Do we need to modify disciplinary assessment? • Do we need to change the timing of assessment? • Could there be other ways for students to develop knowledge/concepts/skills/ attitudes to address the disciplinary objectives?	Where will we go next time? Will the interdisciplinary effort be: • Task/outcome focused? • Skill focused? • Knowledge- or concept-focused? • Problem focused? With the above purpose in mind (see reflections from column at left): • What disciplinary objectives will be met? What existing disciplinary assessment will this involve? • What integration and process skills will students need? ▪ Connection skills? (connect, combine, intertwine, blend) ▪ Communication skills? ▪ Reflection skills? ▪ Thinking skills? ▪ Creativity? • What advancement might happen? ▪ Knowledge? ▪ Concepts? ▪ Skills? ▪ Attitudes?
Integration and Process Skills I&PS	• Did students understand the need to integrate disciplines? How can this be improved? • Were the integration skills fit for purpose? Did students need more skills, more practice, or both? • Were the disciplinary combinations effective? How can we further enable this step? • Were students able to show their integrative thinking? How can this be enabled further? • Do we need to change the timing of assessment of integration and process skills?	
Advancement Adv	• What were the various outcomes of this interdisciplinary endeavour? As predicted? Were there any unpredicted outcomes? • How did the outcomes show the disciplines? How did the outcomes show the integration? Were they appropriate to the task or does this need modifying? • Was the task open enough to allow synergy? Serendipity? Unpredictability? Could it be modified to do so? • Did students recognise the advancement? Do we need to enable this further? • Were students able to talk about the advancement? Do we need to enable this further?	

Appendix F: Framework adapted to the Australian Curriculum

As reported in Chapter Six, the interdisciplinary framework design was intended to be *adaptable* to individual school contexts. It was suggested during the meetings with volunteer teachers that conducting a trial of this adaptability would be useful even if it did not fit within the parameters of the research, given that a modified, curriculum-specific version of the framework would be, by definition, less accessible or less enabling for a wider range of schools.

The Australian Curriculum (AC) version of the framework presented in Appendix F has been developed by the researcher and may support opportunities for further research and development as discussed in Chapter Nine. All elements specific to the Australian Curriculum can be viewed on the Australian Curriculum website (ACARA, 2017a). The example template at the end of the adaptation prompts teachers to create a one-glance overview of planning and is intended to be used by the researcher as a base for e-application development.



Core Elements

Disciplines (Australian Curriculum learning areas)

Identifying and addressing disciplinary objectives within an interdisciplinary endeavour ensures that student work is rigorously grounded in the disciplines. Students can then use the disciplines as building blocks for interdisciplinary transformation.

Disciplines (learning areas) and their corresponding objectives (strands, sub-strands, threads, inquiry, skills) will be defined by the Australian Curriculum or the senior school curriculum, for example, HSC, VCE, SACE. Teachers and students should choose the strands, sub-strands, threads, inquiry and/or skills listed within the learning areas that are most relevant to the interdisciplinary endeavour. General capabilities and cross-curriculum priorities might also be addressed through the interdisciplinary endeavour and the chosen learning areas. Further prompts are contained within the framework that help that align the learning areas, general capabilities or cross-curriculum priorities with the interdisciplinary purpose.

Interdisciplinary skills

Students show the ability to integrate relevant knowledge, concepts and skills from the learning areas in innovative ways to address the situation presented. At various times throughout the interdisciplinary endeavour, students might show:

- understanding of the relationship between learning areas. How do the learning areas support or contrast each other? Do they interlock, intertwine, blend, build upon, borrow, adapt, exapt, reframe?
- an ability to communicate between learning areas to generate mutual understanding of the situation presented and enable a solution, product or more-complex understanding. This may include the development and use of an interdisciplinary vocabulary.
- an ability to reflect upon and analyse the learning area combination, particularly if learning areas are contrasting: how do the learning areas illuminate the issue, problem or challenge?
- creativity in choosing and combining learning areas, when appropriate.

While most general capabilities will be addressed through the learning areas chosen, the *interdisciplinary skills* core element explicitly prompts capabilities related to *Critical and Creative Thinking*, that is, “reflecting on thinking and processes; inquiring into, identifying, exploring and organising information and ideas; generating ideas, possibilities and actions; analysing, synthesising and evaluating reasoning and procedures” (ACARA, 2017a).

Transformation

Students show an enhancement of knowledge, understanding, skills or attitudes that could not have been achieved through a single learning area (discipline). At the end of the interdisciplinary endeavour, students may show:

- a quantitative or qualitative enhancement of knowledge, concepts, skills or attitudes in an integrated context. Enhancement may be reflected in innovation, creativity, and/or complex analysis.
- elements of synergy, emergent complexity or serendipity: deliberate or unexpected enhancements that arise from skilful integration of learning areas.
- the ability to reflect upon and evaluate their own enhancement of knowledge, concepts, skills or attitudes in an integrated context.

This core element has no equivalent in the Australian Curriculum. It addresses the purpose of interdisciplinarity and is part of the original contribution from this research.

Inform Interdisciplinary Design

What is the purpose for interdisciplinarity? How do the core elements influence unit or task design?

Who will find, generate and drive the interdisciplinary endeavour?

Purpose of the interdisciplinary effort	**Questions that guide planning of the unit or task**
Instrumental interdisciplinarity: Task-, Outcome- or Problem-focused • Will it be an aesthetic or literary synthesis: a symbolic work that can help viewers make sense of complex ideas that span disciplines? (Boix Mansilla, 2010; IBO, 2017a; Klein, 2012) • Will it be personal expression: a song, poem, artwork, performance or similar that expresses a concept? (Boix Mansilla, 2010; IBO, 2017a) • Will it be a practical solution: multiple disciplines combine to address a problem and create a product, find a solution, develop an intervention? (Boix Mansilla, 2010; IBO, 2017a; Nikitina, 2006)	Will the interdisciplinary endeavour be: • Teacher-selected? (due to school constraints?) • Student-driven? • A combination of teacher- and student-driven? What is the purpose of this interdisciplinary unit/task? (Choose one from the column at left) Will the students need to find an interdisciplinary challenge? **Core elements** With the purpose in mind: What learning area strands, sub-strands, threads, inquiry and/or skills will be met? What existing learning area assessment will this involve? What general capabilities or cross-curriculum priorities will be involved? What interdisciplinary skills* or general capabilities will students develop? What transformation* might happen? *Check the *Core Elements* and *Assess Interdisciplinary Achievement* for further ideas
Methodological interdisciplinarity: Skill-focused • Will it involve cross-over tooling: use of a skill or concept in multiple disciplines to understand a new issue? (Boix Mansilla, 2010; IBO, 2017a; Klein, 2012) • Will it involve communication through a first or second language that integrates linguistic objectives into the process or outcome?	
Theoretical interdisciplinarity: Knowledge- or Concept-focused • Will it be a complex explanation: combining expertise from multiple disciplines to develop a more complete/complex understanding? (IBO, 2017a; Klein, 2012; Nikitina, 2006) • Will it be a contextualisation: embedding ideas from one discipline into another disciplinary context or into a larger philosophical framework? (IBO, 2017a; Klein, 2012; Nikitina, 2006)	
Critical interdisciplinarity: Philosophical focus • Will the interdisciplinary endeavour critique the structure of knowledge and education? Will philosophy be used as an integrating lens through which one or more disciplines will question what is known and how we know it? (Frodeman, 2013; IBO, 2013; Klein, 2012)	

Enable Interdisciplinarity

How do the core elements enable the interdisciplinary unit or task?

Core Elements	Questioning	Enabling
Disciplines (AC learning areas) 	• What do students need to know from the learning areas? • How will students learn this?	• What are the learning area strands, sub-strands, threads, inquiry and/or skills? • Where do they come from? • How will the learning area strands, sub-strands, threads, inquiry and/or skills be assessed? And ***when***? • Could teachers and students design a task-specific rubric together? • How can the learning area strands, sub-strands, threads, inquiry and/or skills be taught/learned? • What activities will the students need in order to develop expertise in the learning area building blocks? • Is the interdisciplinary endeavour centred through one learning area (for example: arts-based learning), or are the learning areas relatively equal?
Interdisciplinary Skills 	• How will the students (or teachers) combine the learning area strands, sub-strands, threads, inquiry and/or skills? Will the integration interlock, intertwine, blend, build upon, borrow, adapt, exapt, reframe?	• What are the integration skills needed for this unit or task? • How will students combine learning areas? • What skills do students need to think about disciplinary combination? • How can students act upon their integrative thinking? • How can students show their integrative thinking? • How and ***when*** will these skills be assessed? Interdisciplinary skills are often best assessed ***as they occur***, rather than as part of a final product.
Transformation 	• What will students produce? • How will students show their learning? • How will students recognise and show their transformed awareness?	• What do we imagine will be the outcome of this unit or task? A product, solution, explanation? Will students choose? • How will the outcome show the learning area strands, sub-strands, threads, inquiry and/or skills? • How will the outcome show the integration? • Within the above, is the unit or task open enough to allow a transformation to occur? • How will students recognise the transformation? (By using multiple disciplines, do you think you have a better understanding?) • How will students talk about the transformation?

Formative Feedback

How do the core elements and the planning, teaching and assessment sections enable formative feedback?

How will students bridge the gap from where they are to where they wish to be?

Core Elements		**Formative feedback – example guiding questions** **How will the students bridge the gap to achieve an outcome that reflects 'quality'? What learning strategies will be used? What will this look like?**	
Disciplines (AC learning areas) 	**What did we plan to do?** **What could the outcome be?** **What are students aiming for?** **This will reflect information from *Inform* and *Enable***	• How can the student improve the learning area building blocks – strands, sub-strands, threads, inquiry and/or skills knowledge, concepts, skills or attitudes – required? • What does disciplinary quality look like? • How can the student bridge the gap between current and targeted disciplinary performance?	**Where are we heading?** **What is considered 'quality' in this interdisciplinary endeavour?** **This will reflect information from the next section, *Assess***
Interdisciplinary Skills 		• How can the student improve their demonstration of disciplinary interplay? • How can the student improve their communication between disciplines? • How can the student improve their analysis of the disciplinary combination? • Does the student need to experiment with more learning area combinations, ratios or integration methods? • **When** will interdisciplinary skills be formally assessed?	
Transformation 		• How can the advancement – over and above the disciplinary standard – of knowledge, concepts, skills or attitudes be made clearer? Will it be part of the outcome or reflection? • Have there been elements of synergy or serendipity? How can the students highlight these? • Can students recognise and reflect upon their transformation? How can the student improve their reflection on the task?	

Assess Interdisciplinary Achievement

Disciplines (AC learning areas)

Students show achievement of the learning area strands, sub-strands, threads, inquiry and/or skills as defined in the Australian Curriculum through the sequences of achievement, or the senior school curriculum. Teachers, and students where appropriate, will have selected the learning area strands, sub-strands, threads, inquiry and/or skills at the *Inform* and *Enable* stages.

General capabilities and cross-curriculum priorities might also be identified or informally assessed at this stage.

It is recommended that, where possible, learning assessment follows the pattern used in the *Interdisciplinary skills* and *Transformation* rubrics, so that all indicators of interdisciplinary quality are assessed in the same manner. These rubrics have been designed as follows:

1. Attribute is chosen – for disciplinary assessment, this attribute will come from the disciplinary objectives. These attributes could be listed above the rubric table.
2. Attribute is given four *holistic* (Jonsson & Svingby, 2007; Tierney & Simon, 2004; Wiggins, 1998) level descriptions that align with the SOLO taxonomy levels of "uni-structural", "multi-structural", "relational" and "extended abstract" (Biggs & Collis, 1982, pp. 24-25)
3. Each of these general descriptions is supported by *analytic* (Jonsson & Svingby, 2007; Tierney & Simon, 2004; Wiggins, 1998) dot-points that describe in detail what that attribute might look like in a classroom setting
4. Multiple attributes can be combined into one indicator-of-quality rubric, as long as each attribute addresses the overarching indicator of quality

Disciplinary objective 1

Description	Level
Holistic description • analytic • analytic	Uni-structural
Holistic description • analytic • analytic	Multi-structural
Holistic description • analytic • analytic	Relational
Holistic description • analytic • analytic	Extended abstract

Disciplinary objective 2

Description	Level
Holistic description • analytic • analytic	Uni-structural
Holistic description • analytic • analytic	Multi-structural
Holistic description • analytic • analytic	Relational
Holistic description • analytic • analytic	Extended abstract

Disciplinary objective 3

Description	Level
Holistic description • analytic • analytic	Uni-structural
Holistic description • analytic • analytic	Multi-structural
Holistic description • analytic • analytic	Relational
Holistic description • analytic • analytic	Extended abstract

Interdisciplinary skills

Students show the ability to integrate relevant knowledge, concepts and skills from the learning areas (disciplines) in innovative ways to address the situation presented. At various times throughout the interdisciplinary endeavour, students may show:

- understanding of the relationship between learning areas - how learning areas support or contrast each other – do they interlock, intertwine, blend, build upon, borrow, adapt, exapt?
- an ability to communicate between learning areas to generate mutual understanding of the situation presented and enable a solution, product, or more-complex understanding (including the potential use of an interdisciplinary vocabulary)
- an ability to reflect upon and analyse the learning area combination (particularly if they are contrasting): how do the learning areas illuminate the issue, problem, or challenge?
- creativity in choosing and combining the learning areas, when appropriate.

General capabilities such as *Critical and Creative Thinking* might also be identified or informally assessed at this stage.

Description The student shows:	Level (align with disciplinary style)	When assessed? (start, mid, end, *in tempore*?)
Limited understanding of the interplay between disciplines (learning areas) • can identify the disciplines involved • struggles to describe the connections between disciplines Limited ability to communicate between disciplines • uses discipline-specific vocabulary • shows little or no awareness of the interdisciplinary audience Limited reflection on, and analysis of, the disciplinary combination, and how it illuminates the issue/problem/challenge • can identify the disciplines involved, but shows little or no awareness of how multiple disciplines can help address the issue/problem/challenge • reasoning for disciplinary combination may be shallow or show disciplinary bias Shows limited creativity in choosing and combining disciplines • needs assistance to identify which disciplines could help address the issue/problem/challenge • can choose and combine disciplines with assistance	Uni-structural	
Some understanding of the interplay between disciplines (learning areas) • can describe how the disciplines connect, combine, intertwine or blend together Some ability to communicate between disciplines • uses discipline-specific vocabulary • shows some awareness of the interdisciplinary audience Some reflection on, and analysis of, the disciplinary combination, and how it illuminates the issue/problem/challenge • can explain simply how multiple disciplines help address the issue/problem/challenge • reasoning for the disciplinary combination is sound Shows some creativity in choosing and combining disciplines, with minimal support • can identify disciplines that might help address the issue/problem/challenge, with minimal assistance	Multi-structural	

• can choose and combine disciplines with minimal assistance		
Good understanding of the interplay between disciplines (learning areas) • can explain how the disciplines connect, combine, intertwine or blend together • can explain how and why the disciplines support each other Requisite ability to communicate between disciplines • uses discipline-specific vocabulary • shows an awareness of the interdisciplinary audience through clarifications and explanations across disciplines Adequate reflection on, and analysis of, the disciplinary combination, and how it illuminates the issue/problem/challenge • explains in detail how multiple disciplines contribute to addressing the issue/problem/challenge • gives sound reasoning for the disciplinary combination and makes some suggestions to improve the combination Shows some creativity or divergent thinking in choosing and combining disciplines • proposes and explains their choice of multiple disciplines that might address the issue/problem/challenge • chooses and combines disciplines independently and critically	Relational	
Thorough, detailed understanding of the interplay between disciplines (learning areas) • can explain how the disciplines connect, combine, intertwine or blend together, showing awareness that the interplay may be invisible at times • explains in detail how and why the disciplines support each other Sophisticated ability to communicate between disciplines • uses discipline-specific vocabulary • communicates seamlessly to an interdisciplinary audience through clarifications, explanations and disciplinary translations where needed Deep reflection on, and thorough analysis of, the disciplinary combination, and how it illuminates the issue/problem/challenge • evaluates how multiple disciplines contribute to addressing the issue/problem/challenge, describing the strengths and weaknesses of the combination • gives thoughtful reasons for the disciplinary combination and makes suggestions to counter any disciplinary- or combination-related challenges Shows creativity or divergent thinking in choosing and combining disciplines • proposes and justifies their choice of a range of disciplines that might address the issue/problem/challenge: justifications may be insightful • chooses and combines disciplines independently and creatively	Extended abstract	

Transformation

Students show an enhancement of knowledge, understanding, skills or attitudes that could not have been achieved through a single learning area (discipline). Students may show:

- a quantitative or qualitative enhancement of knowledge, concepts, skills or attitudes in an integrated context. Enhancement may be reflected in innovation, creativity and/or complex analysis.
- elements of synergy, emergent complexity or serendipity: deliberate or unexpected enhancements that arise from skilful integration of learning areas.
- the ability to reflect upon and evaluate their own enhancement of knowledge, concepts, skills, or attitudes in the integrated context.

Description The student shows:	Level (align with disciplinary style)	When assessed? (start, mid, end, *in tempore*?)
Limited or no enhancement of knowledge, concepts, skills or attitudes in an integrated context • shows disciplinary knowledge, concepts, skills or attitudes but these are not integrated, and limit any transformation • little or no awareness shown of the value of integrating disciplines Limited or no elements of synergy, emergent complexity or serendipity • difficulty using disciplinary grounding and interdisciplinary skills in combination, even with support, has limited the transformation • consideration of only one potential integration, solution or way of knowing before choosing a course of action, even with support, has hindered enhancement Limited ability to reflect upon their own advancement • has difficulty considering how the integration of disciplines might help in enhancing their own knowledge, concepts, skills or attitudes	Uni-structural	
Supported enhancement of knowledge, concepts, skills or attitudes in an integrated context • has used support structures (scaffolding) to enable creativity, analysis or transformation Some elements of synergy, emergent complexity or serendipity achieved with support • has used the disciplinary grounding and interdisciplinary skills in combination, with support, to enable some transformation • consideration, with support, of more than one potential integration, solution or way of knowing has helped enable an enhancement Some ability to reflect upon their own advancement • considers, with support, how the integration of disciplines has enabled enhancement of their own knowledge, concepts, skills or attitudes	Multi-structural	

Some enhancement of knowledge, concepts, skills or attitudes in an integrated context • shows the beginnings of innovation, creativity and/or perceptive analysis, with little or no support Some elements of synergy, emergent complexity or serendipity • has used the disciplinary grounding and interdisciplinary skills in combination to enable some transformation • consideration of multiple potential integrations, solutions or ways of knowing has helped enable an enhancement Requisite ability to reflect upon their own advancement • considers how the integration of disciplines has enabled enhancement of their own knowledge, concepts, skills or attitudes	Relational	
Clear enhancement of knowledge, concepts, skills or attitudes in an integrated context • innovation, creativity and/or perceptive analysis is shown Clear elements of synergy, emergent complexity or serendipity • has used the disciplinary grounding and interdisciplinary skills to leverage an enhancement • thoughtful consideration of multiple potential integrations, solutions or ways of knowing has helped enable an enhancement Sophisticated ability to reflect upon their own advancement • thoughtfully considers how the integration of disciplines has enabled enhancement of their own knowledge, concepts, skills or attitudes	Extended abstract	

Reflect – Evaluate – Reconnect

How do the core elements enable reflection for future interdisciplinary endeavours?

Core Elements	Reflection on performance	Reflection leading forward
Disciplines 	• Were the learning area strands, sub-strands, threads, inquiry or skills fit for purpose? Do we need to modify/add to/swap them? • Were the learning area objectives assessable? Do we need to modify the learning area (disciplinary) assessment? • Do we need to change the timing of assessment? • Could there be other ways for students to develop knowledge/concepts/skills/ attitudes to address the learning area objectives – strands, sub-strands, threads, inquiry or skills?	Where will we go next time? Will the interdisciplinary effort be: • Instrumental: Task/outcome/problem focused? • Methodological: Skill focused? • Theoretical: Knowledge- or concept-focused? • Critical: Philosophical focus? With the above purpose in mind (see reflections from column at left): • What learning area objectives will be met? What existing learning area assessment will this involve? • What interdisciplinary skills will students need? ▪ Connection skills? (connect, combine, intertwine, blend) ▪ Communication skills? ▪ Reflection skills? ▪ Thinking skills? ▪ Creativity? • What transformation might happen? ▪ Strands, sub-strands, threads? ▪ Concepts or inquiry? ▪ Skills? ▪ Attitudes?
Interdisciplinary Skills 	• Did students understand the need to integrate learning areas? How can this be improved? • Were the interdisciplinary skills fit for purpose? Did students need more skills, more practice, or both? • Were the learning area combinations effective? How can we further enable this step? • Were students able to show their integrative thinking? How can this be enabled further? • Do we need to change the timing of interdisciplinary skills assessment?	
Transformation 	• What were the various outcomes of this interdisciplinary endeavour? As predicted? Were there any unpredicted outcomes? • How did the outcomes show the learning areas? How did the outcomes show the integration? Were they appropriate to the unit or task or does this need modifying? • Was the unit or task open enough to allow synergy? Serendipity? Unpredictability? Could it be modified to do so? • Did students recognise the transformation? Do we need to enable this further? • Were students able to talk about the transformation? Do we need to enable this further?	

Example planning template

What is the purpose for the interdisciplinary endeavour?

How will the core elements influence unit or task design?

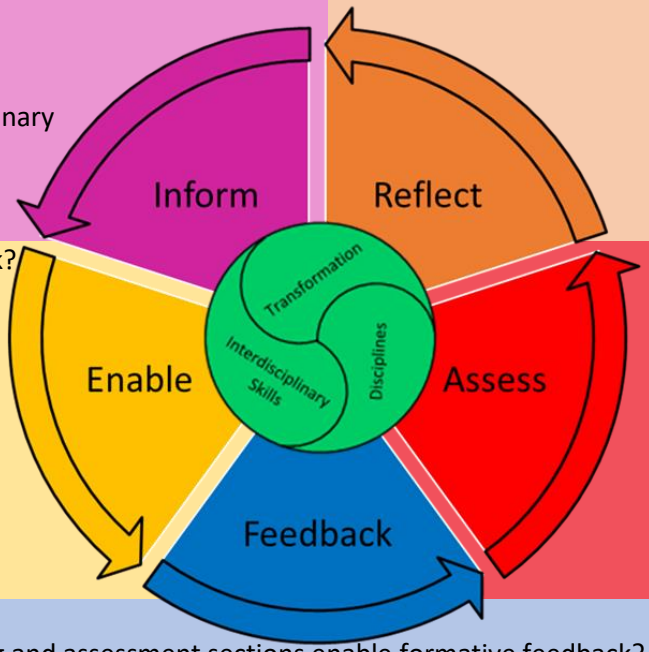
Who will find, generate and drive the interdisciplinary endeavour?

How do the core elements enable reflection for future units or tasks?
Disciplines?

Interdisciplinary skills?

Transformation?

Where will we go next?



How do the core elements enable the unit or task?
Disciplines?

Interdisciplinary skills?

Transformation?

What does interdisciplinary 'quality' look like?

How do the core elements and planning, teaching and assessment sections enable formative feedback?

How will students bridge the gap from where they are to where they wish to be? How will students achieve an outcome that reflects 'quality'?

Glossary

Term	Definition in the interdisciplinary education context
Adapt	A form of integration. Students might borrow knowledge, concepts and/or skills from one discipline and modify them for use in another discipline.
Blend	A form of integration. Similar to intertwining, students draw multiple subject group attributes together in rapid, iterative succession.
Borrow	A form of integration. Students might use knowledge, concepts and/or skills from one discipline to enhance knowledge, concepts and/or skills in another discipline.
Build upon	A form of integration. Students alternate between disciplinary insights, but each addition enhances the understanding or solution. Insights are not discarded after use.
Complex analysis	Students identify or collate ideas into patterns or relationships that demonstrate and explain how multiple, integrated disciplines contribute to a more-complex understanding of an interdisciplinary phenomenon. Complex analysis may involve sub-skills such as deduction, induction and restructuring of ideas.
Creativity	Attribute where students draw upon their knowledge, concepts, skills and/or attitudes to develop an outcome that is innovative and may not follow linear expectations. Creativity may show elements of divergent thinking. Robinson simplifies the idea as *creativity = imagination + action*.
Discipline	"Academic studies that focus on a self-imposed limited field of knowledge" (Cohen & Lloyd, 2014, p. 189). In the Australian Curriculum (ACARA, 2017a) the *Learning Areas* equate to disciplines; in the International Baccalaureate (IBO, 2017c) they are called *subject groups*. In this framework, disciplines are used as the building blocks for interdisciplinary endeavours.
Emergent complexity	A more-complex representation of, or solution to, a problem, challenge or issue that has resulted from the integration of disciplines
Exapt	A form of integration. To co-opt knowledge or skills for a use other than that for which they were originally designed or developed. Students might borrow and/or modify knowledge, concepts and/or skills from a discipline that is conceptually or methodologically distant (Nissani, 1995) from another discipline.
Illuminate	Used in the context of multiple disciplines illuminating an issue, problem or challenge. How is an issue/problem/challenge seen differently when students view it through different disciplinary lenses?

Innovation	One possible representation of the transformation that may have occurred through an interdisciplinary endeavour. Students may have generated an idea or solution that is new and useful through their skilful integration of disciplines.
Integrate, Integration	A combination or combining of disciplines. This may take various forms, for example, disciplines may interlock, intertwine, blend, build upon, borrow, adapt, exapt or reframe. Each of these examples is defined in this glossary.
Interlock	A form of integration. Disciplines are used in tandem to generate a more-complex understanding or solution. This reflects Martin's (2009) idea of the opposable mind, where students hold two different ideas in their head in order to begin to resolve the issue, challenge or problem at hand. Disciplines are not separated at the end of the interdisciplinary endeavour.
Interplay	How the disciplines integrate with each other.
Intertwine	A form of integration. The drawing together of multiple subject groups in rapid, cyclical succession.
Reframe	A form of integration. Students view multiple disciplines through the lens of one central discipline, for example, arts-based learning. While one discipline provides the lens for the interdisciplinary endeavour, disciplinary objectives from all disciplines are clearly addressed and integrated.
Serendipity	In everyday parlance, this refers to unintentional good fortune. In the context of interdisciplinary education, *serendipity* is the idea that students may transform their understanding or abilities in unexpected or surprising but beneficial ways, as a result of integrating disciplines.
Synergy	The concept that *the whole is greater than the sum of its parts*. In interdisciplinary education, students achieve synergy when their knowledge, conceptual understanding, skills or attitudes are enhanced or improved to an extent greater than the sum of the contributing disciplinary knowledge, concepts, skills or attitudes.
Transformation	Students show an emergence or enhancement of knowledge, understanding, skills or attitudes that could not have been achieved through a single discipline

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Appendix G: IBMYP annotated interdisciplinary unit planner

As reported in Chapter Six, the interdisciplinary framework design was intended to be *adaptable* to individual school contexts. It was suggested during the meetings with volunteer teachers that conducting a trial of this adaptability would be useful, even if it did not fit within the parameters of the research, given that a modified, curriculum-specific version of the framework would be, by definition, less accessible or less enabling for a wider range of schools.

The IB Middle Years Programme *annotated* interdisciplinary unit planner presented in Appendix G has been annotated by the researcher and may support opportunities for further research and development as discussed in Chapter Nine. Given that IBMYP teachers are required to use the IBMYP interdisciplinary unit planner process (IBO, 2017a, p. 33), the planner (IBO, 2017a, pp. 42-46) has been annotated for use as a base from which teachers are directed to the interdisciplinary framework for further support. These two documents, the interdisciplinary framework developed in this research (Chapter Six) and the annotated IBMYP interdisciplinary unit planner (Appendix G) should be used in tandem to support effective interdisciplinary practice.

Interdisciplinary unit planner

Teacher(s)		Subject groups **If the Purpose is *Critical Interdisciplinarity*, subject choice may help focus the unit.**			
Unit title		MYP year		Unit duration	

Inquiry: establishing the purpose of an interdisciplinary unit

Purpose of integration **Refer to *Inform Interdisciplinary Design* section of the framework**	
Key concept(s)/(related concepts) **These will come from the subject groups chosen (see IBMYP subject guides). If the Purpose is *Theoretical interdisciplinarity*, the concepts here may focus the unit.**	Global context **What is the lens through which the unit will be viewed? How will the unit be connected to the world? (see IBMYP subject guides for details)**
Statement of inquiry **This will integrate your Purpose, Concept(s) and Global context**	
Inquiry questions **If the Purpose is *Instrumental interdisciplinarity*, the problems or challenges posed here may focus the unit.**	
Factual **Conceptual** **Debatable**	

Summative assessment—interdisciplinary performance(s) of understanding **If the Purpose is *Instrumental* or *Methodological Interdisciplinarity*, these tasks, outcomes or solutions may focus the unit.** **The *Enable Interdisciplinarity* section of the framework provides more scaffolding questions related to the transformative outcome of interdisciplinarity.** **The *Assess Interdisciplinary Achievement* section of the framework provides more detail related to interdisciplinary quality. However, IBMYP schools will need to use the published IBMYP criteria.**	
Interdisciplinary criteria	Task(s)
Approaches to learning (ATL) **If the Purpose is *Methodological Interdisciplinarity*, the ATL skills here may focus the unit.**	

Action: Teaching and learning through interdisciplinary inquiry

Disciplinary grounding **If the Purpose is *Methodological Interdisciplinarity*, cross-over skills from disciplines may focus the unit.** **The *Enable Interdisciplinarity* and *Formative Feedback* sections of the framework provides more scaffolding questions in relation to disciplinary grounding.**	
Subject	**Subject**
MYP objective	MYP objective
Related concepts	Related concepts
Content	Content
Disciplinary learning engagements and teaching strategies	Disciplinary learning engagements and teaching strategies

<table>
<tr><td colspan="2">Interdisciplinary learning process

The Enable Interdisciplinarity and Formative Feedback sections of the framework provides more scaffolding questions relevant to the learning process</td></tr>
<tr><td rowspan="2">Interdisciplinary learning experiences and teaching strategies

For example, how will the students (or teachers) combine the disciplinary knowledge, concepts, skills or attitudes? Will the integration interlock, intertwine, blend, build upon, borrow, adapt, exapt, reframe?</td><td>Formative assessment

The Formative Feedback section of the framework provides more scaffolding here</td></tr>
<tr><td>Differentiation</td></tr>
<tr><td colspan="2">Resources</td></tr>
<tr><td colspan="2"></td></tr>
</table>

Reflection: considering the planning, process and impact of interdisciplinary inquiry

The *Reflect-Evaluate-Reconnect* section of the framework provides more scaffolding questions relevant to the reflection process

Prior to teaching the unit	During teaching	After teaching the unit