Are we closing 'the gap'? Evaluation of the use by Sydney Catholic systemic school teachers of Essential Secondary Science Assessment online data and its impact on the performance of subsequent cohorts sitting ESSAonline

Gary Carey

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Are we closing ‘the gap’? Evaluation of the use by Sydney Catholic systemic school teachers of Essential Secondary Science Assessment online data and its impact on the performance of subsequent cohorts sitting ESSAonline.

Gary Carey

Supervisor: Assoc. Prof. Kevin Watson

University of Notre Dame
Australia

July 2015
Declaration

I declare that except where due acknowledgement has been made this research thesis is my own work and has not been submitted in any form for another degree at any university or other institute of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

*Gary Carey*

22nd July 2015
Acknowledgements

This thesis owes much to the support of my wife Julie, family, University supervisors, colleagues, schools and supervisors at Catholic Education Office Sydney. I want to acknowledge their contributions.

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<td>BOSTES</td>
<td>Board of Studies Teaching &amp; Educational Standards NSW</td>
</tr>
<tr>
<td>CEO</td>
<td>Catholic Education Office Sydney</td>
</tr>
<tr>
<td>DEC</td>
<td>Department of Education and Communities</td>
</tr>
<tr>
<td>DET</td>
<td>Department of Education and Training</td>
</tr>
<tr>
<td>EMSAD</td>
<td>Educational Measurement and School Accountability Directorate</td>
</tr>
<tr>
<td>ESSA</td>
<td>Essential Secondary Science Assessment (pen and paper test)</td>
</tr>
<tr>
<td>ESSAonline</td>
<td>Essential Secondary Science Assessment Online</td>
</tr>
<tr>
<td>ICSEA</td>
<td>Index of Community Socio-educational Advantage</td>
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<td>NAP</td>
<td>National Assessment Program</td>
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<td>NAPLAN</td>
<td>National Assessment Program – Literacy and Numeracy</td>
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<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
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<tr>
<td>PCK</td>
<td>Pedagogical Content Knowledge</td>
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<tr>
<td>PISA</td>
<td>Programme for International Student Assessment</td>
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<td>SMART II</td>
<td>School Measurement and Reporting Toolkit II</td>
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<td>SOLO</td>
<td>Structure of the Observed Learning Outcomes</td>
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Abstract

Formative assessment practices hold the key to improving the quality of student learning in our educational institutions. Unfortunately, these formative practices are often not well understood by practitioners and opportunities to improve the learning outcomes for our students are lost. This study investigated whether the Catholic Education Office Sydney’s (CEO) commitment to the use of the Essential Secondary Science Assessment online (ESSAonline) was having an impact on the performance of subsequent cohorts of students sitting ESSAonline. The findings of the study clearly show that whilst the test is a powerful driver which can lead to improvement in the performance of subsequent cohorts of students its full potential as a formative test is being under-utilised.

Findings show that very few teachers make extensive use of ESSAonline test data or provide feedback to students about ‘the gap’ between what they know and can do and the expected achievement standard. Without feedback there can be no action by the teacher, students or parents to close ‘the gap’. The majority of teachers who have made extensive use of ESSAonline data have only made use of the data in one way. Teachers who have experienced positive growth in the performance of subsequent cohorts sitting ESSAonline have achieved this by engaging in reflective practice and reviewing their Stage 4 programming and pedagogy. Very few teachers across Sydney diocesan systemic schools have used the data to identify what Stage 5 students know and can / cannot do. Teachers do not use the data to provide feedback to students. Until 2013, there has been no effective tool to track the impact of individual learning plans developed for Stage 5 students from ESSAonline data.

With the current development of Year 10 ESSAonline test, the testing process has been expanded to comprehensively facilitate the tracking of student learning outcomes in Science as students move from Stage 4 through to Stage 5. This new test provides an excellent tool for teachers to measure the impact of individual learning plans developed for Stage 5 students based on data from the Year 8 test.

Within the context of the achievement-based learning conceptual framework the full potential of ESSAonline to systemic schools is being under-utilised and the potential for students to gain real and measurable improvements in their learning outcomes is not being realised.
Chapter 1 INTRODUCTION

1.1 Introduction
This chapter introduces the idea that educational assessment is essentially a process or tool for improvement. The study is about the ways in which teachers in Sydney Archdiocese Catholic systemic schools have used data from Essential Secondary Science Assessment online to improve the performance of subsequent student cohorts sitting the test. Essential Secondary Science Assessment began as a pen and paper test in 2005 but changed to an online format in 2011 and became known as ESSAonline. Throughout the study, the instrument will be referred to by its current name ESSAonline. This chapter outlines the research problem; and, as it is an interpretive study, is used to position the researcher in context of the study. This is done in order to make explicit the potential for bias, to establish the researcher’s expertise and capacity to conduct the research, and to describe the motivations behind the research questions and the significance of the study. In doing this, the rationale for the study is made clear. This overall rationale is then used as a basis from which to argue in favour of the research methodology and rigour of the study, including the appropriateness of its scope and limitations.

The study began as a critical reflection upon a commonly held view among teachers that assessment is the process of gathering and discussing information from multiple and diverse sources to develop a deep understanding of what students know, understand, and can do with their knowledge as it interacts with their past experiences. This process of assessment culminates when the results of assessment processes are used to improve subsequent learning (Huba & Freed, 2000). The key insight of this view of assessment is that it is a process. It is this process, as it is applied to the use of data from ESSAonline, which is the focus of this study. More specifically, this study will explore the process of assessment through discussion and modifications responding to emerging changes in the ways assessment is currently conceptualised. It will be argued that assessment remains incomplete unless assessment data are interrogated, reflected upon and actioned upon to improve learning, especially through actioning student participation in the context of the curriculum and pedagogy they experience and in which they participate.

The study employed a combination of quantitative and qualitative enquiry modes set within a methodological framework of case study. The justification of this methodology
is contained in Chapter 3. Data were collected using an online questionnaire sent to all junior secondary science coordinators across the system. Statistical analysis of these data provided general information about the use of ESSAonline in schools to purposively select six schools to take part in an embedded multiple case study. Semi-structured interviews were then be used to ascertain science coordinator beliefs about the efficacy of ESSAonline as a formative assessment tool and the impact it has had on the performance of students in subsequent tests. The interviews also identified how teachers and students responded to feedback from the data analysis. The final part of the study used longitudinal data from the six case study schools over a five year period, 2008 to 2012, to identify trends in student performance. The findings from the longitudinal study were then compared with the findings from the case studies and interrogated in an attempt to elicit cause and effect. That is, to see if there is a relationship between how schools use data from ESSAonline and the performance of subsequent student cohorts. The study then considered the significance of its findings for: students, teachers, schools, parents, Sydney Archdiocese CEO and concluded with an exploration of whether the Sydney Archdiocese CEO should continue to invest in ESSAonline as a formative assessment tool.

1.2 Statement of the Problem

Every study starts with a problem (Berg & Lune, 2012). The problem this study seeks to understand is how participation of the Sydney Archdiocese CEO school system in ESSAonline impacts on the performance of subsequent cohorts in this test. The ESSAonline process, by providing feedback to individual students and schools, also provides feedback to the system. It is this aspect of the overall process that provides the context for the problem for which this study seeks an answer. So, although identifying the problem is straight forward, finding an answer to the problem is more complex. Student and school data will be interrogated in light of how data, is processed, at the school level, to draw conclusions about the effectiveness of system level participation in the ESSAonline process.

The problem that contextualises this study is not the assessment process for student but the implications for the Archdiocese as a whole. Nevertheless, assessment theory for students will inevitably be the starting point for the study. However, this study will apply
understandings and applications of student assessment processes to answer questions to
solve a problem at the system level.

1.3 Personal and Professional Life story
The researcher is an alumnus of the NSW education system and currently holds a
leadership position within the science education community of the Sydney Archdiocese
Catholic Education Office. In his current role as Science Adviser the researcher has a
genuine and professional interest in raising the quality of teaching and learning for the
thousands of students attending school, not just within the Catholic system but for
students across the State.
Since commencing school, the researcher has experienced many changes in educational
philosophy over more than 50 years, both as learner and teacher. From the early years of
schooling he has vivid memories of sitting in large classrooms of approximately 70
students and living in constant fear of being caned for mistakes made, or at times being
punished for no known reason. Since becoming a teacher many positive changes have
occurred in education removing much of the suffering endured by students in the past.

Upon reflection, the researcher’s earliest recollections of learning can be attributed to a
‘colonialist’ approach to learning where mistakes were dealt with by various forms of
punishment, including caning and humiliation exemplified by being made to stand behind
the blackboard or in front of it with his nose against a chalk mark. The first form (now
Year 7) daily curriculum started with spelling, French and mental arithmetic. Students
were consistently caned for each mistake made. It was not unusual to be caned 15 or
more times by recess. Whilst the philosophy underpinning this pedagogy is problematic,
the fear instilled lead to positive educational outcomes for the researcher.

It was at this time that positive signs of reform began to appear and reliance on the cane /
strap began to wane and the emergence of a behaviourist approach to teaching and
learning began to appear. Teachers began using cue cards and rewarding positive
behaviours, ignoring those that were wrong or unwanted. Mazes began to appear in
newly emerging science laboratories as students attempted to train mice, replicating the
work of B. F. Skinner. At university, much time was spent learning about operant
conditioning and the hierarchy of rewards. Whilst the focus on stimulus / response cards
and hierarchy of rewards has all but disappeared from our current approach to education,
Ertmer and Newby (2008) argue that many aspects of behaviourism – the use of measureable and observable outcomes and pre-assessment of what students know and can do – still underpin and are central to current views of teaching and learning.

In the final years of this researcher’s undergraduate teaching degree, the work of Jean Piaget began to dominate the curriculum and the focus changed from behaviourism to a cognitivist approach to learning. Piaget proposed that one's internal cognitive structure changes throughout life and moves through four recognisable stages, sensori-motor (0 – 2 years), pre-operational (2 – 7 years), concrete operational (7 – 11 years), and finally formal operational (11 years and above). These changes occur as a result of: maturational changes in the nervous system, the organism's interaction with the real world, and exposure to an increasing number of experiences (Gregson & Grupetta, 2012).

Since Piaget’s work in the 1960’s, learning theories have continued to develop with many focusing on particular aspects of learning such as memory and metacognition. Piaget’s theory and the work of Jerome Bruner have been linked and further developed by Biggs and Collis (1982; 1991). This combination of theories facilitated a better understanding of the learning processes utilised by students in the classroom and subsequently led to the development of SOLO (Structure of Observed Learning Outcomes) taxonomy which is now used to measure student achievement in Essential Secondary Science Assessment (Panizzon, Arthur and Pegg, 2006).

Within five years of the researcher starting to teach, the dreaded cane and strap had disappeared and no longer played a role in learning and teaching. Rewards and fear having been removed from the practice of teaching, theorists began to focus on the role of the learner as an active participant in the learning process. The researcher clearly remembers as a young teacher how his practice reflected that described by Hackling, Goodrum and Rennie (2001), which favoured a predominantly teacher-centred approach consisting of two main strategies, directed practical activities, and note taking / working from the textbook. His teaching toolkit included: teacher directed experiments, knowledge recall worksheets, and writing copious pages of notes on the backboard. Whilst there was some focus on the learner as a participant in the learning process, the overall focus was teacher centred.
At this time, the essential components of the teaching and learning process were the organization of the information to be learned, developing an awareness of the learner's prior knowledge and knowing that the new information would build on the student’s existing knowledge. An understanding of the role of the learner as an active participant in the learning process was beginning to form and teaching followed what was emerging as a cognitivist view of teaching and learning.

As time moved on, understandings of instructional design began to focus on the way learners stored, processed and linked new with existing information. For this researcher these new elements became important in the learning process. As part of the promotion process, an inspector checked the researcher’s students’ work books and complemented him for the diligence he had shown in checking their work. The inspector then asked “What are you going to do about the fact that only a small number of students have responded to the feedback you have given them?” Whilst failing to recognise the significance of what had been said, the current movement from a cognitivist to a constructivist paradigm along with the work of Black and Wiliam (2009) are now impacting on the researcher’s theories of learning and teaching. He now believes that teachers must exploit all learning / teaching activities as opportunities for formative assessment and use them to provide appropriate feedback and opportunities for students to respond, thus empowering them to achieve the desired learning outcomes.

By the mid 1990’s a constructivist approach to education had become the focus of teacher professional development. Constructivists believe that the mind filters input from the world to produce its own unique reality (Jonassen, 1991). People learn by building schemata to interpret the world; as the schemata become more sophisticated, so does our understanding of the world. Building upon the work of Piaget, who believed that children construct understanding through many channels: e.g. reading, listening, exploring and experiencing his or her environment, teachers began to move away from a ‘transmission’ model of education to a paradigm where learners need to be supported in their endeavours to build personal interpretations of the world based on their individual experiences and interactions (Ertmer & Newby, 2008). Teachers were and are to this day encouraged to identify learning contexts that are meaningful and relevant to the learner. Contexts need to be realistic and relevant to the lived experiences of students if their conceptual understandings are to evolve. In other words, learning is most effective when it is embedded in the situation in which it is used (Ertmer & Newby, 2008).
Constructivists posit that learning is an active process in which the learner must dialogue with and critically explore their own views in conjunction with the views of others to construct new meaning. Gregson and Gruppetta (2012) report that Vygotsky argued that the most important factors influencing learning are the social and cultural contexts. Vygotsky believed that an individual’s social environment accounts almost entirely for the development of higher order processes and that learning is socially mediated through a culture’s symbols and language.

In recent years ‘making meaning’ has become a dialogic process involving persons-in-conversation, and learning is seen as the process by which individuals are introduced to a culture by a more knowledgeable ‘other’ who has a better understanding or a higher ability level than the learner (Driver et al., 1994, p. 7). The role of the teacher has become, but is not exclusively that of the ‘more knowledgeable other’. Along with this change in focus has been the emergence of a variety of socially mediated teaching strategies including collaborative group work, role play, and peer mentoring.

Gregson and Gruppetta (2012) argue that according to Vygotsky’s theories, conceptual development occurs through a process of internalisation of the concepts which require the learner to have a functional use of it. The learner can then create new meaning by constructing a view of the distinctive features of the concept, and extend this meaning by using their language skills and prior experiences to analyse and synthesise the concept.

Vygotsky’s social constructivist model forged a strong link in the researcher’s mind with the need for feedback to students. According to Vygotsky, the Zone of Proximal Development (ZPD) is where learning occurs and is the distance between a student’s ability to perform a task under adult guidance and / or with peer collaboration and the student’s ability to solve the problem independently. Hence the researcher now perceives the role of the teacher as the more knowledgeable other as vital in not only providing feedback but in facilitating the opportunity for students to respond to feedback. Through an ongoing process of feedback (whether by teacher or peers) and response, students are helped to close ‘the gap’ between their ability to complete a task with assistance and being able to do it independently.
In his current role as Science Adviser for the Archdiocesan systemic school system, the researcher is passionately dedicated to working with science teachers to help them develop learning environments in which students play an active role in learning. The roles of the teacher and student have shifted. The teacher can no longer simply ‘map’ learning onto students. Rather, teachers collaborate with students to facilitate meaning construction. The role of the teacher is to use learning and teaching activities as opportunities for formative assessment. Teachers must provide opportunities for an ongoing cycle of feedback and student response to feedback until students have ‘closed the gap’ and achieved the desired outcome. Teachers function as the ‘more knowledgeable other’. They facilitate feedback / response cycles so students can construct their own meaning in their zone of proximal development.

Teachers can only facilitate this process when they have data about ‘what their students know and can do’. Whilst it has already been said that teachers must view all teaching and learning activities as opportunities to collect data, this researcher believes that diagnostic information provided by external, impartial authorities about student attainment can improve learning for all students. Hence, the purpose of this study is to evaluate the use of diagnostic ESSAonline data by teachers within Sydney’s Catholic systemic schools and its impact on the performance of subsequent student cohorts sitting ESSAonline.

1.3 Research questions

The primary research question to be investigated by this study is:

*How have teachers, in Sydney Catholic systemic schools, used data from Essential Secondary Science Assessment online (ESSAonline) and what have been the impacts of their use on the performance of subsequent cohorts sitting ESSAonline?*

This study will respond to the research question by systematically interrogating the following subsidiary questions.

- What are science coordinators’ beliefs about the value of ESSAonline as a formative assessment tool?
- How are ESSAonline data accessed, shared and analysed within the science faculty?
• How is SMART II used by teachers within the science faculty, what feedback has been provided to students and how have they responded?
• What interventions have been developed in response to ESSAonline and how have they impacted on the performance of subsequent cohorts sitting ESSAonline?
• Should the Catholic Education Office Sydney continue to invest in ESSAonline as a formative assessment tool?

Hackling et al. (2001, p. 16) in their report on the State of Science Education in Australian Secondary Schools remarked:

As we commence the third millennium, a greater priority must be given to building the scientific literacy of our people if Australia is to experience social and economic well-being. At this time the greatest priority is to improve the quality of school science in the compulsory years of secondary schooling so that all students can experience a science education that will make a difference in their lives, and attract our best young minds into science research and careers to make Australian industry competitive.

Following the recommendations made by Hackling et al. (2001) and the performance by Australian students in PISA 2000 the NSW Department of Education and Training, as it was then called, began the development and production of Essential Secondary Science Assessment (ESSA pen and paper test) to test the level of student attainment of Stage 4 learning outcomes listed in NSW Board of Studies, Science Years 7 – 10 syllabus (2003). The purpose of this test was to improve student achievement of the syllabus outcomes by providing teachers with data about what students ‘know and can do’. The testing of Year 8 students began in ‘pen and paper’ format in 2005 and remained this way until changing to ESSAonline in 2011. Throughout this study, the name ESSAonline will be used collectively to refer to the test in its two forms. In situations where it is important to differentiate between the two formats, the ‘pen and paper’ instrument will be called ESSA and the online form ESSAonline. A copy of the 2014 test and related stimulus material can be found in Appendix 1. Appendix 2 contains the Physics section of the ESSA Framework that specifies the required standards for the different Levels of Achievement.

According to Black and Wiliam (2009), for any task to improve student learning, teachers must use the data obtained from the task to provide feedback to students. This feedback must then be used to inform teacher classroom practice to help students close ‘the gap’ between their current level of achievement and expected standards.
During the five year period 2008 to 2012, Catholic Education Office Sydney paid for all Year 8 students to sit ESSAonline. CEO purchased access to the test with the intention that teachers use data from the test to develop school-based interventions designed to assist current students improve their learning outcomes and future students improve performance in future diagnostic testing. Working within a conceptual framework built on formative classroom practices, this study aims to identify whether teacher use of ESSAonline data has led to improved performance of subsequent cohorts of students. It is noted at this point that ESSAonline data can be used by teachers in two ways, a) to reflect on Stage 4 programming and pedagogy and b) to develop individual learning plans for students in Stage 5. This study, through interrogation of the subsidiary questions, will identify how teachers have used the data and the impact it has had on the performance of subsequent cohorts of students.

Since Black and Wiliam (1998a) showed that formative assessment has the potential to raise the standard of student learning, research has continued into the impacts of assessment on student learning and the ways assessment for learning can be used in the classroom to improve student outcomes (Black et al, 2004). Whilst the terms assessment for learning and formative assessment are widely used in educational literature it is important to make a distinction between the two: “the former relates to the purpose for which the assessment is carried out whilst the latter relates to the function it serves” (Wiliam 2011, p.10).

For any assessment to be formative, it must “provide feedback which indicates the existence of ‘a gap’ between the actual level of the work being assessed and the required standard. It also requires an indication of how the work can be improved to reach the required standard” (Taras 2005, p.467). Black and Wiliam (2009, p.10) further extend this view by highlighting that for feedback to be effective it must be interpreted and used by teachers, learners and their peers. Without student action on feedback there can be no improvement in learning.

For the purpose of this study, the term formative assessment is used throughout as it is the researcher’s desire for teachers to use the data from whatever source, be it classroom observation or ESSAonline, to improve student achievement of the desired learning outcomes through the provision of quality feedback and the facilitation of opportunities for students to respond to feedback.
1.4 Significance of the research

This study was undertaken at a significant time in the development of both the National Assessment Program (NAP) (Australian Curriculum, Assessment and Reporting Authority, 2014) testing within the Australian education context and ESSAonline through High Performance Directorate within the NSW Department of Education and Communities (DEC). On May 13, 2013, the then Labour Federal Minister for School Education, Early Childhood and Youth, Mr Peter Garrett AM announced that under the National School Improvement Plan (NSIP) online Science testing would be introduced as part of NAP Testing from 2016. At the same time, NSW Department of Education and Communities expanded ESSAonline with the introduction of tests into Stages 3 and 5.

Within a very short period of Mr Garret’s announcement, a new Coalition Federal Government was elected in October 2013 and changed the future direction of the NAP testing program. At this stage, no final announcement has been made about the future of national science testing. At a State level it will, however, become an even stronger component of testing within the NSW DEC. Irrespective of future developments at a national level, the findings of this study will have real significance for students, teachers, schools, parents, and system within the Sydney Archdiocese CEO.

Dependent upon the findings of this study, one or more outcomes may occur within the Sydney CEO. The direction future developments will take will depend upon two factors, a) the degree to which teachers make use of the data and b) the ability of schools utilising the data to identify improvements in the performance of subsequent cohorts.

Should the findings of this study show that schools are not making use of the data there are two options available. CEO may decide to implement more stringent controls mandating use of the data, reporting student performance and development of school-based interventions. Conversely, they may abandon involvement in ESSAonline and divert the financial resources to other initiatives designed to improve the quality of learning and teaching in science.

On the other hand, if it is found that some teachers / schools are making use of the data in ways that have led to improvements in learning and teaching CEO may leave the current procedures in place and use ‘gentle’ methods of persuasion to encourage more schools to
engage in detailed data analysis and development of intervention programs. Other options could include adopting a more structured approach to making schools accountable for analysis of the data, or abandoning the testing and using the financial resources in other ways designed to bring about improvements in learning and teaching.

Irrespective of the findings of this study, it is anticipated that this study will lead to further improvements in the performance of students in science across the Sydney Archdiocese. Potential exists for benefits to students, teachers, schools, parents and the system.

1.4.1 Students
Impacts on students may occur in one of three ways. In those schools in which the data is carefully analysed and successful interventions implemented, teachers could be encouraged to share their practices across other schools providing opportunities for larger numbers of students to benefit.

In situations where the data is used but there is no evidence of improvement in student results, the CEO may pursue one of two options. The adviser may be directed to work with the schools to explore other intervention strategies that have previously improved student performance, or the CEO may decide to cease allocation of funds to ESSAonline and direct financial resources to other avenues it perceives will improve the learning outcomes of students.

In the event that it is found that teachers are not making sufficient use of ESSAonline data the CEO may develop policies and practises that require schools to analyses and respond to the data. Alternatively, they may direct ESSAonline funding to other ways of improving learning and teaching in science.

1.4.2 Teachers
Black and Wiliam (2010, p.81) argue that the sum of the many education reforms that have been put in place in the past have not produced effective policy because something is missing. The demands of teachers managing up to 30 students in a complex competitive classroom provide a significant challenge for teachers. Standards will only be raised if teachers are helped to improve the quality of their teaching practices. As a
diagnostic test, ESSAonline provides data to teachers about student learning at the end of Year 8. Armed with this feedback, teachers have the potential to identify areas of need for their students and faculty and be better equipped to improve learning outcomes of students.

Findings which show that teachers who make extensive use of test data and have positive impacts on the performance of subsequent cohorts may also have a secondary benefit of allowing these high performing teachers to further develop their skills by mentoring less experienced teachers.

Where attempts to use ESSAonline data have failed to improve student outcomes the use of the professional discourse described above may prove beneficial. The McKinsey Report (Barber & Mourshed, 2007) showed that the most effective professional learning occurs when teachers learn from one another.

Negative findings of this study would indicate that once again ‘something is missing’ and that financial resources previously spent on ESSAonline should be redirected to other initiatives.

1.4.3 Schools
As places of learning, schools are always seeking ways to improve the outcomes for all students. The McKinsey report into effective school systems (Barber & Mourshed, 2007) concluded that effective systems recognised that developing teachers into effective instructors was paramount and that effective professional development occurs when teachers learn from one another in a collaborative framework. The sharing of ideas and problem solving contributes towards the development of a positive attitude toward learning and teaching. Positive findings from some schools about the impacts of the use of ESSAonline data on student performance in testing may provide an opportunity for schools to collaborate and share ideas and information about the work of their practitioners. Teachers from schools that benefitted from their use of ESSAonline should be given the opportunity to share their experiences and practices. This allows students in lower performing schools to benefit from the work being undertaken in high performing schools. When teacher performance improves, both schools and students benefit.
Negative study findings would preclude money being spent in all schools on ESSAonline allowing funding to be redirected into other areas which have the potential to produce positive impacts for all schools.

1.4.4 Parents

Seyfreid and Chung (2002, p.109) report, “Parent involvement and parent expectations are fundamental to academic success.” The findings of this study could have positive implications for parents. Seyfried and Chung (2002) have shown that both parent involvement and parent expectations have positive impacts on the academic achievement of their sons and daughters. Through reporting on students achievement in ESSAonline parents are provided with mechanisms and opportunities for involvement in their children’s education, which can lead to more positive outcomes for students.

Positive findings for this study may lead to ongoing involvement in ESSAonline. Consequently, a direct outcome of this study may be that parents will receive diagnostic data about their sons and daughters strengths and weaknesses. Armed with this information, parents who wish to support their children’s education are given the necessary information to allow them to facilitate their child’s learning and engagement in the science curriculum. Positive findings may also increase opportunities for teachers to engage in further professional learning activities leading to further improvements in student science learning outcomes.

1.4.5 Catholic Education Office, Sydney

Hall and Simeral (2008, p 169) argue that school improvement has always been a priority but can only be achieved by building teacher strengths, abilities and potential. Hence, as a system the Sydney CEO can only benefit from the findings of this study.

Should it be shown that schools are using ESSAonline data and facilitating improved student learning outcomes, then the reflection and planning in which teachers engage has built teacher capacity which, in turn, has impacted positively on both student and teacher performance.

Should it be shown that teachers are not using ESSAonline data then the system will either put in place structures that ensure use of the data, leading to subsequent school
improvement or redirect the financial resources to a different area and so increase the potential to improve student learning.

1.5 Overview of the methodology
This study employed a combination of quantitative and qualitative enquiry modes. As schools are naturalistic environments an interpretivist view of research was adopted as the overall approach for the study. Hence, the researcher as participant will be immersed in the given contexts and work towards forming trusting relationships with other participants to develop deep understandings of the social realities within participating schools.

The study was undertaken in three phases. An embedded multiple case study methodology was used in the first two phases of the study. A grounded approach was used in the analysis of the qualitative data to identify emergent themes (Janetti, 2005). During the third phase of the study a positivistic paradigm was adopted to identify relationships between reported school use of ESSAonline data and student performance in science testing (Ulin, Robinson & Tolley, 2004). This analysis was used to triangulate and validate the qualitative aspects of the study.

In Phase 1, science coordinators from all 33 Sydney Archdiocese Catholic systemic junior secondary schools were invited to respond to an online questionnaire. An online questionnaire was chosen because it has: greater authenticity; less human error in processing data; is quick to distribute and collect and allows respondents the flexibility to complete it when they have time (Cohen, Manion & Morrison 2011, p.280).

Data from the questionnaire was then used to provide both a broad overview of school practices surrounding the use of ESSAonline data and to purposively select six schools as case studies to participate in Phase 2. Two schools were purposefully selected for each of the following three cases. Schools that make:

- extensive use of ESSAonline data to inform and improve learning and teaching;
- some use of ESSAonline data to inform and improve learning and teaching; and
- no use of ESSAonline data.
In Phase 2, the six science coordinators from the schools selected after analysis of the online questionnaire were invited to take part in a semi-structured interview. The purpose of the interviews was to seek deep knowledge and understanding of the ways science coordinators analyse and use ESSAonline data, how students and teachers responded to feedback provided from data analysis, and how school-based interventions have impacted the performance of subsequent student cohorts (Ulin, Robinson & Tolley, 2004).

The third and final phase of the study assessed the ESSAonline data using the School Measurement, Assessment and Reporting Toolkit (SMART II) for students from the six schools that participated in Phase 2. Phase 3 identified trends in student performance over the five year period 2008 – 2012 to validate the findings obtained from the interviews. Data were analysed in terms of five reportable areas: Science Overall; Extended Response; Knowing and Understanding; Communicating Scientifically and Working Scientifically.

The combination of the three data phases provided a rich complexity of information and findings to answer the research questions. By triangulating interview findings with ESSAonline data from the case study schools, improvements in the performance of subsequent cohorts sitting ESSAonline testing were identified.

1.6 Scope and limitations
This study takes place in the field of assessment. It is therefore bounded by the theory that supports and informs this field. Normally, this would be straightforward. However, assessment is one of those dynamic areas of educational theory that is under constant interrogation as it generates and assimilates theoretical advances (Black and Wiliam, 1998b). Consequently, to say the scope of this study is bounded in terms of assessment would be misleading as it would indicate a defined context. Assessment as a theoretical entity is developing and expanding rapidly. It now intimately overlaps with curriculum and pedagogy (Office of Teaching and Learning, 2005). So, the scope of this study is assessment but in saying that it is a dynamic field that intersects and overlaps with curriculum and pedagogy.

The scope of this study is within the Sydney Archdiocese CEO secondary school system. More particularly, it is bounded by the science departments within that system. Indeed,
the scope of this study is even more restricted to the interactions of the science departments with ESSAonline. In one sense the scope of this study extends to the cutting-edge of the educational dynamic – assessment. In another, it is limited to a particular interaction that occurs in a defined set of schools.

As the first two phases of the study collected data about the specific schools studied, the study findings are not able to be generalised. This is the main limitation of this study. However, those who read this study will be able to make comparisons between the schools participating in this study and other schools with similar contexts. In addition, the methodology used for this study can be used to inform similar studies.

Another limitation of this study is that as School Certificate testing has ceased there is no standardised testing tool available to assess the long term impact of ESSAonline on individual students. The study is therefore limited to the impact of ESSAonline on future cohorts of students participating in ESSAonline.

1.7 Outline of the thesis
Chapter 1 presented an introduction to the study. It outlined the research problem; positioned the researcher in terms of personal context; stated the research questions and discussed the significance of the study for students, teachers, parents, schools and the Catholic Education Office Sydney. The chapter also presented a brief overview of the methodology and the scope and limitations of the study.

Chapter 2 reviews the literature that informed the study. It includes a discussion of the impacts of formative and summative assessment on student learning and contextualises this within a theoretical framework linking curriculum, assessment, and pedagogy. The chapter then discusses the role of feedback and reviews an historical account of the development of learning theory and its impact on instructional design. The discussion culminates in the development of a conceptual framework that clearly articulates assessment and its relationship to curriculum and pedagogy. An explanation of Biggs and Collis’s SOLO Taxonomy is included along with an overview of its use in ESSAonline.
Chapter 3 conceptualises the theoretical basis for the methodology and outlines the research design. The mixed methodology that informs the research design is justified within the context of an embedded case study and analysis of ESSAonline data. Data collection is described, discussed and justified as well as data analysis.

Chapter 4 presents the findings from the data analysis. The data analysis is derived from qualitative and quantitative sources. The qualitative sources include the results of the online questionnaire conducted across the 33 systemic junior schools along with the results of the structured interviews conducted by the participant researcher. The quantitative aspects of the data accessed through SMART II are used to triangulate the qualitative data and identify trends in performance across the five cohorts of students.

Chapter 5 discusses the study findings and conceptualises them within the framework of the research questions and propositions listed in Chapter 3. Throughout this process, findings are integrated and discussed in terms of the relevant literature. The discussion attempts to relate findings to the achievement-based learning conceptual framework in an attempt to inform greater understandings of the relationships between assessment, curriculum and pedagogy.

Chapter 6 summarises the study findings and evaluates the Catholic Education Office’s continued investment in ESSAonline as a formative assessment tool. It discusses the implications of the study findings in terms of assessment, curriculum, pedagogy the use of feedback and structures teachers should develop to facilitate student response to feedback within the achievement-based learning framework. The chapter concludes with a set of recommendations directed at CEO Sydney in terms of its continued investment in ESSAonline.
2.1 Introduction
Wiliam (2011) argues that despite the best efforts made by teachers to plan and execute their lessons, even if all students are at the same starting point, students develop different understandings. As students learn differently and at different rates, learning outcomes often bear no relationship to what was intended. The implications of this claim for classroom practitioners, in a society which aims to maximise the learning outcomes for all students, are significant (Hackling et al, 2001). According to Wiliam (2011), if teaching and learning is to be effective for all learners then assessment must be central to all teaching, as it is through assessment that the teacher is able to monitor the learning of each individual student so that he / she is empowered to achieve the planned outcomes. This chapter will review current literature relating to assessment, curriculum and pedagogy within a theoretical framework of formative classroom practice. The chapter will conclude by identifying the ‘missing link’ which Wiliam (2011) argues prevents formative assessment from achieving its potential to promote real growth in student learning outcomes.

2.2 Assessment and learning
For many years teaching sequences developed by practitioners were aimed at the average student. For those who fell within this ‘normal’ range and were able to adapt well to the teaching style of the teacher, learning was successful. In these instances, students were deemed to be good students and enjoyed notoriety (Wiliam, 2011). Unfortunately, for those who fell outside this range, schooling was not necessarily a good experience. For students who were gifted, the learning experiences may have been exceptionally boring, leading to poor behaviour and the student never realising his / her true potential. Likewise for those with lesser ability the material was deemed to be too difficult, leading to failure and students being encouraged to pursue less academic pursuits. Wiliam (2011) reports that Benjamin Bloom and his students at the University of Chicago in the 1960’s were the first to recognise that the failure of many students may be a product of the failure of instruction to meet their learning needs rather than a product of a natural distribution curve. The first steps towards meeting the instructional needs of students were beginning to emerge (Wiliam, 2011).
2.2.1 Two types of assessment

Black and Wiliam (1998b) cite Bloom et al. (1971a) who recognised the role and need for assessment strategies to evaluate and improve the educational outcomes of students. Bloom et al. (1971a) began to use two new terms: summative evaluation and formative evaluation. The term ‘summative evaluation’ was first introduced to describe the type of testing used at the end of units of work, mid-year or end of year, designed to determine or ‘judge’ the extent of student learning. Bloom et al. (1971a) identified the purpose of such tests as grading, certification or evaluation of progress. They contrasted this type of evaluation with what they called ‘formative evaluation’. This type of evaluation involved both teachers and students and was intended to help students improve what they were trying to do. More recently, the terms summative assessment and formative assessment have become widely used in the context of educational research.

Kizlik (2012) makes a distinction between the terms assessment and evaluation. Kizlik (2012, p.1) defines assessment as “a process by which information is obtained relative to some known objective or goal” whereas evaluation is the process of “making a judgment about a given situation.” Watson (2012) argues that assessment and evaluation differ in that assessment requires the gathering of evidence of student performance over a period of time as opposed to evaluation which occurs when a judgement is made about the information or data gathered. Often a mark is assigned as an outcome of evaluation. In other words, assessment is the process of gathering information while evaluation occurs when a judgement is made about the information. Wehlburg (2010, p.169) described assessment “as a tool for gathering evidence of student learning in order to transform teaching and enhance the learning process.” Kizlik (2012) and Watson (2012) differ somewhat in their definitions to that of Taras (2005, p.467) who states “I take ‘assessment’ to refer to a judgement which can be justified according to specific weighted set goals, yielding either comparative or numerical weightings.” In their seminal work “Inside the Black Box” Black and Wiliam (1998a), define assessment as “the general term to refer to all those activities undertaken by teachers, and by their students in assessing themselves, that provide information to be used as feedback to modify teaching and learning activities.” Whilst this definition overtly refers to the process related to collecting information it only implies a process of making a judgement. Black and Wiliam (1998a) appear as does Taras (2005) to draw the processes of assessment and evaluation together under the one umbrella of assessment. Bloom et al
(1981, p4) view evaluation “as the collection of evidence to determine whether in fact certain changes are taking place in the learners as well as to determine the amount of degree of change in individual students.”

Irrespective of the way assessment and evaluation are defined by various authors, there appears to be two distinct processes which need to be undertaken by the classroom teacher if he / she is to provide an opportunity for students to improve their learning. The teacher must first collect data about a student’s progress in achieving a specified outcome and then he / she must make a judgement about ‘the gap’ in the student’s learning and use his / her pedagogical content knowledge (PCK) to decide how best to close that gap. Schulman (1987, p.4) describes PCK:

Pedagogical content knowledge identifies the distinctive bodies of knowledge for teaching. It represents the blending of content and pedagogy into an understanding of how particular topics, problems or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction.

The teacher having considered all factors must provide feedback to the student about his / her learning, where they need to be heading and how he / she can get there. In this study, assessment will be viewed as the process of collecting data from students about their achievement of desired outcomes whilst evaluation is a more complex process of making a judgement about the student’s ability to achieve a desired outcome against a defined standard and then deciding upon the feedback most appropriate to the student’s needs. Evaluation can be performed by either student, peer or teacher.

Assessment and evaluation should therefore be seen as complimentary processes whereby during assessment activities, teachers collect data and through evaluation, make judgements about student learning against specified criteria for the purpose of providing appropriate feedback. Watson (2012, para. 4) argues that assessment may take many forms, for example “a review of journal entries, written work, presentations, research papers, essays, story writing, tests, exams etc. and can be used to demonstrate learning.” Evaluation on the other hand requires the teacher to use his / her professional knowledge and skills to make judgements against set criteria about student learning and provide feedback that is both diagnostic and prescriptive reinforcing what students are expected to learn, identifies what they learnt well, and describes what needs to be learnt better (Guskey, 2007). According to Bloom et al (1976) feedback alone does little to help
students improve their learning unless paired with correctives: activities that offer
guidance and direction to students on how to remedy their learning problems. Because of
individual differences among students, teachers must differentiate their instruction, both
in the initial teaching and especially when developing corrective activities.

The definitions of assessment and evaluation, in the context of this research, provide
significant issues in terms of interpreting past literature as most studies reported in the
next section of this chapter use the terms assessment and evaluation synonymously as
umbrella terms encompassing both the data collection and judgement making processes.
Nevertheless, in the final section of this chapter a conceptual framework will be
presented that underpins and informs the study. The framework will be used as a basis to
further develop and refine the terms assessment and evaluation. Within this framework,
‘correctives’ are deemed to be part of the feedback provided to students.

Since the 1970’s, researchers have been examining the relationship between assessment
and learning and have concluded beyond doubt that when used appropriately assessment
can have positive impacts on student learning (Black & Wiliam, 1998a; Black et al.,
2004; Taras, 2005; Wiliam, 2011). Given the positive role assessment can play in the
process of learning, how then is formative assessment different from summative
assessment? What is assessment for and of learning? How do these terms relate to one
another? Bloom et al. (1971a) described ‘summative evaluation’ as the type of testing
used at the end of units of work, mid-year or end of year, designed to judge the extent of
student learning. They contrasted this type of assessment with what they called
‘formative evaluation’ as this type of evaluation, involved both teachers and students and
was intended to help students improve what they were trying to do. More recently, the
phrase assessment for learning has gained notoriety and favour and at Third International
Conference on Assessment for Learning. Dunedin, New Zealand, March 2009, was
defined as “part of everyday practice by students, teachers and peers that seeks, reflects
upon and responds to information from dialogue, demonstration and observation in ways
that enhance ongoing learning” (Klenowski, 2009, p. 264). Black and Wiliam (1998a)
and their colleagues have pointed out, the distinction between assessment for learning
and assessment of learning on the one hand, and formative and summative assessment on
the other. They argue that the former relates to the purpose for which the assessment is
carried out; while the later relate to the function they serve (Wiliam, 2011).
Syllabus documents published in NSW since 2003 also refer to assessment as learning. The NSW Syllabuses for the Australian curriculum website (2014) defines assessment as learning in the following way:

Assessment as learning occurs when students are their own assessors. Students monitor their own learning, ask questions and use a range of strategies to decide what they know and can do, and how to use assessment for new learning.

This view of learning aligns with Bloom’s original definitions of formative evaluation. Assessment as learning clearly assumes a formative role in which students are responsible for collecting data about their own progress and deciding how to improve their learning.

For the purpose of this study, assessment as learning will be grouped with assessment for learning as forms of formative assessment and evaluation. Assessment of learning will be viewed as summative assessment and evaluation. Consequently, this study will also view assessment and evaluation as separate yet complimentary processes which can be used in either formative or summative ways.

Assessment can be uniquely summative where a judgement is made and the process comes to an end. Alternatively, assessment cannot be uniquely formative. To be formative implies that a judgement has been made about the performance of a student in a given task. Once a judgement has been made, then feedback must be provided highlighting ‘the gap’ between actual performance and the required standard. Assessments do not need to be uniquely summative or formative. For example, tasks that are designed to be summative can be used in formative ways, in the same way that formative tasks can be used summatively (Black et al., 2004).

Unfortunately, according to Wehlburg (2010), summative assessment has become too closely aligned to accountability in order to demonstrate performance to stakeholders. Heritage (2007) found that the use of assessment of learning has promoted extreme practices. She asserts that summative assessment is now used too often to competitively evaluate schools, teachers and students.

### 2.2.2 Understanding the conditions for formative assessment

This study is about how teachers are using data from ESSAonline formatively to improve achievement of their students in science. According to Black and Wiliam (1998) for
teachers to improve the learning outcomes of students, assessment must be an integral component of pedagogy within the context of what is taught, that is, the curriculum.

Figure 2.1 situates student learning using ESSAonline data at the centre of three intersecting circles each representing one of curriculum, pedagogy and assessment. Curriculum and pedagogy are closely linked as they determine the content of student learning and how teachers facilitate learning. Assessment functions to gather evidence about the effectiveness of curriculum and pedagogy in promoting student learning. Assessment practice can then be used to inform possible changes in curriculum and / or pedagogy. When assessment is used to inform pedagogy then classroom practice becomes formative. The model indicates that to understand what and how students learn and how teachers teach, curriculum, pedagogy and assessment need to inform each other. This study interrogates how ESSAonline is being used to inform student learning.

Figure 2.1  
Situating student learning using ESSA

Situating student learning that makes use of ESSAonline data as the intersection of assessment, pedagogy and curriculum effectively identifies the theoretical framework for this study. To unpack and describe elements of this framework in more detail it will be
necessary to cite key research that includes seminal works dating back to 1986 as reviewed in a meta-analysis by Wiliam (2011).

Data about the impact of assessment on student learning has been highly variable making it difficult to identify the conditions required to improve assessment and feedback techniques.

The first of the meta-analyses reviewed by Wiliam (2011) was conducted by Fuchs and Fuchs (1986). In their work the authors reviewed 21 research reports and were able to identify 96 different effect sizes. The majority of students studied in this meta-analysis were suffering minor learning disabilities and ranged in schooling from pre-school to Grade 12. The study reported significant effect sizes where teachers focussed on providing feedback. In some studies, teachers were required to follow specific guidelines in using feedback. In these instances the effect sizes were as high as 0.92, where teachers were left to make their own decisions the average effect size fell to 0.42. The mean effect size for students with disabilities was 0.7. The study showed that the appropriate use of feedback led to improved learning outcomes for students.

Crooks (1988) undertook a much narrower study on the impact of formal classroom-based assessment practices on students. Crooks (1988) included the impact of strategies such as formal testing and teacher questioning. In his findings Crooks (1988, p.468) argued that far too much time was spent on the grading aspects of assessment and needed to be rebalanced with assessment strategies that were designed “to assist student learning.” Crooks (1988, p.468) found that when assessment was used predominantly for summative purposes it had many negative effects, particularly on weaker students. At their worst, assessment practices were found to lead to reduction of intrinsic motivation and debilitating anxiety. Teachers must be encouraged to adopt a balanced approach to assessment practices to build student self-efficacy.

In a study designed to identify the impacts of regular classroom testing on student learning Bangert-Drowns, Kulik, and Kulik (1991) found that students who took at least one test in a 15 week period scored 0.5 standard deviations better than those who did not. The authors found that an increase in the frequency of testing was beneficial up to a point where the students were tested at a maximum of once every two weeks.
Bangert-Drowns, Kulik, Kulik, and Morgan (1991) reported the results of a meta-analysis of 58 effect sizes from 40 studies of the effects of feedback in assessments which incorporated ‘test-like’ strategies, for example, review tests. In this analysis the authors found that the impact of feedback was variable and depended upon the manner in which it was provided. The authors concluded that where feedback was provided in a manner which empowered students to engage with the material, the impact on student learning was greater. They found that where correct answers were provided to students, along with information about whether their answer was correct or not, provided an effect size of 0.58 standard deviations.

Elshout-Mohr (1994) published a review of many studies in which he concluded that for students to develop more complex skills it was not sufficient for the teacher to simply provide correct responses. To enable students to learn and develop their skills they need to become active in managing the learning process and engage in meaningful dialogue with the teacher.

In the final report reviewed by Wiliam (2011), Kluger and DeNisi (1996) published a review of the effects of feedback which extended to colleges and workplaces. From their meta-analysis of 131 studies, covering 12,652 participants they found that eight possible responses could result from feedback; six of these being negative and two being positive. When feedback was given it either indicated that current performance fell short of the desired goal or that current performance exceeded the current goal. In either situation the respondent would respond in one of four ways: change behaviour, change goal, abandon goal or reject feedback. This combination lead to only two positive situations: where people increased aspiration when feedback indicated that performance exceeded expectation, or where participants increased effort when feedback fell short of the goal. Despite the fact that only two of the eight possible reactions were positive, Kluger and DeNisi (1996) found the mean effect size to be 0.41 standard deviations.

Black and Wiliam (1998a) undertook a review of more than 250 studies into formative assessment that had been written between 1987 and 1997. As highlighted by Wiliam’s (2011) review of the eight articles listed above, they found there was no simple answer about how formative assessment can be made to work easily in the classroom. One clear message from their review was that formative assessment can make a difference. Black
and Wiliam’s (1998a) review yielded an average effect sizes ranging from 0.4 to 0.7 standard deviations. Black and Wiliam (1998a, p.16) concluded that to raise the standard of student learning through formative assessment significant change must occur in classroom practice. Pedagogy must involve the teacher engaging in quality interactions with students about the feedback provided to them. It is not good enough to simply provide feedback to students, the students need to be open to the feedback and be assisted to make use of the information. Deci and Ryan (1994) found that the way students receive and respond to feedback is influenced by many factors including their self-motivation and self-perceptions.

Consequently, based on this review, the key elements of assessment in the theoretical framework are as shown in Figure 2.2.

![Key elements of assessment](image)

Figure 2.2  **Key elements of assessment**

### 2.3 The impact of teacher feedback on student learning

Sadler (1989) quotes seminal work on feedback undertaken by Ramaprasad (1983) who noted: “Feedback is information about the gap between the actual level and the reference level of a system parameter which is used to alter the gap in some way” (Ramaprasad, 1983, p. 4). The use of this information was reinforced by Sadler (1989):
An important feature of Ramaprasad’s definition is that information about the gap between actual and reference levels is considered as feedback only when it is used to alter the gap. If the information is simply recorded, passed to a third party who lacks either the knowledge or the power to change the outcome, or is too deeply coded (for example, as a summary grade given by the teacher) to lead to appropriate action, the control loop cannot be closed, and “dangling data” substituted for effective feedback (Sadler 1989, p. 121).

From this work by Ramaprasad (1983) and Sadler (1989) an understanding of the nature of feedback was beginning to develop. For feedback to be effective it must be provided within a particular context, for a specific purpose, not too deeply coded, and be capable of affecting the future performance of the student. Black and Wiliam (1998a) added, for it to be counted as good, the information must improve student learning. Two additional substantial reviews of feedback have added to our understanding of feedback and how it can contribute to raising the standard of student learning.

Hattie and Timperley (2007) summarized an extensive program of work conducted by Hattie and his colleagues, Hattie (1999), which reviewed 180,000 studies on assessment. The average effect size of the 5755 studies that Hattie and Timperley summarized as ‘Feedback’ was 0.95 standard deviations.

Hattie and Timperley (2007) define the purpose of feedback as reducing discrepancies between current understandings or performance and a desired goal, as proposed by Ramaprasad (1983). Their model specifies three kinds of questions that feedback is designed to answer: Where am I going? How am I going? Where next? Each feedback question operates at four levels: feedback about the task, feedback about the processing of the task, feedback about self-regulation and feedback about the self as a person. They demonstrate that feedback about self is the least effective form of feedback, feedback about self-regulation and processing “are powerful in terms of deep processing and mastery of tasks” (Hattie & Timperley 2007, p. 91) while feedback about the task is powerful when the feedback is used either to improve strategy processing, or for enhancing self-regulation.

In a similar but different way, Shute (2008) examined a total of 141 publications and confirmed, yet again, that feedback does have an impact on student learning with reported effect sizes between 0.4 and 0.8. However, she concluded that significant gaps exist in the literature and that there is no simple answer to the question, ‘what feedback
works’? Shute (2008) offered a number of preliminary guidelines for the design of effective feedback including:

- **Guidelines to enhance learning.** Feedback should focus on the specific features of the task, and provide suggestions on how to improve, rather than focus on the learner; it should focus on the ‘what, how and why’ of a problem rather than simply indicating to students whether they were correct or not. Feedback should not be so specific that it scaffolds the learning so completely that students do not need to think for themselves. Feedback is also more effective when from a trusted source (whether human or computer).

- **Guidelines in relation to the timing of feedback.** The optimum timing of feedback appears to depend strongly on the kind of learning being undertaken. Immediate feedback appears to be most helpful for procedural learning, or where the task is well beyond the learner’s capability at the beginning of the learning, while delayed feedback appears to be more appropriate for tasks well within the learner’s capability, or where transfer to other contexts is sought.

### 2.4 Formative classroom practice

Experience reveals that often curriculum, pedagogy and assessment are not integrated in the classroom. Although some teachers may teach skills to help students with assessment, classroom pedagogy and assessment remain unaligned. Black et al. (2004) conducted the King’s-Medway-Oxfordshire Formative Assessment Project to identify practical steps that teachers can take to more closely align formative assessment with pedagogy.

Black et al. (2004) concluded the following four strategies can help improve student learning.

- **Teachers need to allow longer wait time.** Teachers need to conduct classroom dialogue in ways that may help students learn. By providing students with adequate wait time teachers empower students to ponder the question being discussed and hence move beyond the mere surface level.

- **Teachers must stop awarding marks or grades to assigned work and provide written feedback.** When marks or grades are provided alongside written comments, students focus on the mark or grade and ignore the comment. This problem can be overcome by omitting the mark or grade; students soon come to see the comments as a way of helping them improve.

- **Students must be taught how to engage in peer and self-assessment.** Students achieve better when they fully understand the learning goal and what they need to do to achieve it. Students are more likely to engage in deep analysis and
discussion with peers about what needs to be done and how it can best be achieved.

- Summative tasks must be used formatively. Whilst summative tasks may be used extensively in schools at the end of units of work or at the end of reporting periods, students should be encouraged to use the data from these tasks to identify areas of strength and weakness. Students must be taught how to use summative tasks to improve their learning.

It is through classroom practices such as these that teachers can more closely align pedagogy with assessment, ensuring that ALL classroom practice is formative.

Wiliam (2011, p.10) reports that the Assessment Reform Group proposed seven precepts that summarise the characteristics of assessment that promotes learning:

- it is embedded in a view of teaching and learning of which it is an essential part;
- it involves sharing learning goals with pupils;
- it aims to help pupils to know and to recognise the standards they are aiming for;
- it involves pupils in self-assessment;
- it provides feedback which leads to pupils recognising their next steps and how to take them;
- it is underpinned by confidence that every student can improve; and
- it involves both teacher and pupils reviewing and reflecting on assessment data (Broadfoot et al., 1999, p. 7).

With these characteristics in mind, Black and Wiliam (2009) restated their original definition of formative assessment in a slightly different way:

Practice in a classroom is formative to the extent that evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers, to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have taken in the absence of the evidence that was elicited (Black & Wiliam, 2009, p. 9).

Consequently, in this study, the use teachers, students and peers make of feedback will be explored as well as what feedback is provided.

2.5 The use of feedback

Havne et al. (2012, p.21) argue strongly that much of the current literature about formative assessment focuses on the positive aspects of teacher feedback and its impact on student learning without giving attention to the potential negatives as noted by Kluger and DeNisi (1996) who found that more than one third of the effect noted negative
impact on learning. Havne et al (2012) continue to argue that an important aspect of feedback that achieves little attention is that “to enhance learning, the feedback needs to be formulated in such a way that it invites learners’ active engagement with the feedback” (Havne et al., 2012: p21). Hence, careful consideration needs to be given by teachers to:

- how and by whom the feedback is given to the learner;
- the nature of the feedback; and
- the structures provide to facilitate the teachers and students acting upon the feedback.

Both quantitative and qualitative findings by Havne et al. (2012, p22) from their two year project undertaken in six Norwegian secondary schools, across four core subjects, Norwegian, English, mathematics and vocational studies revealed:

The interviews confirmed the dominant tendency in the quantitative analyses: systematic use of feedback as a support of students’ learning is a weak element in the educational practice. Likewise, the teachers do not have systematic strategies for implementing feedback they have given to students in their future teaching. The provision, as well as the reception, of assessment feedback is an individual endeavour for both teachers and students, and neither is systematically tied to future action.

These findings demonstrate that significant effort must be made by teachers to provide meaningful feedback and to develop processes by which students can respond to feedback to improve their learning.

2.6 Learning Theories

Researchers have been grappling with understanding how students learn for a long time. However, this is especially the case more recently in the context of formative classroom practice. Gregson and Grupetta (2012, p29) define learning as “using experiences to acquire or change our knowledge, understanding and skills”. Wiliam (2011) argues that learning is an ongoing and evolving process that continues throughout life and is a product of many factors which include past life experiences and emotions. No matter how well prepared a teacher is, what students learn in the classroom is not necessarily what the teacher intended (Wiliam, 2011). To help students learn, teachers must not only have a good understanding of their needs, prior experiences and abilities, they must also have a good understanding of how students learn (Gregson & Grupetta, 2012).
Learning is so central to human existence that the question of “How we learn?” has been a driving force of inquiry for thousands of years. Even today the rationalist views of Plato, who believed that the mind was the source of all meaning, and the empiricist views of Aristotle, who believed that all knowledge came through the senses, still underpin much of the work of our modern day psychologists, educators and researchers (Merriam et al., 2007). Over the centuries many theories have been developed to explain what is happening when we learn or fail to learn. Learning theories are conceptual frameworks that describe how information is absorbed, processed, and retained during learning. Learning brings together cognitive, emotional, and environmental influences and experiences for acquiring, enhancing, or making changes in knowledge, skills, values, and world views (Illeris, 2004).

Hill (2002) observed that learning theories have two chief values. One is providing a vocabulary and a conceptual framework for interpreting learning that we observe. The other is providing suggestions about where to look for solutions to practical problems. Such theories do not provide solutions, but rather a framework and the tools to identify potential solutions. Consequently, recent changes in learning theory will be reviewed to identify those aspects of instructional design, which when linked with both formative assessment practices, and structures designed to facilitate teacher and student response to feedback will lead to improvements in student learning outcomes.

When working with students it becomes obvious that learning occurs in many different ways and what works well for one student may not work well for others. Students learn through reading, memorising, thinking, writing, note-taking in lectures, observing, listening to and talking with others and by doing things. For some, formal situations like instructional lessons provided by the teacher work best, while for others, informal settings are better (Brown, 2004). Unfortunately, these descriptions do not explain how students learn, nor do they account for why students learn.

For many years the study of learning remained the work of philosophers and it was not until the nineteenth century that the study of the mind and how it works began to be scientifically investigated (Merriam et al., 2007). Many theories have been developed and attempts made to classify these theories according to the processes involved. These may be placed on a continuum with behaviourism at one end and radical humanistic approaches at the other. In between are Gestalt psychology, cognitive psychology, and
constructivism. As one moves along the continuum, the theories become less positivistic, less concerned with control and prediction and more ostensibly concerned with social values (Brown, 2004). In an attempt to understand contemporary learning theory, three paradigms of learning theory will be explored, behaviourism, cognitivism and constructivism.

These three paradigms of learning were selected for two reasons. Firstly, they were historically significant in understanding of the nature of learning. Secondly, they demonstrate the evolution or change in thinking about the nature of learning. In the move from behaviourism through cognitivism to constructivism a change from passive transfer of facts to the active application of ideas to solve problems is seen (Ertmer & Newby, 2006). As each of these learning theories is described, the change from passive stimulus / response learning to learning as an active cognitive process will become evident. For each paradigm the appropriate instructional design features deemed to be still appropriate in today’s pedagogical practices will be identified. Throughout the discussion the conceptual framework linking the key elements of learning theory, instructional design, formative assessment, feedback and teacher / student response will emerge. This framework has the potential to close the ‘gap’ between student performance and expected standards.

2.6.1 Behaviourism

Behaviourism encompasses a number of individual theories (Merriam et al., 2007). For behaviourists, learning is the modification of behaviour brought about by experience (Brown, 2004). Behaviourists focus on the observable, and attempt to measure behaviour. Its roots are found in early twentieth-century American psychology and were first developed by John B. Watson in 1913. Throughout the twentieth century behaviourism was strongly influenced by the work of Thorndike and Skinner (Ormrod, 1995).

Behaviourists hold the view that learning is a product of the human response to stimuli that results in a change in behaviour. Behaviourists believe inner processes such as introspection, thinking and the brain have no role to play in changing behaviour. For Watson, to understand learning, all that was required was a careful analysis of the inputs (stimuli) and outputs (responses) (Brown, 2004). Thorndike developed much of our understanding relating to the stimulus – response theory of learning. Using animals in
controlled experiments he showed that repeated trial and error learning led to change in behaviour. He was able to show that the animals learnt to respond in particular ways to sensory stimuli which resulted in satisfying after effects. He also theorised that when the organism was ready for learning, repetition of the response could lead to substantial learning (Ormrod, 1995). Much of his work can still be seen reflected in current educational practice.

Along with building connections between stimuli and responses, three other tenets characterise the assumptions of the behaviourists. Firstly, the environment shapes behaviour; what one learns is determined by the elements in the environment, not by the individual learner. Secondly, tasks must be subdivided into their components so that objectives of learning can be set and, if necessary, the pre-requisites for tackling a task must be mastered before attempting the next. The simplest components are taught first, reinforced and then built into increasingly complex hierarchies. Finally, the timing between two events is critical for a link to be formed and reinforced (Grippin & Peters, 1984).

Skinner worked with rats, pigeons and other animals and through his work on operant conditioning developed much of the theory relating to the use of reinforcements (Gregson & Gruppetta, 2012). Simply stated, operant conditioning means “reinforce what you want the individual to do again; ignore what you want the individual to stop doing” (Grippin & Peters, 1984, p. 65). If behaviour is reinforced or rewarded, the response is more likely to occur again under similar conditions. Behaviour that is not reinforced is likely to become less frequent and may even disappear (Merriam, 2007). Reinforcement schedules can be used to shape behaviour. There are many examples of the use of rewards that still exist in a contemporary education system. Awarding marks for achievement of ‘intended learning outcomes’ is one such example (Brown, 2004).

By the end of the twentieth century, many of the notions about stimulus–response psychology had waned, but ‘behaviour’ – what a person can do, input / output analysis, task analysis and reinforcement schedules continue to influence both education and industry (Brown, 2004).
In a behaviourist view of learning, the teacher’s role is to design an environment that elicits desired behaviour toward meeting a set of objectives and to extinguish undesirable behaviour. Since behaviourism focuses on the measurable, overt activity of the learner, behavioural objectives are used to specify the conditions (or stimuli), the behaviour to be performed, and the criteria by which the behaviour is to be judged (Merriam et al., 2007). Today the use of objectives and outcomes are much favoured by government agencies and are used to develop policies and curriculum. The recently released The Shape of the Australian Curriculum (2009) that underpins the development of the Australian Curriculum is based on the use of measurable outcomes. Curriculum documents should specify both the outcomes and the standards to be achieved by the students.

### 2.6.1.1 Implications for Instructional Design

The behavioural orientation to learning has had lasting effects on our educational system. Within this perspective, the task of the teacher is to design and control the learning environment and the students’ learning. “Learning is accomplished when a proper response is demonstrated following the presentation of a specific environmental stimulus” (Ertmer & Newby, 2006, p.55). The primary concern for the teacher is how the association between the stimulus and response can be maintained and used as the foundation for more complex activities. No focus is placed on the mental processes used to produce the response. The learner does not play an active role in the learning process. Behaviourists attempt to develop instructional design that best supports building stimulus response associations including instructional cues, practice and reinforcement. For the behaviourist, feedback is seen as a form of reinforcement intended to help students formulate the correct response.

The following assumptions or principles and strategies that evolved out of a behaviourist paradigm are still worthy of consideration as part of appropriate pedagogy to support learning:

- emphasise producing observable and measureable outcomes in students e.g. use of behavioural objectives, task analysis, criterion referenced assessment;
- pre-assessment of students to determine where instruction should begin, e.g. identify what students already know and can do;
- emphasise the achievement of outcomes before moving onto more complex activities; and
• use of reinforcements to impact performance, that is, providing informative feedback.

Despite its lasting legacy, behaviourism has been challenged by theorists from a cognitivism perspective. As we move into a review of cognitivism, the role of the learner is seen to become more active and the cognitive demand of the learning process becomes evident.

2.6.2 Cognitivism

In 1929, Bode, a Gestalt (meaning pattern or shape) psychologist began to criticise the behaviourists for being too concerned with particular events and actions and too dependent on behaviour to explain learning (Merriam et al., 2007). Bode began to argue that learning needed to be looked at as a whole process rather than isolated independent events. By the mid-twentieth century Gestalt views of learning began to dominate and cognitivism began to replace behaviourism as the dominant paradigm or view of learning.

At the same time cognitivism was developing, the new field of computing sciences was also gaining recognition. Theorists began making comparisons between the processes taking place in the mind with those of coding, storing and processing information in computer systems (Bush, 2006). Cognitivists began to realise that learning is concerned not so much with what learners do but with what they know and how they come to acquire it. Merriam et al. (2007) reports, these views came to be labelled cognitive or information-processing learning theories. Merriam et al. (2007) cites (Gredler, 1997, p. 144) who argues two key assumptions underlie the cognitive or information-processing approach: “that the memory system is an active organized processor of information, and that prior knowledge plays an important role in learning”.

As a response to behaviourism, cognitivists argue that people are not “programmed animals” that merely respond to environmental stimuli; but are rational beings that require active participation in order to learn. Cognitive theories stress the acquisition of knowledge and active internal mental structures that focus on: how information is received, linked to prior learning, organised, stored and retrieved by the mind (Ertmer & Newby, 2008).
The initial thrust of the Gestalt psychologists was to shift the locus of control for the learning process from the environment (including teachers) to the individual learner. For Gestalt psychologists, perception, insight, and meaning are key concepts in cognitivism. Learning involves the reorganization of experiences in order to make sense of stimuli from the environment. The coding of new information, linking to past experiences, storage and processing comes from within the individual. This new focus demonstrated a significant shift away from operant conditioning as proposed by the behaviourists and is still present in current educational thinking.

Jean Piaget (1966) clarified the focus on internal cognitive processes and developed a model of learning. Piaget proposed that a learner’s internal cognitive structure changes throughout life and moves through four recognisable stages. The journey through these changes occurs as a result of: maturational changes in the nervous system, the organism's interaction with the real world, and exposure to an increasing number of experiences. Gregson and Gruppetta (2012) cite Marsh’s (2010) description of these changes, (these levels will be referred to again within the review of Biggs and Collis’ SOLO Taxonomy):

- Sensori-motor (0 – 2 years). The first stage where children are aware of their environment in terms of how their bodies fit with that environment. They initiate actions that are goal dependent, such as reaching for a toy, trying to stand, point. They learn that objects exist even when they can’t see them, such as peek-a-boo games or when a parent leaves the room.
- Pre-operational (2 – 7 years) is recognised as a stage of immense growth as children learn to use symbols such as those used for numeracy and literacy, classify objects and understand pretend actions.
- Concrete operational (7 – 11 years) is the stage when children develop and can apply logical thought processes. They are able to solve problems, classify and evaluate, and are less egocentric as they become part of a wider community.
- Formal operational (11 and above) students are able to hypothesise, use deductive reasoning, show an appreciation of abstract concepts, imagine, apply logical thinking, and explore alternatives.

Since Piaget’s work in the 1960’s cognitivist learning theories have continued to develop with many focusing on particular aspects of learning, for example, memory and metacognition, and mathematical learning theory. Converging with this; however, were
theories of instruction that attempted to link how learning works and the best ways to facilitate it (Merriam, 2007). The work of Bruner provides a good example of how learning can be facilitated. His three stage theory of growth has been linked with the work of Biggs and Collis (1982, 1991) as they developed SOLO Taxonomy.

Bruner, made numerous contributions to learning over the years. Two of his contributions include: a schema which recognises 3 stages of growth, and the idea of a spiral curriculum. Gregson and Gruppetta (2012) cite Marsh’s (2010) summary of his 3 stages, which unlike Piaget’s are not hierarchical or linked to age. According to Bruner, learning occurs when the learner is ready to process the stimulus they receive from the environment. The three stages include:

- enactive, where learning is by doing;
- iconic, where learning requires the use of imagery; and
- symbolic, where understanding is linked to the knowledge and use of symbols such as those of language and numeracy.

Bruner also introduced the idea of a spiral curriculum, in which the student revisits ideas repeatedly, building upon them until the student has fully grasped the concepts and all that goes with it. According to Bruner the student should, firstly, be introduced to the concept in a simple way and then given the opportunity to build on this learning at a later time and explored at greater depth (Gregson & Gruppetta, 2012).

In summary, cognitivist learning theories encompass a wide range of topics with a common focus on internal mental processes that are under the learner's control. “Essential components of learning are the organization of the information to be learnt, the learner's prior knowledge, and the processes involved in perceiving, comprehending, and storing information” (Gredler, 1997, p. 143). It is evident from this discussion that in moving from a behaviourist perspective to a cognitivist perspective that our understanding of learning was becoming more sophisticated. The role of the learner as an active participant in the learning process became prominent.

2.6.2.1 Implications for Instructional Design
Cognitive theories contend that environmental cues, instructional components, and the way learners’ code information, link new with exiting information, store and process
information are all vital elements of the learning process. Hence, teachers when planning instructional design must give due consideration to ensuring that all these key elements are carefully considered when planning learning / teaching sequences.

Whilst some elements of behaviourist instructional design are suited to cognitivism, others may discarded or used to support other paradigms. It is the active nature of the learner that informs the purpose and use of the design element. A good example of this is the use of feedback. For the behaviourist, feedback is used as a source of reinforcement, whilst the cognitivists use feedback to guide and support accurate mental connections (Ertmer & Newby, 2008). However, the question to be asked is what are the basic assumptions / principals of cognitivism that are relevant to instructional design?

According to Ertmer and Newby (2008, p.59) teachers must consider:

- the predisposition of the learner to the learning process and student attitudes and values towards learning;
- student prior learning;
- how the learner activates, maintains, and directs his / her learning; and
- how the learner will assimilate the learning.

Ertmer and Newby (2008, p.60) list the following specific assumptions or principles that have direct relevance to instructional design:

- emphasis on active involvement of the learner in the learning process e.g. learner control and metacognitive training;
- use of hierarchical analysis to identify and illustrate prerequisite relationships, for example, cognitive task analysis procedures;
- emphasis on structuring, organising and sequencing information to facilitate optimal processing, for example, use of cognitive organisers such as outlining, summarising, synthesising advanced organisers; and
- creation of learning environments that allow and encourage students to make connections with previously used materials, for example, recall of prerequisite skills use of relevant examples and analogies.
2.6.3 Constructivism

Like cognitivism, constructivism encompasses a number of related perspectives. Basically, a constructivist view of learning maintains that learning is a process of constructing meaning; it is how people make sense of their experience. Beyond that basic assumption, constructivists differ as to the nature of reality, the role of experience, and what knowledge is of interest.

Constructivism encompasses a number of related perspectives, e.g. von Glaserfeld’s (1917 – 2010) work in mathematics and science education and feminists’ views on knowledge construction. Where these strands converge is in the debate over whether the process of meaning-making is primarily individual or social (Merriam et al., 2007).

Constructivists maintain that learning is a process of constructing meaning. Constructivists believe that the mind filters input from the world to produce its own unique reality (Jonassen, 1991). We learn through building schemata to interpret the world; as the schemata become more sophisticated, so does our understanding of the world. Unlike behaviourists who believe that knowledge can be acquired, constructivists believe that humans create meaning. Learners do not transfer knowledge from the external world into their memories; rather they build personal interpretations of the world based on individual experiences and interactions (Ertmer & Newby, 2008). Since there are many possible meanings to glean from an experience we cannot achieve a predetermined ‘correct’ meaning. As knowledge emerges within contexts that are deemed meaningful and relevant to the learner, knowledge is constantly open to change; there is no objective reality to be acquired by the learner. In order to understand the learning which has taken place within an individual, the actual experience must be examined (Bendar et al., 1991). Learning is a dynamic process, as new experiences and knowledge are encountered existing schemata are re-evaluated and either changed or the new knowledge rejected (Brown 2004).

All constructivists posit that learning is an active process in which the learner must dialogue with and critically explore the views of others to construct new meaning. Gregson and Gruppetta (2012) report that whilst Vygotsky (1896 – 1934) acknowledged that genetic and environmental factors do impact on learning, the most important factors impacting learning are the social and cultural contexts. Vygotsky believed that the
individual’s social environment accounts almost entirely for the development of higher order processes. Vygotsky proposed that learning is socially mediated through a culture's symbols and language, which are constructed in interaction with others in the culture. Making meaning is thus a dialogic process involving persons-in-conversation, and learning is seen as the process by which individuals are introduced to a culture by a more knowledgeable other who has a better understanding or a higher ability level than the learner (Driver et al., 1994, p. 7). The more knowledgeable other is normally thought of as being a teacher, coach, or older adult, but could also be a peer.

Both the learner and environmental factors are critical to the constructivist as it is the specific interaction between these two variables that creates knowledge. For this reason it is critical that learning occurs in realistic settings, relevant to the student’s lived experience if concepts are to evolve. Content knowledge should be embedded in the situation in which it is used (Ertmer & Newby, 2008). Gregson and Grupetta (2012) argue that according to Vygotsky’s theories, conceptual development occurs through a process of internalisation of the concepts which require the learner to have a functional use of it. The learner can then create new meaning by constructing a view of the distinctive features of the concept, and using their language skills and prior experiences to analyse and synthesise the concept.

Vygotsky's social constructivist model forges a strong link in this conceptual framework with the need for feedback to students. According to Vygotsky, the Zone of Proximal Development (ZPD) is where learning occurs and is the distance between a student’s ability to perform a task under adult guidance and / or with peer collaboration and the student’s ability to solve the problem independently. Hence, the role of the teacher is vital in providing the feedback necessary to the student to help close ‘the gap’ between the student’s ability to complete the task with assistance as opposed to being independent.

As Vygotsky’s theory promotes learning contexts in which students play an active role in learning, the roles of the teacher and student are therefore shifted; the teacher should collaborate with his or her students to facilitate meaning construction. No longer can the teacher simply ‘map’ the learning onto the student. The teacher must use instructional design which facilitates the student’s active role as a co-constructor of knowledge. Adam
(2000) lists a number of principles which should be considered by the teacher when establishing a constructivist classroom:

- focus on learning not performance;
- view learners as active co-constructors of meaning and knowledge;
- establish a teacher–pupil relationship built upon the idea of guidance not instruction;
- seek to engage learners in tasks seen as ends in themselves and consequently as having implicit worth; and
- promote assessment as an active process of uncovering and acknowledging shared understanding.

### 2.6.3.1 Implications for instructional design

An essential concept in the constructivist view is that learning always takes place in a context and that the context forms an inexorable link with the knowledge embedded in it (Bednar et al., 1991). Therefore, the goal of instruction is to accurately portray tasks in authentic, meaningful contexts that facilitate transfer. An underlying belief for the constructivist is that if learning is decontextualised there is little chance of transfer.

As constructivists believe that knowledge is not abstract but linked to both the context under study, and the learner’s existing schemata, and experiences that he / she bring to the context, then it is the designer’s role to develop instructional methods and strategies that will assist learners in actively exploring complex topics. As such, learners will be empowered to become co-constructors of their own understanding and to validate their learning through social negotiation.

The following are specific strategies / focus areas from the constructivist’s position that have direct relevance for the teacher:

- ascertaining prior knowledge and schemata through a variety of tasks e.g. discussion, or the use of mind maps;
- identifying authentic real world contexts in which content and skills will be learnt and applied;
- creating a supportive climate in which students feel safe to reveal their conceptions and engage in social negotiation about learning;
- establishing a teacher–pupil relationship, where the teacher is seen as guide in the process of the learner constructing his / her own knowledge;
- developing the capability of the learner to manipulate information;
- presenting information in a variety of different ways, e.g. revisiting content at different times and in rearranged contexts;
- providing opportunities for students to use problem solving skills that allow them to go beyond the information given; and
- assessment focussed on uncovering and acknowledging shared understanding (Adams, 2000; Brown, 2004; Ertmer & Newby, 2008;).

Cunningham (1991) summarises the role of the constructivist teacher:

The role of teacher in the constructivist view is to show the students how to construct knowledge, to promote collaboration with others to show the multiple perspectives that can be brought to bear on a particular problem, and to arrive at self-chosen positions to which they can commit themselves, while realising the basis of other views with which they may disagree (p. 14).

From this discussion, the key elements of pedagogy and curriculum can be summarised as shown in Figures 2.3 and 2.4.

Figure 2.3  Key elements of pedagogy
In summary, student learning is a product of three key variables: the curriculum, pedagogy and assessment. Learning occurs as shown in the formative classroom practice theoretical framework depicted below and is most effective at the point where curriculum, pedagogy and assessment coincide symbiotically as shown in Figure 2.5 on the following page.
Figure 2.5  *Theoretical Framework – Formative Classroom Practice*

The key elements that comprise the three key areas of the theoretical framework are shown in Table 2.1 on the following page.
<table>
<thead>
<tr>
<th>Pedagogy</th>
<th>Curriculum</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Teacher uses outcomes specified in the curriculum to plan tasks that are broken down into simple sequential activities that develop in complexity</td>
<td>• Set within a constructivist paradigm</td>
<td>• Teachers make use of pre-assessment to identify student learning needs</td>
</tr>
<tr>
<td>• Teachers use their knowledge of their learners needs, the content and instructional design to plan strategies appropriate to teaching the content</td>
<td>• Based upon the belief that all students can learn and improve</td>
<td>• Teachers attempt to structure all teaching and learning activities as opportunities for formative assessment</td>
</tr>
<tr>
<td>• Teachers create safe and engaging learning environments</td>
<td>• Provided within a safe and engaging learning environment</td>
<td>• Teachers make use of peer and self-assessment strategies</td>
</tr>
<tr>
<td>• Teachers allow appropriate wait time</td>
<td>• Based on student centred learning activities designed to meet the learning needs of all students</td>
<td>• Teachers provide meaningful and accessible feedback</td>
</tr>
<tr>
<td>• Teachers collect and reflect upon assessment data and encourage students to engage in self-reflection</td>
<td>• Based on the belief that students must take an active role in their own learning hence teacher role is that of learning facilitator</td>
<td>• Teachers engage in discourse with the students about the feedback</td>
</tr>
<tr>
<td>• Timely, appropriate and accessible feedback is provided to students by teacher or peers</td>
<td>• Promotes deep understanding allowing students to reach self-chosen positions tolerant of other solutions</td>
<td>• Teachers turn summative tasks into formative learning opportunities</td>
</tr>
<tr>
<td>• Teachers provide opportunities for students to engage in meaningful dialogue about feedback and to act upon it until the outcome is achieved</td>
<td>• Sets shared learning goals</td>
<td>• Maintain a balance between formative and summative assessment practices</td>
</tr>
</tbody>
</table>
Raising the standards of student learning has been a priority of State and Federal Governments in this country for many years. Despite the introduction of numerous programs, for example, the Australian Government’s Digital Educational Revolution (2008 – 2014) and Smarter Schools National Partnerships (2009- 2015), student learning outcomes have not improved at a rate many authorities would have hoped. In the 2009 PISA Test (Thomson et al., 2011), the range of scores between the 5th and 95th percentile for Australian students in scientific literacy was comparatively wider than the Organisation for Economic Co-operation and Development (OECD) average, reminiscent of the Programme for International Student Assessment (PISA) results from 2000 (ACER, 2001). Twelve per cent of Australian students did not reach Level 2 (Thomson et al. 2011, p.5). Black and Wiliam (2010, p.81) argue, the sum of many education reforms has not added up to an effective policy because something is missing. Teachers have a difficult job managing the complexities of the classroom where they may have up to 30 students competing with one another in a naturalistic environment. Student learning in this context is driven by what teachers do. Standards can only be raised if teachers are helped to improve the quality of what they do.

Within the theoretical framework for formative classroom practice outlined in Figure 2.5, teachers must work towards developing an understanding of what it is they must do to improve the quality of student learning. The framework argues that teachers must come to value all teaching and learning activities as opportunities for formative classroom practice and provide students with the feedback need to ‘close the gap’.

When examining the theoretical framework - formative classroom practice (Figure 2.5) it is apparent that there are a number of terms that require definition or more accurately, conceptualising within the context of this study. Consequently, the following sections will argue for a conceptual framework that will guide this study. In particular, three assessment frameworks will be examined to identify the ‘missing link’ and provide a way to improve science learning outcome for students.

2.7 Towards a Conceptual Framework for Learning and Assessment

Three assessment-based frameworks will be reviewed to develop a detailed conceptual framework linking curriculum, pedagogy and assessment.
2.7.1 Aspects of Formative Assessment

Black and Wiliam (2009) attempted to draw together ideas developed in their earlier publications to provide a unifying basis for the diverse classroom practices deemed to be formative. Their framework was based on the following five practices:

- sharing success criteria with learners;
- classroom questioning;
- comment-only marking;
- peer- and self-assessment; and
- formative use of summative tests

In building a strong theoretical base, they drew on the previous work of Wiliam and Thompson (2007) who used Ramaprasad’s (1983) three key processes in learning and teaching:

- establishing where the learners are in their learning;
- establishing where they are going; and
- establishing what needs to be done to get them there.

The framework they developed is shown in Table 2.2 on the following page.
Table 2.2  *Aspects of formative assessment* (Wiliam and Thompson, 2007)

<table>
<thead>
<tr>
<th>Teacher</th>
<th><strong>Where the learner is going</strong></th>
<th><strong>Where the learner is right now</strong></th>
<th><strong>How to get there</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Clarity</td>
<td>1. Clarifying learning intentions and criteria for success</td>
<td>2. Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding</td>
<td>3. Providing feedback that moves learners forward</td>
</tr>
<tr>
<td>Peer</td>
<td>Understanding and sharing learning intentions and criteria for success</td>
<td>4. Activating students as instructional resources for one another</td>
<td></td>
</tr>
<tr>
<td>Learner</td>
<td>Understanding learning intentions and criteria for success</td>
<td>5. Activating students as the owners of their own learning</td>
<td></td>
</tr>
</tbody>
</table>

Black and Wiliam (2009) argue that the five steps listed in the Table 2.2 provide a strong basis for formative assessment. The steps shown in the table are listed as follows:

1. clarifying and sharing learning intentions and criteria for success;
2. engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding;
3. providing feedback that moves learners forward;
4. activating students as instructional resources for one another; and
5. activating students as the owners of their own learning.

Once again, the work of Black and Wiliam (2009) only implies the teacher is making judgements about the work of students against criteria for success. According to this framework, there is little or no need for teachers to know and understanding of the learning needs of students. Without deep knowledge of students’ needs teachers cannot provide appropriate instruction or feedback. To ‘activate the students as owners of their
own learning’ students must be receptive to feedback from the teacher or other knowledgeable persons (e.g. peers), be reflective in their own work, and be provided with the opportunity to act on the feedback. This framework fails to clearly articulate these elements for success or acknowledge the need for active response to feedback until the students have achieved the desired outcome to the specified standard.

Another important element missing from this framework is teacher response to the data he / she has collected. Assessment practices must provide feedback to the teacher about the effectiveness of the learning / teaching activities provided to students. Teachers need to reflect on this evidence and use it to inform future planning.

2.7.2 Phases of Effective Instruction Models

Burns (2008) attempted to use Algozzine and Ysseldyke’s (1992) phases of effective instruction to illustrate how both formative and summative evaluation could integrate seamlessly with effective instruction. His framework is shown in Table 2.3.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Instructional Focus</th>
<th>Primary Formative Evaluation Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning Instruction</td>
<td>Deciding what and how to teach, and how to best communicate realistic expectations.</td>
<td>Assess student baseline skill before instruction.</td>
</tr>
<tr>
<td>Managing Instruction</td>
<td>Preparing students and classroom for instruction, using time productively, and establishing a positive classroom environment.</td>
<td>Assess the instructional level for individual children, identify specific skills and/or items that need to be pre-taught or taught, and assess the classroom environment.</td>
</tr>
<tr>
<td>Delivering Instruction</td>
<td>Providing relevant practice, keeping the students interested and motivated, and providing feedback.</td>
<td>Continuous assessment of mastery of the material during guided and independent practice. Noticing and immediately correcting student errors.</td>
</tr>
<tr>
<td>Evaluating Instruction</td>
<td>Deciding whether the approaches, methods, and materials used were effective.</td>
<td>Assess student learning and set goals for future instruction.</td>
</tr>
</tbody>
</table>
Within Burn’s (2008) framework the terms Evaluation and Assessment are used interchangeably. There is no recognition in this framework that evaluation and assessment are two separate processes. Whilst there is recognition of effective instruction occurring in a linear well-defined fashion this simplified framework shows little recognition of either the need for regular teacher evaluation of student learning and subsequent dialogue nor of the students being required to respond to feedback. Feedback, within this framework, is limited to correcting student errors. ‘Assess’ in this model is also applied to the classroom environment rather than to student ability to achieve the specified outcomes. Burn’s framework does however make reference to communicating realistic expectations and maintaining a positive classroom environment. Summative assessment is referred to in the evaluation stage but no indication is given that that the summative task could / would be used in a formative way.

2.7.3 Mastery Learning

Guskey (2008) reports that whilst laying much of the foundational groundwork for formative and summative evaluation (Bloom, 1971a) Bloom also attempted to close the performance gap between different groups of students by developing his theory of Mastery Learning (Bloom, 1971b). His work, along with that of some of his graduate students, played a key role in the development of current theories of learning.

Figure 2.6 outlines the key framework underlying Mastery Learning and its relationship with formative evaluation.

![Mastery Learning Instructional Process](image)

**Figure 2.6 The mastery learning instructional process** (Guskey, 2008)

The teacher’s first role when using mastery learning is to organise the key concepts and skills into instructional learning units lasting 1 to 2 weeks. At the end of each unit students undertake a formative evaluation task to identify what they have learnt well and
can do along with what they still need to learn and be able to do. Following feedback from the teacher students are assigned prescriptive pathways to follow. Concepts within the formative evaluation are paired with correctives, prompts that match what the student did not know or could not do and to other resources designed to help students improve their mastery of the work. This process is designed to help prevent a minor learning difficulty from becoming major. As a result, more students learn well, master the important learning goals in each unit, and gain the necessary prerequisites for success in subsequent units. At the completion of the correctives students undertake a second formative task before moving onto the next unit. Students who performed well in the original task are intended to undertake enrichment activities, providing the students with the opportunity to develop deep knowledge and skills.

Whilst this is only a simplified outline of mastery learning it does provide a key insight into what is needed for students to improve their learning outcomes. The use of correctives is paramount in insuring students overcome what might be minor learning difficulties or misconceptions. As Havne (2012) clearly demonstrated, many teachers provide little or no feedback nor do they establish processes or procedures needed to be followed by students to respond to feedback. In this model the feedback, in the form of correctives, is directly linked to the task insuring students are responsible for their own learning. The model provides clear information to the students about the learning goals to be achieved and divides them into clearly defined units. In this model there is no defined role for peer assessment or feedback.

2.8 Conceptual framework

It must be remembered that learning is a complex process and is influenced by many different factors, the learning process itself is constantly changing, both in nature and diversity as it progresses (Shuell, 1990). What constitutes good learning process in one situation isn’t necessarily appropriate in other situations. For example, simple knowledge recall in one context would require a different approach to more complex problem solving in another. It is the teacher’s role in the following conceptual framework to select the best learning process and use it formatively by providing feedback to students and insuring that they respond to it. Tasks requiring high levels of cognitive processing are best taught using constructivist strategies such as social negotiation. For this reason, the conceptual framework outlined below sets the curriculum within a constructivist
paradigm empowering teachers to engage their students in higher order thinking activities allowing them to commit to self-chosen positions and at the same time acknowledging the existence of other solutions. As additional justification for setting the conceptual framework within a constructivist paradigm, teachers within Catholic Education Office Sydney (CEO), are asked to reflect the CEO Learning Framework in their practice. The Learning Framework Discussion Paper (Catholic Education Office Sydney, 2004) was developed and published after extensive research and is based upon a constructivist paradigm. Amongst other characteristics the framework defines the learner as: bringing knowledge, skills and attitudes to the learning environment, building on prior knowledge and experience, requiring a variety of rich learning opportunities to construct meaning, strengthening learning through sharing problem solving strategies with others, retains and transfers learning when explicit connections are made to other learning and real life contexts and creates meaning for themselves (Catholic Education Office, 2004).

The conceptual framework – achievement-based learning has been developed out of the formative classroom practice theoretical framework and attempts to encapsulate and show the relationship between the key elements of: curriculum, pedagogy and assessment. The framework reflects some of the ideas and limitations discussed in the previous section. It also recognises that learning occurs within a spiral curriculum and that ‘the gap’ will never be closed unless teachers provide appropriate and timely feedback and that structures and processes are established which insure all feedback is responded to until the learner is able to demonstrate achievement of the specified outcome. The conceptual framework is shown in Figure 2.7 on the following page.
Instructional design
- student centred
- content knowledge
- PCK
- teacher as facilitator of learning

Teacher
- professional knowledge of curriculum and standards.
- sets expectation of learning environment

Teacher
- content knowledge
- PCK
- classroom management
- questioning
- formative observations

Teacher
- content knowledge
- PCK
- classroom management
- questioning
- formative observations
- uses alternate method

Teacher Planning
Selection of outcome’s

Teacher planning
Development of teaching / learning sequence within context

Teacher / students
Develop and share learning goals and standards to be achieved

Teacher delivery and management of learning sequence

Student achievement of outcome
No Yes

Feedback
Teacher and peer

Student response to feedback
Achievement of outcome
Yes No

Move onto new concept within current module
Module complete?
Yes No

Pre-assessment
Teacher identifies student learning needs

Formative assessment
All classroom activities assume a formative role
Teacher collects data

Teacher evaluation
Teacher compares student performance against expected standards and formulates appropriate feedback

Summative assessment
Teacher collects data then uses task formatively
Students work until they achieve the outcome
Outcome achieved?
Yes

Figure 2.7 Conceptual framework - achievement based learning
2.9 ESSAonline and SOLO Taxonomy

In 2005, in an attempt to improve learning in science in NSW schools, the then Department of Education and Training (DET) through its Educational Measurement and School Accountability Directorate (EMSAD) commissioned the development of a formative assessment tool designed to identify what students know and can do in the context of the NSW Board of Studies Year 7 – 10 Science Syllabus. The test was called Essential Secondary Science Assessment (ESSA) and took the form of a ‘pen and paper test’ until 2011 when it was modified to an ‘online’ format and became known as ESSAonline. The test closely reflected similar moves being made at that time in the United States of America under the No Child Left Behind Act that required all states to introduce state-wide assessment programs in science.

Wilson and Bertenthal (2005, p.4) argue that for an assessment to provide valid information about student learning it must be designed with a specific purpose in mind. During the development stages of ESSA the team were clearly focussed on developing an assessment tool that would improve student learning by providing specific detailed data on what students know and can do. As part of the development process the ESSA Framework was formulated to define a set of standards that students were expected to achieve. Appendix 1 contains a copy of the 2014 ESSAonline test and stimulus, whilst Appendix 2 contains a section of the ESSAonline Physics Framework.

Following a limited pilot of the test in 15 schools in 2005 and extensive trialling later in 2005 and again in 2006, the test was eventually made compulsory for all students in NSW DET (now Department of Education and Communities (DEC)) Schools in 2007. The test is also available to students in non-government schools and is sat during November each year by students in Year 8. Panizzon et al. (2006, p.23) describe ESSA’s 3 main purposes as:

- provide formative information about student achievement;
- provide resources and training for teachers; and
- raise the profile of science education in NSW schools.

Over time, ESSAonline has continued to develop, in 2013 a pilot of Year 10 ESSAonline test was held with an associated trial in 2014. In 2014 a pilot of Year 6 ESSAonline was conducted with further trialling planned for 2015.
The original test reflected a constructivist paradigm of learning and attempted to provide information about student understanding of the Stage 4 section of the NSW Science Syllabus for Years 7 – 10. Panizzon et al. (2006) argue “underpinning both the syllabus and ESSA is the notion of teaching science within contexts. When implementing the syllabus teachers develop the contexts within schools to embrace the interests of students and help them recognise and appreciate the relevance of science in their everyday lives”.

All ESSAonline items are designed to be topical, relevant and interesting to the students and centred on a piece of engaging and interesting real world stimulus. Today, the three forms of ESSAonline attempt to test the content and skills of the current NSW Science K–10 (incorporating Science and Technology K–6) Syllabus.

To assess the quality of student learning against the ESSA Framework (Appendix 2) developers elected to use the Structure of the Observed Learning Outcomes (SOLO) model (Biggs & Collis, 1982; 1991). This model was chosen as it allowed examiners to assess the quality of student learning in a manner which is both content and context specific. When using the SOLO taxonomy to mark student responses two important features are considered. The first is the mode of thinking required by students and relates to the level of abstract thinking required. The second is the level of response and relates to student ability to deal with cues.

2.9.1 Modes of cognitive functioning
SOLO taxonomy adopts a post-Piagetian theory of cognition and reflects aspects of both Piaget’s four level model of cognition and Bruner’s three stages of growth. SOLO taxonomy identifies five modes of cognitive functioning rather than the four developmental stages of Piaget. Biggs and Collis (1982, 1991) have provided a post-formal mode of development to describe shifts in cognitive growth beyond that normally observed among school children. One important difference from the views of Piaget is that as new modes become available they do not replace the old mode but develop in parallel to it. That is the “modes accrue from birth to maturity” (Biggs & Collis 1991, p. 61). The latter level represents the upper ceiling to the level of abstraction at which the child can perform, not the level that all performances must conform to. Typically, as more modes become available multi-modal functioning becomes the norm. The five modes are as follows and reflect aspects of both Piaget’s four stages of cognitive growth and Bruner’s stages of growth (listed earlier):
• sensorimotor;
• ikonic;
• concrete symbolic;
• formal; and
• post-formal.

The modes, the approximate age of availability, and the forms of knowledge represented by each mode are shown in Figure 2.8.

Figure 2.8  Modes and Forms of Knowledge (Biggs and Collis, 1991)

Within the modes described in Figure 2.8, young people may adopt alternative passages of transition through the modes. This variability is referred to by Biggs and Collis (1991) as multimodal learning. In Figure 2.8, four alternative learning paths are shown by the arrows A, B, C and D. Arrow A is the path assumed by stage theories in which the emerging stage replaces its predecessor. However, the model also allows for the continued development in a mode even if other modes are available to the learner. If the continued development is restricted to one mode (as in arrow B of Figure 2.8) then the development is called unimodal learning.

More typically, to account for the difference between the physical skills of young children and those of elite athletes, more than continued development in the sensorimotor modes is needed. Elite athletes will call on other modes to better understand their performance and hence improve their performance in the target mode. Such modal
interaction is called “top-down facilitation of lower order learning” (Biggs & Collis 1991, p. 70) and is represented by arrow C in Figure 2.8.

In addition, to top-down learning, there is the “bottom-up facilitation of higher order learning” (Biggs & Collis 1991, p. 71). In this model, learning activities are located initially in the lower modes and trace a developmental sequence to the target mode. This type of learning is illustrated by arrow D in Figure 2.8.

### 2.9.2 Levels of response

Just as Piaget discriminated between cognitive structures within each stage, Biggs and Collis identified structural differences of performance within each mode. These differences were called levels and repeated in a cyclical fashion. Within each mode there are three broad levels of structural complexity, namely, unistructural, multistructural and relational. The levels and their characteristics are now described below.

- **Prestructural**: The response indicates an inability to engage with the question in a meaningful way.
- **Unistructural**: This set of responses uses only one relevant element of data from the stimulus item.
- **Multistructural**: The learner at this level can use multiple data elements, but the elements are not integrated.
- **Relational**: In contrast to a multistructural response, a relational response reflects the ability to integrate the elements and operations of the question in a way that enables an overview of the stimulus item.
- **Extended abstract**: The use of data elements external to the system is a feature of an extended abstract response and is the link with the next mode.

A diagrammatic representation of the interaction between modes and levels is presented in Figure 2.9 on the following page.
In a typical progression of learning, students are deemed to move through these three levels of response twice for every mode of thinking as they grow from infancy through to adulthood. As most students who undertake the ESSA online test are in a concrete symbolic mode of thinking, the ESSA Framework defines six levels of performance to measure their standard of achievement. Level 1 is the lowest level of understanding while Level 6 the highest. The standards are defined within the content and context of the syllabus.

During an interview with Joanne Sim, test developer with EMSAD (now known as the High Performance Directorate) (personal communication, August 10, 2012), she stated that every test item in ESSAonline is pretested and checked for validity by a team of 20 academics.

2.9.3 School Measurement and Reporting Toolkit

ESSAonline results are reported to schools using the School Measurement and Reporting Toolkit (SMART II). At the recent Education World Forum Ministerial Exchange, the current NSW Director-General of Education and Communities, Michele Bruniges (2014) reported:

We (BOSTES) have designed and delivered a School Measurement, Assessment and Reporting Toolkit (SMART II) – a software package which provides classroom teachers with the tools to examine and craft appropriate responses to student achievement data. It also enables teachers to link relevant data sets to support the evaluation of intervention programs, discuss teaching and learning in the light of curriculum evidence, and make the next set of teaching decisions to progress student learning.
Bruniges (2014) went on to argue that there must be a balance between teacher effort and teacher time. Teachers must be empowered with the right tools to identify where students have made mistakes and how best to rectify these. Bruniges claims that SMART II will empower teachers to engage online with the rich data from NAPLAN and ESSAonline teaching to improve student learning outcomes in a time efficient way.

2.10 Summary

The review of literature, as presented in this chapter, clearly shows that the appropriate use of formative assessment can lead to improvements in student learning. The theoretical framework shows that the setting for this study is at the intersection of curriculum, pedagogy and assessment. The conceptual framework, achievement based learning, shows that the formative classroom practice occurring at this point of intersection must include the provision of feedback to the student and structures insuring that the students respond to the feedback.

Chapter 3 will provide details of the overall research process by describing and justifying the research methodology and methods of data collection and analysis. The impact of ESSAonline will be considered as a key component of student learning at the point of intersection of curriculum, pedagogy and assessment.
3.1 Introduction

This chapter details the overall research process by describing and justifying the research methodology and methods of data collection and analysis. The theoretical basis for the methodology is justified within the context of the study. The methodological framework of case study is discussed and the perspective of participant observation justified. Data collection and analysis are described, discussed and justified. Discussion of the study sample and limitations of the research design are included. Issues of data trustworthiness and credibility and ethics are considered.

3.2 Theoretical basis for this study

This study is set within a naturalistic environment, an educational system consisting of 150 schools and over 70,000 students spread across three regions. The research question is:

*How have teachers, in Sydney Catholic systemic schools, used data from Essential Secondary Science Assessment online (ESSAonline) and what have been the impacts of their use on the performance of subsequent cohorts sitting ESSAonline?*

This study is contextualised by a relativist view of research. Relativism is when some aspects of experience or culture are relative to other aspects. Thayer-Bacon (2003) argues that people are social beings who hold views that are dependent on particular circumstances and specific situations. Relativism acknowledges that different social circumstances provide different outcomes, depending on context. A major component of any study is the researcher him or herself. Since this researcher is a component of the study itself, a participant researcher, it can be argued that the predisposed views of the researcher may have a significant impact on the study itself as well as the interpretation of the study findings.

Consequently, before commencing this study the researcher sought to clarify beliefs about his own worldviews to facilitate the emergence of an appropriate methodology. This is because, as Lankshear and Knobel (2004) argue, different people have different views, interpretations, attitudes and belief systems, collectively known as worldview.
Therefore, such people, specifically this researcher, will have different interpretations of data based on their worldviews.

3.2.1 Researcher’s worldview

Whilst philosophical ideas often remain largely hidden in much research they still influence the practice of research and need to be identified. As the more fundamental philosophical ideas researchers espouse influence the methodology and methods used, they need to be made explicit. In planning a study, researchers need to carefully link their philosophical worldview assumptions, the strategy of inquiry that is best suited to this worldview, and the specific methods or procedures that translate the approach into practice (Creswell, 2009, p.5). Funk (2001) argues, ‘a worldview is the set of beliefs about fundamental aspects of reality that ground and influence all one's perceiving, thinking, knowing, and doing.’

This researcher began planning the methodology for this study by defining his own worldview and considering his beliefs about each of the following tenets underpinning worldview as listed by Funk (2001): epistemology, metaphysics (ontology), cosmology, teleology, theology, anthropology and axiology.

Ascertaining the researcher’s epistemology or beliefs about the nature and sources of knowledge was a good starting point in developing an understanding of his worldview. Given the naturalistic environment of the classroom, knowledge cannot be collected in objective ways that reflect a world that adheres to predetermined laws. Knowledge must be collected through subjective ways that reflect the human response to the world around them. People possess a set of values that they bring to the workplace and other aspects of their social world which impact the way they respond to their external real world. This researcher believes that the purpose of this study is to identify the ways ESSAonline data was used to improve the performance of future cohorts of students, an interpretative framework based on pragmatism should be used to collect and analyse data.

Although trained as a science educator it would be understandable to expect the researcher’s metaphysical beliefs (ontology) about the nature of reality to be strongly ensconced in cause and effect relationships governed by a set of universal laws. However, after 38 years of working as a teacher in the naturalistic setting of the
classroom, this researcher has developed an understanding of the world in which reality must be useful, and constructed by people interacting within a set of values which govern their reaction to the random parameters placed upon them by the real world. Consequently, truth is what works at the time and may not be based on a reality that exists within the mind (Creswell, 2013, p 28).

Given his strict Catholic upbringing along with training as a geologist, this researcher’s cosmological beliefs about the origin and nature of the universe, life, and especially ‘Man’ are based neither in pure chance nor on an act by a supernatural creator. This researcher adopts a view in which the universe came into being through the act of a ‘Creator’, but then its development continued over a very long period of time as the result of ‘natural processes’ governing the interaction of matter and energy. The researcher believes that the ‘natural processes’ did not come about simply by chance as the chance of the Earth being as it is today are so infinitesimally small, rather the creator had a role in their design. Hence, life has purpose and what we do should reflect that purpose and be undertaken for the well-being and benefit of all life.

So what then is the purpose of the universe, the elements and life? The researcher’s teleological beliefs are that the universe and life coexist to create an ever-increasing complexity and interdependence of all the elements within the universe. This interdependence is designed by the Creator to develop a growing consciousness of its inhabitants and their relationship with God, one another and the universe itself. Therefore, any methodology employed by this study must seek to develop and respect relationships between the researcher and participants in an effort to create knowledge within the reality of the participants.

This deep purpose is built upon the theological belief in a loving God who exists outside of and above nature but seeks to develop personal relationships with all people. Whilst God desires an intimate relationship with each individual person he allows the Laws of Nature to develop and shape the universe. Within this framework God has empowered us with freewill to work things out on our own. In the context of teleology we must seek to understand one another in the context of reality so that we can continue to develop knowledge to do good works.
Anthropologically, humankind is a key step in the process of evolution, a part of Earth's global ecosystem, a steward responsible for the well-being of the lower organisms and inanimate elements. Humankind has a unique place in the universe as a moral agent, to think and act to realize good. All actions must therefore be undertaken to benefit creation. Consequently, any methodology chosen must respect the dignity and worth of participants.

As has been argued, all elements of the researcher’s worldview stem from axiological beliefs about what is right and good. Within the context of this study what is right and good is pragmatic actions that lead others to realize their innate potential and capacity to build a body of knowledge about learning and teaching and how this can be achieved in the naturalistic environment of the classroom.

### 3.2.2 Implication of researcher’s worldview on methodology

The worldview outlined above demanded an interpretivist paradigm dependent on inductive reasoning that required the researcher to build partnerships with participants in an attempt to understand how they constructed and interpreted the meaning of their actions in the reality of their schools and classrooms. Consequently, knowledge was constructed by developing high levels of trustworthiness and deep relationships with participants and placing strong emphasis on understanding the reality of their world by talking with people in non-intrusive ways sensitive to their unique context (Ulin, Robinson & Tolley, 2004).

The study, whilst set primarily within a qualitative methodology, was informed by quantitative data collection and analysis. The quantitative aspect of the methodology collected objective data about student performance in ESSAonline tests over the five year period 2008 - 2012. This data was used in an interpretive way to answer the research question and triangulate the data collected from the qualitative components of the study.

### 3.3 Methodology that can best answer the research question

For the purpose of immersing the researcher in the reality of the context and enhancing the development of trusting relationships with participants, case study emerged as the most appropriate methodology. Yin (2009, p. 18) uses a two part technical definition of case study:
A case study is an empirical inquiry that:
- investigates a contemporary phenomenon in depth and within its real-life context, especially when;
- the boundaries between phenomenon and context are not clearly evident.

The case study inquiry:
- copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result;
- relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result;
- benefits from the prior development of theoretical propositions to guide data collection and analysis.

As defined by Yin (2009) case study is an empirical form of inquiry meaning that it is based on observed and measured phenomena and derives knowledge from actual experience rather than from theory or belief (Amsberry, 2008). Case study is ideally suited to the school environment where there are many variables operating and is able to penetrate situations in ways that are not always perceptible by numerical analysis. Case study can provide rich description and detail of this naturalistic setting (Cohen, Manion & Morrison, 2011). Participant observation was also a dimension of the case study methodology as the researcher had a direct connection with each school participating in the study (Creswell, 2013). The researcher, in his capacity as Science Advisor, helped teachers understand how ideas about assessment and learning theory, as discussed in the achievement-based conceptual framework, can lead to improved student performance in formal testing.

3.3.1 Participant observation

Participant observation is one type of data collection method widely used in many disciplines engaging in qualitative research. Whilst its origins can be traced back to cultural anthropology and ethnography it has become an important research tool in many fields of sociology including communications, nursing and education. It aims to gain a close and intimate familiarity with a particular community and learn at first-hand about their practices through an intensive involvement with the people over an extended period of time.
Finlay (2005) argues that when using this data collection method the researcher’s task is not simply to listen to another’s story, but be open to being with the participant in a relationship. The researcher needs awareness of how the relationship between participant and researcher is mutually constituted.

Whilst participant observation can, in itself, be considered a research methodology, this study utilised case study as the principal methodology. However, use was made of a variety of data collection methods including online questionnaires, semi-structured interviews, observations and documents which were analysed and evaluated using the ‘lens’ of participant observation.

Although formal observations were undertaken during this study they took place over a relatively short period of time. Nevertheless, they need to be considered in the broader context that the researcher has worked with the science education community within CEO as a Science Adviser for over 7.5 years. During this time he has influenced the ideas and opinions of the participants and worked alongside them in the development of their pedagogical skills. Within this framework care was taken whilst interviewing participants to avoid directly influencing their responses. Care was also taken when analysing data to record the intent of responses.

The ethnographic studies of DeWalt and DeWalt (2011) define the key elements of participant observation as: living in the context for an extended period of time, using the local language, participating in a wide range of activities, engaging in everyday conservation, informally observing leisure activities, recording observations in field notes and using both tacit and explicit information in analysis and writing.

Having been a science teacher within the CEO for over 25 years the researcher is well immersed in the community, and thoroughly knows the local language and culture of participants. Using Howell’s (1972) framework he has built rapport, and ‘blended into the field’. For the specific purpose of this study he made observations and collected and recorded data and then consolidated it through thematic analysis. The researcher attempted to maintain a moderate role as observer to maintain a balance between being an insider and a researcher, allowing for a good blend of involvement along with a level of detachment to remain objective.
DeWalt and DeWalt (2011, p. 10) believe that there are three main advantages to participant observation. It:

- enhances the quality of the data collected;
- enhances the quality of the data interpretation; and
- encourages the formulation of new research questions grounded in the on-scene observation.

The participant researcher was able to improve the quality of the data collected as he already had deep knowledge and understanding of the context, good trusting relationships with the participants and knew what data to collect. Having been ‘well blended into the field’, quality data interpretation was facilitated as the researcher was able to avoid the risk of misrepresentation of the intent of participant responses. The open and free discussion resulting from the positive relationships within the setting facilitated deep inquiry into the use of ESSAonline, which when linked with changes taking place in ESSAonline lead to new research questions with the view to further improving learning outcomes for all students.

These advantages must be balanced against the limitations of the potential influence of the personal beliefs of the observer about what is relevant and important and the influences of the researcher’s worldview on the interpretation and evaluation of the data.

One final concern regarding participant observation relates to Finlay’s (2005) beliefs about the relationship embodied between the observer and the participant. Whilst the researcher makes every attempt to build trust he / she can never be fully sure that the participant acts in accord with what he / she believes the researcher wants to see. With this in mind the role of the quantitative dimensions of the study will be to triangulate collected data with that reported through ESSAonline test results and faculty documentation. Through this cross checking the researcher should be able to discern discrepancies between what participants say and do.

3.3.2 Case Study

Yin (2003) bases his approach to case study on constructivism. Baxter and Jack (2008) argue that constructivists claim that truth is relative and dependent on one’s worldview and hence construction of meaning is based on a person’s perceptions of reality. With this
in mind one of the advantages of case study is that through building trustworthy relationships between the researcher and participants the researcher is better able to understand the participants’ actions.

As this study attempted to answer ‘how’ questions, without manipulating the behaviour of participants and at the same time trying to understand contextual conditions and how they relate to phenomenon, case study was considered an ideal methodology (Yin 2009). Yin (2003) categorised case studies as explanatory, exploratory or descriptive based on their function. Case studies are differentiated as single, multiple, holistic or embedded depending on their structure.


Table 3.1  Definitions of Different Types of Case Studies (Yin, 2003)

<table>
<thead>
<tr>
<th>Case Study Type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explanatory</td>
<td>This type of case study is used to answer questions that seek to explain the presumed causal links in real-life interventions that are too complex for survey or experimental strategies. In evaluation language, the explanations would link program implementation with program effects.</td>
</tr>
<tr>
<td>Exploratory</td>
<td>This type of case study is used to explore situations in which an intervention being evaluated has no clear, single set of outcomes.</td>
</tr>
<tr>
<td>Descriptive</td>
<td>This type of case study is used to describe an intervention or phenomenon and the real-life context in which it occurred.</td>
</tr>
</tbody>
</table>

Yin (2009) identifies four main case study designs, the:

- single case design which can focus on a particular case (holistic) for a specific reason;
- embedded single case design in which more than one ‘unit of analysis’ is incorporated into the design;
- multiple case design in which multiple cases are included in the one study (holistic) for comparative purposes; and
- embedded multiple case design in which different sub-units may be involved in each of the different cases.

Diagrammatically, these four different forms of case study are represented by Yin (2009) in Figure 3.1.

<table>
<thead>
<tr>
<th>Single case designs</th>
<th>Multiple case designs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Context</td>
<td>Context</td>
</tr>
<tr>
<td>Case</td>
<td>Case</td>
</tr>
<tr>
<td>Embedded unit of analysis 1</td>
<td>Embedded unit of analysis 2</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Embedded unit of analysis 2</td>
<td>Embedded unit of analysis 2</td>
</tr>
</tbody>
</table>

Figure 3.1  *Basic types of designs for case studies* (Yin, 2009)
The matrix in Figure 3.1 shows that any case must be considered within its context. The dotted line around the case shows that the distinction between the case and the context is not likely to be well defined (Yin, 2009). Within this framework either as a single or a multiple case design a study can be either holistic (single unit of analysis) or embedded. An embedded case contains more than one sub-unit of analysis (Yin, 2009). Similar to a single holistic case study, an embedded case study methodology provides a means of integrating both qualitative and quantitative methods of data collection and analysis into a single study which converge through triangulation, but as the data is obtained from a number of sub-units a more detailed level of inquiry is achieved.

Yin (2009) argues that case study has a distinctive place in evaluation research. As this study aims to evaluate how ESSAonline data is being used by teachers in CEO systemic schools and the impact its use has on the performance of subsequent cohorts of students, then the study will have two key applications. It will:

- *enlighten* understandings of how ESSAonline data is being used; and
- *explain* the causal links in real life interventions that result from the use of ESSAonline data.

Using Yin’s (2009) framework this study was designed as an empirical explanatory study in which the context of the study is CEO Sydney systemic schools. Three cases are embedded within this context and relate to the level of use of ESSAonline data by coordinators and teachers. Two sub-units (schools) will be studied within each case. The three cases include schools that make:

- extensive use of ESSAonline data;
- some use of ESSAonline data; and
- no use of ESSAonline data.

### 3.4 Research design

A research design, according to Yin (2009) is the logical sequence that links empirical data to a study’s initial research question and ultimately to its conclusion.

In naturalistic inquiry, such as this educational study, it is simply not possible for investigators to undertake a classic scientific experimental design, in which the researcher manipulates an independent variable to see its effect on one or more other dependent
variables. Rather, a non-experimental design has to be employed in which the researcher analyses variables or concepts of interest without undertaking any manipulations or interventions (Creswell, 2008). Since this study dealt with the ‘normal’ or ‘natural’ research settings of schools and the individualities and biases of the people from whom data were obtained, a study design was developed to capture the experiences of people in their specific contexts and to promote understandings of their actions set within their own social reality (Cohen, et al., 2011).

The purpose of the study was to investigate the research question:

How have teachers, in Sydney Catholic systemic schools, used data from Essential Secondary Science Assessment online (ESSAonline) and what have been the impacts of its use on the performance of subsequent cohorts sitting ESSAonline?

Hence, to make the links between the research question, empirical data (using many forms of evidence) and the conclusion (Yin, 2009) the qualitative methodology of embedded case study, incorporating a participant observation perspective, was employed. Although the study predominantly used qualitative methods to understand how science coordinators used or did not use data from the ESSAonline process, it also incorporated statistical analysis of ESSAonline data to provide for enhanced understandings and opportunities for triangulation.

Yin (2009) argues that a set of propositions that direct attention to key elements being investigated should be identified early in the design phase. This is to ensure the study moves in the right direction. The following propositions were identified from the research question. These propositions, in conjunction with relevant literature, guided the development of the subsidiary questions. The subsidiary research questions, in turn, influenced the research design. These propositions were used to guide data analysis and to position the study within the conceptual framework developed in Chapter 2. The research question and subsidiary questions also informed the formulation of the conclusions. The propositions were:

- Schools predominantly use a constructivist paradigm of learning.
- Formative and summative assessment can, when used appropriately, improve student learning.
• Formative and summative assessment data provides the information needed by teachers to evaluate student learning against a set of standards.
• Following evaluation, teachers should provide timely feedback to students.
• Teachers should provide guidance to and opportunities for students to respond to feedback.

Within this framework the study was conducted in three phases. A brief overview of each phase is provided below and then described and justified in detail.

Phase 1: Online questionnaire
Nisbet and Watt (1984, p. 78, as cited in Cohen et al., 2011) suggest that because case studies capture the dynamics of unfolding situations it is advisable to commence with a very wide field of focus. They suggest a study should start with an open phase without selectivity or judgement. Thereafter, progressive focusing enables the researcher to identify key foci for subsequent study and data collection. In Phase 1, so as to commence with a wide focus, all science coordinators in CEO Sydney systemic schools that had junior secondary classes were invited to complete a questionnaire designed to determine:
• the many ways coordinators and teachers internally access and share ESSAonline data;
• the many ways schools process data to derive useful feedback for both teachers and students;
• the many ways teachers and students respond to feedback; and
• number of schools that make:
  o extensive use of ESSAonline data;
  o some use of ESSAonline data; or
  o no use of ESSAonline data.

A covering letter and questionnaire were distributed electronically via the Internet. No prejudgment or selectivity of schools was involved.

Phase 2: Semi-structured interviews
Following the initial open phase of the study, which provided a broad indication of the use being made of ESSAonline data, six coordinators from respondents were selected to take part in semi-structured interviews to gain understandings and insights into how
ESSAonline data was or was not used. Purposive sampling was used to obtain a representative sample of coordinators who fell into each of the 3 cases (extensive, some and no use of ESSAonline data) listed above (Cohen et al., 2011, p. 156). As only two coordinators indicated they made extensive use of ESSAonline data and two made no use of ESSAonline data the decision was made to select two coordinators as sub-units for each of the three cases. Additional criteria used to select the two coordinators who made some use of ESSAonline data will be discussed in section 3.4.2.1. The reason coordinators were selected as interviewees was because responses from the questionnaire showed that:

- the ESSAonline process was mostly coordinated by the science coordinator;
- coordinators also completed most of the analysis; and
- had the best longitudinal understanding of interventions developed and their impact on student performance.

Phase 3: Review of numerical ESSAonline data
The purpose of Phase 3 was to identify trends in the quantitative ESSAonline data for students from the purposively selected schools to validate, or otherwise, the claims made by the coordinators during the conduct of the study.

The methodology, data collection and data analysis processes will now be described and justified for each of the three phases.

3.4.1 Phase 1 Science coordinator questionnaire
In Phase 1, all science coordinators of schools that had junior secondary classes were invited to complete a questionnaire (see Appendix 3) designed to determine the ways ESSAonline data were, accessed, shared and analysed to provide feedback for teachers and students, and how the teachers and students responded to feedback.

3.4.1.1 Population and sample selection
Following ethics approval from the supervising institution, further ethics approval was obtained from the Catholic Education Office, Sydney. Approval was granted by the system on the condition that no coordinator or teacher was approached without the approval of the respective principal. Approval was then sought from and granted by all relevant principals before data collection commenced.
To achieve a response rate large enough to be representative of the target population (Creswell, 2008) science coordinators from all 33 Sydney Archdiocesan Catholic systemic junior secondary schools were invited to respond to the on-line questionnaire.

Inviting all coordinators to complete the questionnaire meant the field of focus was wide and free of selectivity and judgement. Responses from the questionnaire were used to provide a broad overview of the practices surrounding the use of ESSAonline data and select six coordinators, two sub-units for each of the three cases, schools making extensive, some and no use of ESSAonline data.

3.4.1.2 Data Collection
An on-line questionnaire was developed to seek feedback from the respondents about how they internally accessed, shared, and analysed ESSAonline data. An on-line questionnaire was chosen because coordinators were used to communicating with the science advisor (the researcher) via the Google applications platform and all coordinators were familiar with ‘Google form’ as an application for conducting questionnaires.

Whilst it was recognised that any form of questionnaire was an intrusion into the life of respondents (Cohen et al., 2011, p. 377) an on-line questionnaire provided the greatest benefits. The questionnaire was designed so the covering letter was in the form of an email and:

- highlighted the importance of the study and its potential impact on the learning outcomes of students;
- explained the purpose of the study;
- assured participants they could remain anonymous;
- invited participants to participate in Phase 2 if they were prepared to be interviewed;
- assured participants there would be no negative impacts of participation;
- advised participants of the two week timeline for the return of responses; and
- provided a link to the Google form used to collect data.

The advantages of using the on-line questionnaire were many. Coordinators could not be coerced into completing the questionnaire. The questionnaire was easy to distribute to all coordinators at the same time and provided greater authenticity because it was more
likely to be completed by the coordinators themselves. Data processing was also fast and easy because all responses were collected electronically on a spreadsheet. Consequently, there was less human error in processing data, and it allowed respondents the freedom to complete the questionnaire in their own time (Cohen et al., 2011, p.280). In an attempt to maximise the response rate, coordinators were sent a reminder email, three days before the responses were due.

The on-line questionnaire was developed by the researcher because a suitable pre-existing instrument could not be found. The instrument developed used a combination of closed and open-ended questions. The closed-ended questions were designed to illicit basic demographic and procedural data while the open-ended questions were designed to probe for deeper understandings of findings identified (Creswell, 2008, p. 398).

In developing the instrument, care was taken to avoid ambiguities, wordiness and to reduce the number of questions asking for the same information. The research and subsidiary research questions and propositions were used as a guide to determine both the content and sequence of the questions. The questionnaire was trialled by a small group of ex-science coordinators. The trialling process was used to confirm the purpose of the questions and the overall reliability and validity of the instrument. After trialling, the questionnaire was sent to all 33 volunteering science coordinators using gmail, the email application of the Google applications platform.

3.4.1.3 Data Analysis
Qualitative data collected from the questionnaire were voluminous and required data reduction processes that respected the quality of the data (Cohen et al., 2011, p.559). Processing qualitative data was “a reflexive, reactive interaction between the researcher and the decontextualised data that are already interpretations of a social encounter” (Cohen et al., 2011, p.428). Qualitative data analysis involved organising, accounting for and explaining the data (Cohen et al., 2011). Thematic analysis was used to analyse Phase 1 qualitative data.

3.4.1.3.1 Thematic analysis
Thematic analysis is defined as “a method for identifying, analysing and reporting patterns (themes) within data” (Braun & Clarke, 2006, p. 79). Thematic analysis
describes and organises data in detail to interpret aspects of the phenomenon (Boyatzis, 1998). Therefore, for researchers it “increases accuracy and sensitivity in understanding and interpreting observations about people, events, situations, and organizations” (Boyatzis, 1998, p. 5).

Thematic analysis has a number of advantages. Apart from its flexibility and ease of accessibility, thematic analysis can usefully summarise key features of a large body of data and offer a detailed description, highlight similarities and differences across the data set, generate unanticipated insights, and produce appropriate qualitative analyses to inform policy development (Braun & Clarke, 2006). However, it also has disadvantages. Flexibility can make analysis difficult, and can lead to a loss in focus, as there is a wide range of things that can be said about the data. Thematic analysis has limited interpretative power if it is not used within a pre-existing theoretical framework.

Thematic analysis is used to categorise data and then identify themes. According to Braun and Clarke (2006, p. 82), a theme “captures something important about the data in relation to the research question, and represents some level of patterned response or meaning within the data set”. Ideally, a theme should represent both significance and prevalence; however, prevalence does not guarantee significance (Braun & Clarke, 2006). What determines a theme is whether it captures any important aspect of the research topic, rather than how many times it is repeated or how much space it is given. Whether a theme is able to capture ‘essence’ is a judgement that has to be made by the researcher (Braun & Clarke, 2006).

There are three primary approaches to the development of themes. The first is theory driven, the second is prior data or prior research driven, and the third is inductive, or data driven (Boyatzis, 1998). ‘Theory-driven’ is where researchers begin with theory and then formulate signals, or indicators, or evidence that would support the theory. Prior-research-driven thematic analysis is where researchers identify themes on the basis of prior research. The prior research is often a pilot study or related research that has been undertaken by the researcher. Data-driven analysis is where researchers identify themes directly from raw information (Boyatzis, 1998). The choice among the three forms of thematic analysis is linked to “how and why researchers are coding the data” (Braun & Clarke, 2006, p. 84).
Braun and Clarke (2006, pp. 87-93) provide a six-phase process for thematic analysis:

- familiarisation with the data;
- generating initial codes and allocating categories;
- identifying themes;
- reviewing themes;
- defining and naming themes; and
- producing the report.

This study employed inductive or data-driven thematic analysis situated within the *achievement-based* conceptual framework developed in Chapter 2. Analysis was undertaken on either a line-by-line or phrase-by-phrase basis depending upon the smallest unit that provided meaning for the researcher. Data was then paraphrased at an appropriate level of abstraction omitting unnecessary wordage and coded using a set of emergent categories based upon the researcher’s understanding of the context. Coding was undertaken several times as categories used early in the process were modified and new ones added. By reviewing the data more than once, consistency of judgement was developed and ensured. Patterns identified through this process facilitated the use of a grounded approach to identify emergent themes (Creswell, 2013, p.85). Chapter 4 contains examples of how thematic analysis was used in both Phases 1 and 2.

Throughout the process the following principles were adhered to, to ensure data reliability:

- avoidance of ambiguity in categories;
- consistent application of categories;
- taking care to identify what was intended as opposed to that which could be inferred;
- using data that could be corroborated (by either ESSAonline performance data or faculty documentation);
- attempting to interpret words as intended and avoiding misinterpretation; and
- avoiding researcher bias.

**3.4.2 Phase 2 – Science coordinator interviews**

Phase 2 involved the purposeful selection of six science coordinators to take part in semi-structured interviews to gain understandings and insights into how ESSAonline data was or was not used.
3.4.2.1 Population selection
The science coordinators were selected based on a number of criteria. The first and foremost being the level of usage made of ESSA online data. Two science coordinators were invited to be interviewed as sub-units in each of the three cases. The cases were where schools made:

- extensive use of ESSA online data to inform learning and teaching;
- some use of ESSA online data to inform learning and teaching; and
- no use of ESSA data.

Other criteria included the:
- number of times the school had been involved in ESSA online;
- length of time the science coordinator had held the position at the school; and
- science coordinators volunteering to be interviewed.

During the interviews the researcher attempted to develop trusting relationships with the science coordinators and sought deep knowledge and understandings of:

- how they accessed, shared and analysed ESSA online data;
- the school-based interventions developed in response to data analysis;
- the feedback provided to teachers and students; and
- the way teachers and students responded to the feedback (Ulin, Robinson & Tolley, 2004).

Semi-structured interviews were used because they provide reliable data as the same questions are used in the same order, thus allowing for comparability of responses. To further improve the reliability and validity of the data and to reduce the potential for bias, the researcher conducted all interviews (Cohen et al., 2011).

3.4.2.2 Data Collection
Interviews were used as the data source for Phase 2. An interview is “an interchange of views between two or more people on a topic of mutual interest, sees the centrality of human interaction for knowledge production, and emphasizes the social situatedness of research data” (Kvale, as cited in Cohen et al., 2011). A research interview is “a two-person conversation initiated by the interviewer for the specific purpose of obtaining research-relevant information, and focused by content specified by research objectivities
of systematic description, prediction, or explanation” (Cannell & Kahn, as cited in Cohen et al., 2007). This study used interviews as a source of information to develop true and accurate understandings of each of the five subsidiary questions:

- What are science coordinators’ beliefs about the value of ESSAonline as a formative assessment tool?
- How are ESSAonline data accessed, shared and analysed within the science faculty?
- How is SMART II used by teachers within the science faculty, what feedback has been provided to students and how have they responded?
- What interventions have been developed in response to ESSAonline and how have they impacted on the performance of subsequent cohorts in ESSAonline?
- Should the Catholic Education Office Sydney continue to invest in ESSAonline as a formative assessment tool?

The use of ESSAonline data was the focus of interviews. The interviewer translated these specific objectives within the framework of the research propositions into questions that made up the interview schedule (Cohen et al., 2011).

In this study, a semi-structured interview was employed. A semi-structured interview is a popular interview technique “where a schedule is prepared that is sufficiently open-ended to enable the contents to be reordered, digressions and expansions made, new avenues to be included, and further probing to be undertaken” (Cohen et al., 2011, p. 412). The semi-structured interview schedule allows for a set of interview questions to be developed around themes that address the research questions and propositions in a flexible way. Questions are asked in an order that is appropriate to the discourse that evolves as the interview is conducted, with wording that is contextually appropriate (Gibson & Brown, 2009). Responses were recorded on an electronic voice recorder by the interviewer and later transcribed, and coded.

When preparing the interview schedule, the framing of questions was carefully considered to avoid ambiguity and repetition. The questions ranged from simple straightforward background questions about the faculty members e.g. gender, age, training and work experience, through to open-ended questions about the methods used by the faculty to analyse ESSAonline data and the types of interventions developed. The interview
schedule was developed and trialled by the interviewer on a sample of ex-science coordinators now working in other roles. Throughout the interviews, probing questions (Cohen et al., 2011) were used to obtain comprehensive responses to the questions asked.

Creswell (2008) defined several general steps when conducting interviews:

- identify the intended interviewees;
- determine the type of interview to be conducted;
- audiotape the questions and responses;
- take brief notes during the interview;
- locate a quiet suitable space for conducting the interview;
- obtain informed consent;
- have a plan but be flexible;
- use probes to obtain additional deep information; and
- be courteous and professional.

These recommendations were closely followed. The interviews were recorded with a small audio device. During the interviews the researcher recorded field notes to further inform interpretation of the responses.

Overall, this specific type of semi-structured interview, using open-ended questions to gain information from coordinators had its advantages. The most important advantage was that the interviewer had control over the interviews. Another advantage was that direct interaction allowed for greater depth of interaction and probing, compared with other methods of data collection. The interview provided a platform for the interviewees to express their personal point of view (Cohen et al., 2007). Interviews also have disadvantages, both generally and specifically within the context of this study. Given the relationship between the science coordinators and the researcher (the researcher is an advisor to the coordinators), there was a likelihood that coordinators would modify their responses, telling the interviewer what they thought the interviewer expected them to say. More generally, a disadvantage of interviews is that the interview process is affected by subjectivity and bias on the part of the interviewer. Another disadvantage of interviews is that the process of conducting the interview, transcription, alignment with field notes and analysis is very time-consuming (Cohen et al., 2007).
3.4.2.3 Data Analysis

After inviting and having gained informed consent from science coordinators, the interviews were conducted and recorded. The interviews were conducted in the coordinators own school at a time selected by them so the environment was as positive and non-threatening as possible. The interviews were recorded on a small audio device and field notes kept to record non-verbal cues. Shortly after the interviews the recordings were transcribed.

As the amount of data from interviews was so voluminous, data reduction and thematic analysis processes similar to those described in Phase 1 were used to identify emergent themes (Janetti, 2005). During initial readings of the transcripts and field notes, preliminary attempts were made to identify the best natural units for analysis as either line-by-line or paragraph by paragraph, depending upon the smallest unit that provided meaning for the researcher (Janetti, 2005). Detailed analysis then took place codifying the responses and grounded analysis used to identify the emergent themes.

As three different and separate cases composed the study, once the interviews were analysed the emergent themes from each case were compared and contrasted within and across all cases to identify patterns. Within the framework of thematic analysis, as described and justified in Phase 1, the data analysis process for Phase 2 can be summarised as follows:

- reducing wordage and paraphrasing responses;
- coding and sorting data into categories;
- analysing categories to identify recurring patterns;
- use of grounded theory to identify emergent themes;
- clustering respondents into the three cases of the study;
- making comparisons and contrasts within and across the cases;
- subsuming particulars into generals where appropriate; and
- ensuring conceptual coherence.

Examples of this process are provided in Chapter 4.

Upon completion of the interview analysis, interviewees were asked to check the transcripts, along with a summary of the themes identified. The interviewees were given the opportunity of confirming the transcripts and themes as a true representation of their
reality. As no concerns were raised about the validity of the transcripts or interpretation of themes no further interviews were deemed necessary.

3.4.3 Phase 3 - Review of numerical data
The purpose of reviewing and analysing the ESSAonline numerical data was to identify trends to validate, or otherwise, the claims made by science coordinators during the conduct of the study.

3.4.3.1 Population
ESSAonline data, detailing the performance of all Year 8 students from the six selected schools, for the five years 2008 – 2012, were accessed through School Measurement, Assessment and Reporting Toolkit (SMART II). As Michele Bruniges (2014) reported:

SMART II is a software package which provides classroom teachers with the tools to examine and craft appropriate responses to student achievement data. It also enables teachers to link relevant data sets to support the evaluation of intervention programs, discuss teaching and learning in the light of curriculum evidence, and make the next set of teaching decisions to progress student learning.

Using SMART II, the data were statistically analysed to identify evidence of improved performance of subsequent student cohorts sitting ESSAonline.

3.4.3.2 Data Collection
SMART II software package allowed for analysis of the data at a whole school level for each individual question or reportable area e.g. Knowledge and Understanding or Working Scientifically. Data for each student were only available for the year they sat the test. Longitudinal data for students were not available as students only sit the test in Year 8.

3.4.3.3 Data Analysis
Analysis of data available through SMART II was conducted for the period 2008 – 2012. As ESSA changed from a pen and paper test to an online format in 2011, statisticians from the Department of Education and Communities recommended that levels of achievement in the pen and paper test should not be compared with levels of achievement in the online version as conditions for the running of the assessment had changed and valid comparisons could not be made (personal communication Sim, 2012).
Analysis was conducted for the five reportable areas in ESSAonline, Science overall, Extended Response, Knowing and Understanding, Communicating Scientifically and Working Scientifically. The analysis took two forms as described below.

Firstly, a level analysis was undertaken. As student achievement is measured using SOLO and reported in Levels 1 - 6, student performance was compared across the six schools for the period 2008 - 2012. Patterns in performance for subsequent student cohorts were sought e.g. patterns showing sustained growth, decline or consistent performances were sought. Two sets of graphs were developed, one for the pen and paper version of the test, the other for the online version. The six levels of achievement used by SOLO are described in Table 3.2

Table 3.2 Description of SOLO Levels of achievement as used in ESSAonline

<table>
<thead>
<tr>
<th>SOLO Level</th>
<th>General Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>the response contains a <strong>single piece of common sense information</strong> relevant to the major concept</td>
</tr>
<tr>
<td>Level 2</td>
<td>the response contains <strong>two or more pieces of common sense information</strong> relevant to the major concept</td>
</tr>
<tr>
<td>Level 3</td>
<td>the response contains a <strong>common sense explanation</strong> about the major concept that relates two or more pieces of common sense information</td>
</tr>
<tr>
<td>Level 4</td>
<td>the response contains a <strong>single piece of ‘scientific’ information</strong> relevant to the major concept that clearly reflects syllabus expectations or accepted science</td>
</tr>
<tr>
<td>Level 5</td>
<td>the response contains <strong>two or more pieces of ‘scientific’ information</strong> relevant to the major concept that clearly reflect syllabus expectations or accepted science</td>
</tr>
<tr>
<td>Level 6</td>
<td>the response contains a clearly stated ‘<strong>scientific</strong>’ explanation about the major concept that relates two or more pieces of information, which clearly reflect syllabus expectations or accepted science</td>
</tr>
</tbody>
</table>

The second form of analysis was based on test means for all reportable areas across the five year period. In response to advice that pre-2011 levels should not be compared with 2011 onwards, the difference (School – State) means were calculated as a measure of performance. In doing so, it was assumed that by comparing the mean school
performance with the mean across the state that changes in performance from one cohort to the next could be determined. Patterns in performance within a school within a case were identified and then compared and contrasted with trends identified in the other sub-unit within the case. Patterns were then compared and contrasted across the three cases.

Patterns in performance within schools were triangulated against claims made by coordinators about both the interventions instituted within schools and the impact they believe these interventions had on the performance of subsequent student cohorts.

During the discussion of findings any faculty documentation provided by coordinators was considered to increase the trustworthiness and credibility of the data analysis.

This process provided a rich complexity of information to complete the study. Identified positive trends in student performance data were triangulated with the qualitative data collected from interviews and faculty documentation. These trends could then be used to inform the CEO about their continued use of ESSAonline as a formative assessment tool.

### 3.4.4 Summary of Research design

Table 3.3 on the following page summarises the key Phases of this study.
Table 3.3  
*Research design for the embedded multiple case study*

<table>
<thead>
<tr>
<th>Phase</th>
<th>Population</th>
<th>Data Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase 1</strong></td>
<td>Science coordinators from all 33 Sydney Archdiocese Catholic systemic junior secondary schools</td>
<td>Online questionnaire</td>
</tr>
<tr>
<td>Nisbet and Watt (1984) – Open phase (wide focus)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| **Phase 2** | Six purposively selected science coordinators, two sub-units for each of the following three cases:  
- schools that make extensive use of ESSAonline data;  
- schools that make some use of ESSAonline data; and  
- schools that make no use of ESSAonline data | Structured interview and submitted documentation |
| Nisbet and Watt (1984) – (narrowing focus) | | |
| **Phase 3** | Student data from six purposively selected junior secondary catholic schools, students from two schools (sub-units) for each of the following three cases:  
- Schools that make extensive use of ESSAonline data  
- Schools that make some use of ESSAonline data  
- Schools that make no use of ESSAonline data | Published ESSAonline data |

3.5 Limitations

In this embedded case study it is important for the qualitative data to be allowed to speak for itself and not be over interpreted or judged by the researcher. As argued by Yin (2009) embedded case studies provide for greater reliability as more than one set of data provides the basis for findings. Consequently, care was taken not to over interpret or judge coordinator responses. Whilst the generalizability of the findings of case studies is often criticised, it can also be argued that in the same way that single experiments can be
replicated so too can case studies. As the first two phases of the study collected qualitative data from the schools being studied the data will not be readily generalizable. However, those who read the study will be able to make comparisons between it and their specific situation to inform their particular circumstances.

A significant limitation of this study is that since the NSW State Government abandoned the Year 10 School Certificate Examination there is no longer any state-wide assessment tool available to gather longitudinal data on individual student performance in science tests. Hence, the researcher was not able to assess the impact of ESSAonline on individual students over the long term. Given this situation, the impact of ESSAonline can only be measured by comparing the performance of the test on subsequent cohorts of students. This said, as reported earlier in the study, DEC trialled a new Year 10 ESSAonline test in 2014 making the possibility of the long term tracking of students a future possibility. This new test will be considered further in Chapter 6.

### 3.6 Ethical considerations

Throughout this study, efforts were made to insure that participants were protected at all times and that their anonymity was assured. When completing the online questionnaire coordinators were given the option to remain anonymous. However, those who volunteered to take part in the interview identified themselves. The identity of the interviewees was known to the interviewer. All reporting was completed with no identifying information.

Informed consent was required for the interview process. All participants were:

- voluntary and willing participants;
- fully informed of the purpose of the study;
- fully informed of the procedure used;
- aware they have the right to enquire about the procedures;
- aware that they have the right to withdraw from the study up until the publication of the results, and
- required to sign to acknowledge their participation in the survey. (Cohen, Manion & Morrison, 2011, p.78).
The physical and psychological impacts of the interview environment were monitored to insure participants were comfortable and did not feel threatened.

Ethics approvals were obtained from both The University of Notre Dame Australia and the Catholic Education Office, Sydney.
Chapter 4 DATA ANALYSIS AND FINDINGS

4.1 Introduction

This chapter reports the data collected throughout all three phases of the investigation. Data analysis is presented and findings elicited. The findings will be discussed in detail in Chapter 5. Issues of data credibility and trustworthiness are considered.

4.2 Phase 1 data - Online questionnaire

Phase 1 data collection consisted of an online questionnaire (see Appendix 3) completed by science coordinators across all schools in the study. Of the 33 invited schools 20 responded, which is a 61% response rate. Table 4.1 shows the school ESSAonline participation rate over 8 years.

<table>
<thead>
<tr>
<th>Total number of ESSAonline Exams sat during the 8 year period 2005 - 2012</th>
<th>Number of schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 4.1 shows that all schools sat the ESSAonline test at least five times in eight year period 2005 - 2012. Seven schools sat the exam six times and five schools seven times. No school sat the test in each year of its operation.

4.2.1 Participating CEO schools for each year of ESSAonline

In 2005 three schools were invited to take part in the ESSA pilot. In 2006 and 2007, Sydney CEO sponsored a selection of schools to take part in two additional trial ESSA tests. Since 2008, all schools were registered for the test, however, one school failed to sit
the test because of a prior booking on the school calendar. In 2011 one school failed to complete the online test for technical reasons. This data is shown in Table 4.2.

<table>
<thead>
<tr>
<th>Year of test</th>
<th>Number of participating schools involved</th>
<th>% of reporting schools involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005 (pilot)</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>2006 (trial)</td>
<td>9</td>
<td>45</td>
</tr>
<tr>
<td>2007 (trial)</td>
<td>7</td>
<td>35</td>
</tr>
<tr>
<td>2008</td>
<td>19</td>
<td>95</td>
</tr>
<tr>
<td>2009</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>2010</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>2011 (online)</td>
<td>19</td>
<td>95</td>
</tr>
<tr>
<td>2012 (online)</td>
<td>20</td>
<td>100</td>
</tr>
</tbody>
</table>

4.2.2 Coordinators holding their current role for each year of ESSA testing

Table 4.3 shows the level of leadership stability within participating schools. It states the number of current coordinators who were holding their leadership position for each of the eight years the test has been in operation.

<table>
<thead>
<tr>
<th>Year of ESSA test</th>
<th>Number of coordinators holding their current role</th>
<th>% of reporting coordinators</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005 (pilot)</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>2006 (trial)</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>2007 (trial)</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>2008</td>
<td>9</td>
<td>45</td>
</tr>
<tr>
<td>2009</td>
<td>11</td>
<td>55</td>
</tr>
<tr>
<td>2010</td>
<td>13</td>
<td>65</td>
</tr>
<tr>
<td>2011 (online)</td>
<td>18</td>
<td>90</td>
</tr>
<tr>
<td>2012 (online)</td>
<td>20</td>
<td>100</td>
</tr>
</tbody>
</table>
Only one coordinator has been in his / her leadership role for all ESSAonline tests. The length of service of coordinators in their current role is a significant influence on data reliability as the longer a person has been in the role the deeper the knowledge of ESSA they are able to share in the questionnaire. Consequently, coordinators with continual leadership over the five year period 2008 - 2012 would be most reliable when reporting how data were used.

4.2.3 Planning and running of ESSAonline

In 80% of participating schools the planning and running of ESSAonline was undertaken by the Science Coordinator. In the remaining 20% of schools, the administration of the test was undertaken by the assistant coordinator or another senior science teacher. Deeper analysis revealed that delegation of this duty mostly occurred in schools with a paid assistant coordinator. This was the case in all except one school where, since the test went online, administration was by the eLearning Coordinator. In another school, the responsibility was shared by the coordinator and assistant. This data is shown in Table 4.4.

<table>
<thead>
<tr>
<th>Staff member who administers ESSAonline other than coordinator</th>
<th>Frequency of response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assistant Science Coordinator</td>
<td>3</td>
</tr>
<tr>
<td>Coordinator and Assistant</td>
<td>1</td>
</tr>
<tr>
<td>eLearning Coordinator</td>
<td>1</td>
</tr>
</tbody>
</table>

4.2.4 Sharing ESSAonline data within the faculty

Thematic analysis was used to analyse the question *How ESSAonline data are shared within the faculty*. Table 4.5 on the following page shows the thematic analysis undertaken for this question. Throughout the analysis process the unit to be analysed was listed, followed by the meaning ascribed to it by the researcher. A category was then allocated to the unit under analysis and then the theme identified.
<table>
<thead>
<tr>
<th>Unit of meaning</th>
<th>Meaning</th>
<th>Category</th>
<th>Emergent Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>brief discussion at science meeting</td>
<td>Results are shared at faculty meetings</td>
<td>Sharing – faculty meeting</td>
<td>ESSAonline data are shared by the coordinator during a faculty meeting</td>
</tr>
<tr>
<td>some sharing was done at department meeting</td>
<td>Results are shared at a faculty meeting</td>
<td>Sharing – faculty meeting</td>
<td>ESSAonline data are shared by the coordinator during a faculty meeting</td>
</tr>
<tr>
<td>at a faculty meeting</td>
<td>Results are shared at faculty meetings</td>
<td>Sharing – faculty meeting</td>
<td>ESSAonline data are shared by the coordinator during a faculty meeting</td>
</tr>
<tr>
<td>we look at results</td>
<td>Results are shared at faculty meetings</td>
<td>Sharing – faculty meeting</td>
<td>ESSAonline data are shared by the coordinator during a faculty meeting</td>
</tr>
<tr>
<td>The coordinator shares the results</td>
<td>Results are shared with individual teachers and then discussed at a faculty meeting</td>
<td>Sharing – individual teachers</td>
<td>ESSAonline data are shared by the coordinator with individual teachers</td>
</tr>
<tr>
<td>which are then discussed at the faculty meeting</td>
<td>Results are shared with individual teachers and then discussed at a faculty meeting</td>
<td>Sharing – faculty meetings</td>
<td>Analysis of ESSAonline data occurs during faculty meetings</td>
</tr>
<tr>
<td></td>
<td>Analysis – during faculty meeting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>brief discussion at science meeting</td>
<td>Results are shared at faculty meeting</td>
<td>Analysis – during faculty meetings</td>
<td>ESSAonline data are shared by the coordinator during a faculty meeting</td>
</tr>
<tr>
<td>Unit of meaning</td>
<td>Meaning</td>
<td>Category</td>
<td>Emergent Themes</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>------------------------</td>
<td>--------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>we analyse the results in one of our science meetings</td>
<td>Results are shared and analysed at faculty meetings</td>
<td>Analysis – during faculty meetings</td>
<td>occurs during faculty meetings</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sharing – during faulty meetings</td>
<td>ESSAonline data are shared by the coordinator during a faculty meeting</td>
</tr>
<tr>
<td>We discuss the overall results and the difficult questions I've identified, as a faculty</td>
<td>Results are shared and reviewed during faculty meetings</td>
<td>Analysis – firstly by coordinator and then at faculty meeting</td>
<td>Analysis of ESSAonline data occurs during faculty meetings</td>
</tr>
<tr>
<td>viewing of group data and analysis by the faculty, then a discussion of trends</td>
<td>An analysis of cohort data is undertaken by the coordinator and then shared and</td>
<td>Analysis – by coordinator</td>
<td>The coordinator undertakes a preliminary analysis and then further analysis occurs at faculty meeting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sharing – during faulty meetings</td>
<td>ESSAonline data are shared by the coordinator during a faculty meeting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The coordinator undertakes a preliminary analysis of cohort data</td>
</tr>
<tr>
<td>Unit of meaning</td>
<td>Meaning</td>
<td>Category</td>
<td>Emergent Themes</td>
</tr>
<tr>
<td>----------------</td>
<td>---------</td>
<td>----------</td>
<td>-----------------</td>
</tr>
<tr>
<td>During a faculty meeting. I analyse the results and give feedback to the faculty</td>
<td>discussed at a faculty meeting. Trends are identified and discussed</td>
<td>Analysis – trends identified</td>
<td>During faculty meetings trends are identified and discussed</td>
</tr>
<tr>
<td></td>
<td>Data analysis is completed and shared by the coordinator and then discussed as a faculty</td>
<td>Sharing – during faculty meetings</td>
<td>ESSAonline data are shared by the coordinator during a faculty meeting</td>
</tr>
<tr>
<td>Overview data is disseminated to all science teachers</td>
<td>A summary of the data is given to all science teachers</td>
<td>Sharing – faculty meeting</td>
<td>The coordinator undertaking an analysis and then further analysis occurs at faculty meeting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Analysis – by coordinator</td>
<td>ESSAonline data are shared by the coordinator with individual teachers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The coordinator undertaking a preliminary analysis of cohort data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ESSAonline data are shared by the coordinator during a faculty meeting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The coordinator</td>
</tr>
<tr>
<td>Unit of meaning</td>
<td>Meaning</td>
<td>Category</td>
<td>Emergent Themes</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------</td>
<td>----------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Science Faculty meeting - I present an overview of cohort results</td>
<td>Data and analysis is shared and discussed as a faculty</td>
<td>coordinator</td>
<td>undertakes a preliminary analysis of cohort data</td>
</tr>
<tr>
<td>During KLA faculty meetings, teachers gain access to their class results.</td>
<td>Data is shared with teachers on a class by class basis</td>
<td>Sharing - faculty meeting</td>
<td>ESSAonline data are shared by the coordinator during a faculty meeting</td>
</tr>
<tr>
<td>Overall analysis is discussed at faculty meetings</td>
<td>Analysis of cohort data is completed by coordinator and shared at a faculty meeting</td>
<td>Analysis – by coordinator</td>
<td>ESSAonline data are shared on a class by class basis</td>
</tr>
<tr>
<td>I show my analysis at KLA meetings.</td>
<td>Analysis of data is completed by coordinator and shared at a faculty meeting</td>
<td>Analysis – by coordinator</td>
<td>ESSAonline data are shared by the coordinator during a faculty meeting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sharing – faculty meeting</td>
<td>The coordinator undertakes a preliminary analysis of the data for the cohort</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ESSAonline data are shared by the coordinator during a faculty meeting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The coordinator undertakes a prelim. analysis</td>
</tr>
<tr>
<td>Unit of meaning</td>
<td>Meaning</td>
<td>Category</td>
<td>Emergent Themes</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------</td>
<td>----------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Staff are invited to view results on SMART II data</td>
<td>Staff are invited to view student data online using the SMART II data package</td>
<td>Sharing – SMART II</td>
<td>Teachers are provided access to the data through SMART II</td>
</tr>
<tr>
<td>Each faculty member has access to the SMART II data program and is encouraged to investigate further.</td>
<td>Teachers are encouraged to go online and use SMART II to analyses student data</td>
<td>Sharing – SMART II</td>
<td>Teachers are provided access to the data through SMART II</td>
</tr>
<tr>
<td>results were given to classroom teachers and individual students considered.</td>
<td>Results shared with teachers leading to analysis of individual student achievement</td>
<td>Analysis – individual student</td>
<td>ESSAonline data are shared by the coordinator with individual teachers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Teachers review the performance of individual students</td>
</tr>
</tbody>
</table>

A summary of the nine themes identified within the two categories, sharing and analysis is contained in Figure 4.1 on the following page.
• Sharing
  o at a faculty meeting
  o with individual teachers
  o through SMART II
• Analysis is undertaken
  o independently by the coordinator prior to faculty meetings
  o by coordinator along with the teachers during faculty meetings
  o at an individual student level
  o at a class level
  o at the cohort level
  o to identifying trends

Figure 4.1  Theme focuses for the sharing of ESSAonline data within the faculty

Figure 4.1 identifies each theme according to category. However, the themes identified are for a single, individual question. In an attempt to achieve a more insightful perspective, these single question themes were further refined by combining them with the themes identified through analysis of the remaining questions. Consequently, the themes identified from the analysis of each question will be referred to as theme focuses. Themes will be the term used to describe the combined theme focuses at the end of each data source analysis.

• ESSAonline data are shared by the coordinator either individually with teachers or during faculty meetings.
• Some teachers are provided with access to ESSAonline data through SMART II.
• Data analysis may be undertaken at the individual student, class or cohort level.
• Data analysis may either be completed by the coordinator prior to faculty meeting or by the coordinator with the teachers during faculty meetings.
• Analysis may identify trends in ESSAonline data.

Figure 4.2  Theme outcomes for: How ESSAonline data is shared within the faculty?

Sharing ESSAonline data within faculties was controlled by the coordinator. ESSAonline data was shared in three main ways – within the faculty, either at faculty meetings, at a personal level with individual teachers or through the SMART II package. Prior to
sharing data some coordinators completed either a full or partial analysis. When shared at faculty meetings, data was discussed and teachers were invited to contribute to the analysis. Analysis may have taken place at the individual student, the class or whole cohort level.

4.2.5 Level of use made of ESSAonline data
From the 20 schools that responded to the on-line questionnaire, two coordinators reported making extensive use of ESSAonline data to inform learning and teaching. Sixteen coordinators reported making some use of the data and two reported making no use of the data.

![Figure 4.3](image)

Figure 4.3 Extent to which ESSAonline data was used within the faculty

4.2.6 Responsibility for ESSAonline data analysis
In 85% of responding schools the person responsible for analysis and use of data was the Science Coordinator. In 15% of schools responsibility was delegated to a senior teacher. This finding should be considered in the context that only larger schools have a designated assistant coordinator.

![Figure 4.4](image)

Figure 4.4 Responsibility for ESSAonline data analysis
In the three schools in which the responsibility for analysis and use of ESSA data was delegated, one school delegated responsibility to the Assistant Coordinator. In a second school, the assistant coordinator and the coordinator were both responsible and in a third school the analysis was undertaken by a senior teacher.

### Table 4.6  
**Staff member responsible for analysis of ESSA online data**

<table>
<thead>
<tr>
<th>Staff member who analyses ESSA</th>
<th>Frequency of response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assistant Coordinator</td>
<td>1</td>
</tr>
<tr>
<td>Coordinator and assistant coordinator</td>
<td>1</td>
</tr>
<tr>
<td>A senior teacher</td>
<td>1</td>
</tr>
</tbody>
</table>

Open-ended, written responses were used to triangulate coordinator responses about who contributed to data analysis and how it was completed. Thematic analysis was used to analyse these responses in the same way it was employed to provide the analysis presented in Table 4.5. The categories analysis, evaluation and intervention were identified with the emerging themes as shown in Figure 4.5.

- Analysis of data may be completed at the individual student, class or cohort level.
- Analysis of data may either be completed by the coordinator independently or with assistance prior to faculty meeting, or by the coordinator with assistance from the teachers during faculty meetings.
- During faculty input Year 8 teachers from the previous year may be called upon to assist with the analysis.
- Analysis focuses upon identifying strengths and weaknesses at the individual student, class and cohort levels.
- Through evaluation of data the faculty may try to identify causes of weaknesses.
- Faculties attempt to develop interventions to address student weaknesses by developing new teaching strategies and literacy-based strategies and by using SMART II to identify misconceptions and modifying teaching programs.

*Figure 4.5  Theme outcomes for: How is ESSA online data analysed, evaluated and interventions developed?*
In many schools the coordinator undertook a general analysis of the data at cohort level, either independently or with some assistance. At this level, significant strengths and weaknesses within the student body were identified. In some cases an effort was made to isolate the causes of student strengths and weaknesses. Once identified the coordinator then attempted to work with the faculty, in particular Year 8 teachers from the previous year, to further identify student strengths and weakness at a class and/or individual student level. In many schools further faculty time was devoted to planning intervention strategies to address the learning needs of the cohort. These learning needs are addressed in a variety of ways that include: developing new teaching/learning strategies, modifying existing teaching/learning programs and developing literacy-based strategies to assist student reading and writing skills. Some teachers used SMART II to identify student misconceptions.

4.2.7 Using SMART II to access and analyse ESSAonline data

To access data and use analysis tools available in SMART II, teachers needed to be provided with a login, password and training. Not all schools provided teacher access to SMART II nor training to use it. Figure 4.6 shows the proportions of staff trained in the use of SMART II and the likelihood of teachers using the package.

![Proportion of staff trained and using SMART II](image)

Figure 4.6 Proportion of staff trained and using SMART II

4.2.8 Number of Year 8 classes in schools

Across the Archdiocese the size of schools was highly variable which impacted the number of Year 8 classes. In the Inner Western and Eastern Regions smaller schools
operated four streams while larger schools in the Southern Region had up to nine streams. Table 4.7 shows the number of schools in terms of the number of Year 8 classes.

Table 4.7  Number of schools in terms of the number of Year 8 classes

<table>
<thead>
<tr>
<th>Number of Year 8 classes</th>
<th>Number of schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
</tr>
</tbody>
</table>

4.2.9  Year 8 teacher access to ESSAonline data using SMART II

The percentage of Year 8 teachers who accessed ESSAonline data using SMART II varied from school to school. Figure 4.7 shows the percentage of schools claiming the likelihood of their Year 8 teachers accessing ESSAonline data online in any one year.

![Figure 4.7](image)

Figure 4.7  Percentage of schools with the proportion of Year 8 teachers accessing ESSAonline data online

Whilst it was encouraging to see that 25% of schools had between 75% - 100% of their teachers accessing ESSAonline data through SMART II, it was very disappointing to see that 40% of schools had no one accessing the data online.
The ways teachers reported using data from SMART II was analysed using thematic analysis. The categories ‘analysis’ and ‘intervention’ were identified, generating the themes shown in Figure 4.8.

- Only a small number of Year 8 teachers from the previous year formulate their class in SMART II and reflect on their students’ results or engage in reflection on their own teaching practice.
- Teachers who formulate their own classes compare their students’ results with those of students across the State to identify the strengths and weaknesses of both the individual students and the class as a whole. A very small number of teachers attempt to correlate their students’ results in ESSA with the students’ NAPLAN results.
- Teachers who do analyse their students’ Year 8 results reflect on their own practice to plan interventions incorporating new teaching and learning strategies e.g. modelling, joint and individual construction of responses and modifications to existing teaching programs.

Figure 4.8  Theme outcomes for: How do Year 8 teachers use SMART II analysis package?

Not all teachers analysed ESSA online data to develop interventions, or to provide feedback to students. The level of analysis of ESSA online data by schools was highly variable and changed from one school to the next. Analysis within schools changed from year to year. In many schools the initial analysis was undertaken at faculty level, followed by teachers using data at class level.

Following the use of SMART II to identify the learning needs of students many teachers reviewed their teaching programs to address the weaknesses identified by the data. Programming changes in some cases led to a review of the pedagogy used by teachers in the classroom.

Teachers adopted a range of pedagogical approaches to address student learning needs. Some teachers used ‘ESSA like’ questions in class. Such questions were used to teach students how to deconstruct the question and then scaffold the construction of an appropriate response.
Only a small number of schools and teachers reviewed the ESSAonline data at an individual student level to identify what students can and can’t do. Teaching strategies were then developed to cater for individual students. A very small percentage of teachers used both ESSAonline data and NAPLAN data to build in-depth student profiles.

4.2.10 Year 9 teacher access to ESSAonline data using SMART II
Consistent with Year 8 teacher use of ESSAonline data, the percentage of Year 9 teachers likely to access and use data from SMART II also varied from school to school. Figure 4.9 shows the estimated percentage of teachers likely to access ESSAonline data online in any one year.

![Figure 4.9 Percentage of schools with the proportion of Year 9 teachers accessing ESSAonline data online](image)

Figure 4.9 shows that Year 9 teachers are less inclined to access data about their current cohort than teachers who taught the students when they were in Year 8 the previous year.

When Year 9 teachers were asked how they would use ESSAonline data their open-ended responses were, also, analysed thematically. The categories identified were again ‘analysis’ and ‘intervention’ with the emergent themes shown in Figure 4.10 on the following page.
Only a small number of Year 9 teachers formulate their class in SMART II and reflect on their students’ results. Those who do compare their students’ results with those of students across the State to identify the strengths and weaknesses of both the individual students and the class as a whole.

Teachers who analyse their students’ Year 9 results plan interventions incorporating new teaching and learning strategies, differentiated programs to address the personal needs of their students (misconceptions) and general modifications to existing teaching programs to address the needs of the cohort.

One school attempted to use ESSAonline data to inform Year 11 subject selection.

Figure 4.10  Theme outcomes for: How do Year 9 teachers use SMART II analysis package?

Many teachers of Year 9 classes did not access ESSAonline data to build an awareness of the strengths and weaknesses of their students. Hence Year 9 teachers were not likely to provide specific feedback to students based on an analysis of the previous year’s ESSAonline test.

Use of the previous year’s ESSAonline data by Year 9 teachers with their current class was found to be minimal. In a small number of schools teachers did set up their Year 9 classes in SMART II and identify what their current Year 9 students could and could not do. These teachers did strive to use this information to provide specific interventions to address the learning needs of their students. Some teachers viewed ESSAonline as a pre-test for students as they entered Stage 5 Science.

A small number of teachers used ESSAonline and SMART II to identify misconceptions held by their current students. Armed with this knowledge, teachers reviewed their future programming to address these misconceptions.

At a cohort level, a small number of teachers used SMART II data to identify the strengths and weaknesses of the current Year 9 cohort. Teachers then developed teaching strategies designed to build on student strengths and address weaknesses.
From a ‘best practice’ perspective, teachers made use of ESSAonline data to develop differentiated learning opportunities. Armed with detailed knowledge about the needs of each individual student, some teachers organised class groupings based on student needs and developed strategies to use with them.

One school made use of ESSAonline data to supplement other information to assess student suitability for Stage 6 Science courses.

4.2.11 Impact of ESSAonline on student performance in formal testing

Beliefs among coordinators about the impact of ESSA on the performance of students in formal testing varied as shown in Figure 4.11 with 25% believing there were definite improvements, 55% believing there were some improvements and 20% saying there was no improvement.

![Figure 4.11 Percentage of schools and amount of improvement resulting from the use of ESSAonline data](image-url)

Thematic analysis was used to analyse coordinators responses about the evidence they have to support claims about the impact of ESSAonline on student performance in formal tests.
Coordinators listed evidence as: improvements in overall results reported in SMART II, improvements in areas that had been addressed by targeted interventions, e.g. improvements in writing skills as evidence through the extended response questions and experimental skills as seen through improvements in Working Scientifically.

Figure 4.12  Theme outcomes for: What evidence do you have to support claims of the positive impact ESSAonline has had on student performance in formal testing?

In many schools involvement in ESSAonline led to improvements in student performance in subsequent cohorts sitting ESSAonline. Some coordinators were able to point to overall improvements in data as reported in SMART II.

The results of ESSAonline data analysis provided information that science faculties used to improve student learning outcomes. After reviewing data and identifying areas of concern, faculties developed targeted interventions by reprogramming and developing new strategies to address identified needs. Many schools reported that student achievement improved in subsequent years.

Many coordinators reported developing specific literacy-based strategies which lead to improvements in student writing skills, especially in their ability to formulate extended response questions.

The findings show that faculties and teachers that engaged in analysis and reflection can improve student understandings of concepts and skills leading to further improvements in student testing.

4.2.12 Reporting student achievement in ESSAonline testing

Coordinators reported student achievement in ESSAonline to a wide range of audiences as shown in Table 4.8 on the following page.
Table 4.8  *Groups to whom science coordinators provide feedback on ESSAonline testing*

<table>
<thead>
<tr>
<th>Feedback provided to</th>
<th>Number of schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 9 Cohort</td>
<td>8</td>
</tr>
<tr>
<td>School executive</td>
<td>14</td>
</tr>
<tr>
<td>Whole school staff meeting</td>
<td>1</td>
</tr>
<tr>
<td>KLA Coordinators meeting</td>
<td>3</td>
</tr>
<tr>
<td>Parent body</td>
<td>5</td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
</tr>
</tbody>
</table>

The groups to whom coordinators reported student achievement and the type and way feedback was provided, varied enormously across schools. Analysis revealed the themes shown in Figure 4.13.

- Coordinators provided feedback to a wide range of audiences including: the Year 9 cohort, the School Executive, the whole school staff, KLA Coordinators, and parents.
- Feedback took many forms including: how to read the report, how students can identify individual strengths and weaknesses, positive reinforcement, summary of results, trends across classes, strengths and weaknesses of the cohort, growth in targeted areas, growth in achievement at Levels 5 and 6.

Figure 4.13 *Themes outcomes for: Who did you report student achievement in ESSAonline to, what feedback was provided and how was it delivered?*

Reporting ESSA data to the wider school community took many forms as did the focus of that feedback. The type and method of delivery of the feedback provided depended on the audience. Many coordinators used ESSAonline data to provide positive feedback to students and took the time to explain how to read the report and identify strengths and weaknesses. Motivated and self-directed learners were therefore empowered to identify and address their learning needs.
4.2.13 Respondents prepared to be interviewed
From the 20 respondents, 17 indicated they were prepared to participate in a further structured interview while three were not.

4.2.14 Summary of key findings - Phase 1
How is ESSAonline data shared and analysed within the faculty?
All schools that took part in the questionnaire sat the test at least five times. No school sat the test in each year of its operation.

Considerable change in leadership took place within science faculties across the life of ESSAonline. To ensure the reliability of Phase 2 data, one of the criteria used to select coordinators was their length of service as coordinator in their current school.

The sharing of ESSAonline data within faculties was controlled by coordinators. When shared at faculty meetings, data were discussed and teachers were invited to contribute to the analysis. Analysis took place at one or a combination of: the individual student, the class or cohort level.

Across the system, coordinators engaged in using ESSAonline data at different levels. Some made extensive use of the data while others made either some or no use of the information. Normally, it was the coordinator who administered the ESSAonline test and shared the data. In some large schools with an assistant coordinator, these duties were delegated to the assistant or another senior faculty member or shared between the coordinator and assistant.

How is SMART II used by teachers within the faculty, what feedback has been provided to students and how have students responded?
Whilst ESSA data was provided to schools via SMART II, not all schools provided teachers with access to and training in the use of the package. In many schools it was only the coordinator who had access to SMART II.

In 25% of schools, most teachers who taught Year 8 in the previous year engaged in reflective analysis of the ESSAonline data. Many teachers reviewed their teaching
programs to address the weaknesses identified by the data. Consequently, programming changes led to a review of pedagogy used in the classroom.

A minority of schools and teachers reviewed the ESSAonline data at the individual student level to identify what students could and could not do. Teaching strategies were then developed to cater for individual student learning needs.

Many teachers of Year 9 classes did not access available data to build an awareness of the strengths and weaknesses of students. Hence, Year 9 teachers were not likely to provide specific feedback to students based on the outcomes of the ESSAonline test.

**What interventions have been developed in response to ESSAonline and how have they impacted on the performance of subsequent cohorts sitting ESSAonline?**

In many schools, coordinators claimed that involvement in ESSAonline led to improvements in student performance in external tests. Schools were able to point to overall improvements in student achievement as reported in SMART II. Many schools reported improvements in student achievement as a result of interventions implemented in response to ESSAonline data analysis. The findings show that faculties and teachers that engaged in analysis, reflection and the development of school-based interventions can improve student understandings of concepts, writing and working scientifically skills, leading to improvements in performance of subsequent cohorts sitting ESSAonline.

Most coordinators provided feedback to a wide range of audiences including; the Year 9 cohort, the School Executive, the whole school staff, KLA Coordinators, and parents. Feedback took a variety of forms including how to read the report, how students can identify their individual strengths and weaknesses, positive reinforcement, summary of results, trends across classes, strengths and weaknesses of the cohort, growth in targeted areas, and growth in achievement at Levels 5 and 6.
4.3 Phase 2 data - Coordinator semi-structured interviews

Based on the analysis of Phase 1 data, six coordinators were invited to take part in Phase 2 of the case study. Coordinators selected to take part in the embedded multiple case study volunteered to be interviewed. Each had been in their faculty for the last 5 years as either the science coordinator or curriculum coordinator and met the criteria for one of the three identified cases.

4.3.1 Faculty teacher experience

Table 4.9 on the following page reports the number of teachers who taught in the six schools that composed the six sub-units of the case study. It shows their main science teaching discipline and years of teaching experience.
Table 4.9  Summary of the number, main science discipline and years of teaching experience of teachers in the three identified cases

<table>
<thead>
<tr>
<th>Use of ESSA</th>
<th>School</th>
<th>Level of teaching experience and main teaching area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extensive</td>
<td>A</td>
<td>Years of experience: 0 – 5, 6 - 10, 11 - 15, 16 - 20, 21 - 25, 26 plus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of teachers: 4, 2, 1, 1</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Years of experience: 0 – 5, 6 - 10, 11 - 15, 16 - 20, 21 - 25, 26 plus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of teachers: 3, 1, 1, 1, 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Main teaching area: Chem / Phy PDHPE Bio / Sen Sc, Jnr Sc Chem / Bio, Chem, Phy</td>
</tr>
<tr>
<td>Some</td>
<td>C</td>
<td>Years of experience: 0 – 5, 6 - 10, 11 - 15, 16 - 20, 21 - 25, 26 plus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of teachers: 3, 1, 1, 2, 1</td>
</tr>
<tr>
<td>None</td>
<td>D</td>
<td>Years of experience: 0 – 5, 6 - 10, 11 - 15, 16 - 20, 21 - 25, 26 plus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of teachers: 1, 2, 1, 2, 2</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>Years of experience: 0 – 5, 6 - 10, 11 - 15, 16 - 20, 21 - 25, 26 plus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of teachers: 3, 2, 2, 2</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>Years of experience: 0 – 5, 6 - 10, 11 - 15, 16 - 20, 21 - 25, 26 plus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of teachers: 1, 1, 2, 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Main teaching area: Jnr Sc Jnr Sc / TAS Jnr Sc / Religion Jnr Sc / TAS</td>
</tr>
</tbody>
</table>
The spread in teaching disciplines for the 45 teachers is as shown in Table 4.10.

Table 4.10  *Major teaching disciplines for the 45 teachers*

<table>
<thead>
<tr>
<th>Teaching discipline</th>
<th>Number of teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>9</td>
</tr>
<tr>
<td>Chemistry</td>
<td>8</td>
</tr>
<tr>
<td>Physics</td>
<td>6</td>
</tr>
<tr>
<td>Junior Science</td>
<td>4</td>
</tr>
<tr>
<td>Senior Science</td>
<td>2</td>
</tr>
<tr>
<td>Biology / Senior Science</td>
<td>1</td>
</tr>
<tr>
<td>Biology / Physics</td>
<td>1</td>
</tr>
<tr>
<td>Chemistry / Biology</td>
<td>5</td>
</tr>
<tr>
<td>Chemistry / Physics</td>
<td>3</td>
</tr>
<tr>
<td>Junior Science / other</td>
<td>5</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 4.10 shows a significant range in the number of teachers teaching science disciplines across the schools. Whilst biology is the discipline which has the largest number of teachers teaching a single key subject there are 16 staff teaching chemistry or chemistry in combination with another discipline. One teacher in school F, a junior secondary school, was teaching out of his / her trained area. Most teachers were teaching across at least two disciplines.

There was a spread in teaching experience across the six case study schools. Table 4.11 demonstrates that the number of teachers working in the classroom decreases as the length of teaching experience increases.

Table 4.11  *Spread in teaching experience across the six case study schools*

<table>
<thead>
<tr>
<th>Years of teaching experience</th>
<th>Experience</th>
<th>0 – 5</th>
<th>6 – 10</th>
<th>11 – 15</th>
<th>16 – 20</th>
<th>21 – 25</th>
<th>26 plus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of teachers</td>
<td></td>
<td>11</td>
<td>10</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>
An overview of the six schools shows that all schools had a range of teachers with a variety of lengths of teaching experience. School A had the highest number of teachers with the least experience whilst school E had the highest number of teachers with the greatest experience.

### 4.3.2 Explain why you make Extensive use of ESSAonline data

The six interviewees were asked about their attitudes towards ESSAonline as a formative assessment tool. In the case of the two coordinators who made extensive use of the data, they were asked why they made extensive use of the data. Thematic analysis of their responses was undertaken to identify emergent themes. Table 4.12 details the thematic analysis of responses of these two coordinators.

<table>
<thead>
<tr>
<th>Units of meaning</th>
<th>Meaning</th>
<th>Category</th>
<th>Emergent Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Extensive Use</strong></td>
<td><strong>Coordinator AAA</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The questions are quite well developed open ended and the multiple choice questions tell you something about the students by the options they choose.</td>
<td>The ESSAonline test contains both well-developed open ended questions and multiple choice questions. Analysis of the students’ responses provide the teacher with some insight into student learning</td>
<td>Questions – extended response</td>
<td>Extended response are well developed</td>
</tr>
<tr>
<td>Instead of giving you two nonsense responses some examiners often give two close options.</td>
<td>Options to the multiple choice may be very similar</td>
<td>Questions – multiple choice</td>
<td>Multiple choice questions are well developed and contain similar options</td>
</tr>
<tr>
<td></td>
<td>Student responses - insight</td>
<td></td>
<td>Student responses provide insight into their learning needs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Multiple choice questions contain similar options</td>
</tr>
<tr>
<td>Units of meaning</td>
<td>Meaning</td>
<td>Category</td>
<td>Emergent Themes</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-------------------</td>
<td>--------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Sometimes the answers the students give in multiple choice can be quite informative to you.</td>
<td>Responses students provide to multiple choice questions can provide insight into their learning</td>
<td>Student responses - insight</td>
<td>Student responses provide insight into their learning needs</td>
</tr>
<tr>
<td>It informs and it did quite often that we have an issues in a variety of different things.</td>
<td>ESSAonline provides good diagnostic information about problem areas the faculty has</td>
<td>Analysis - faculty</td>
<td>ESSAonline data provides feedback about problem areas the faculty has</td>
</tr>
<tr>
<td>You get feedback that did allow you to and it’s similar to the RAP analysis you can actually analyse it quite well if you went into it.</td>
<td>ESSAonline data provides good diagnostic data that when carefully analysed provides useful information at many levels, individual student, class and cohort</td>
<td>Analysis - level</td>
<td>ESSAonline data can be analysed at many different levels</td>
</tr>
<tr>
<td>You need the time it really is a full time job.</td>
<td>Analysis and dissemination of data is very time consuming</td>
<td>Analysis - problems</td>
<td>Analysis and sharing of data is time consuming</td>
</tr>
<tr>
<td>It gave me insight into the students</td>
<td>ESSAonline data can provide good insight to the learning needs of individual students</td>
<td>Analysis - individual</td>
<td>ESSAonline data can provide good insight into the learning needs of individual students</td>
</tr>
<tr>
<td>You can work with ESSAonline at a lot of different levels.</td>
<td>ESSAonline data can be analysed at many different levels</td>
<td>Analysis - level</td>
<td>ESSAonline data can be analysed at many different levels</td>
</tr>
<tr>
<td>Units of meaning</td>
<td>Meaning</td>
<td>Category</td>
<td>Emergent Themes</td>
</tr>
<tr>
<td>------------------</td>
<td>---------</td>
<td>----------</td>
<td>----------------</td>
</tr>
<tr>
<td><strong>Extensive use</strong> Coordinator BBB</td>
<td>ESSAonline is a good resource for monitoring student learning</td>
<td>Analysis – student learning</td>
<td>ESSAonline is a good tool to monitor student learning</td>
</tr>
<tr>
<td></td>
<td>ESSAonline has provided ongoing feedback to both the faculty and the students. It has helped both the faculty and students identify areas of strength and weakness</td>
<td>Analysis / feedback - level</td>
<td>ESSAonline provides good feedback to both the students and the faculty about their strengths and weaknesses</td>
</tr>
<tr>
<td></td>
<td>The faculty likes the way ESSA questions are integrated.</td>
<td>Questions - structure</td>
<td>ESSAonline questions effectively integrate content matter</td>
</tr>
<tr>
<td></td>
<td>The faculty also likes the structure of the open ended questions and uses ESSAonline as a source of questions for school-based assessment</td>
<td>Questions – extended response</td>
<td>Extended response questions are well developed</td>
</tr>
<tr>
<td></td>
<td>ESSAonline as a source of questions for school-based assessment</td>
<td>Questions - resourcing</td>
<td>ESSAonline questions are used</td>
</tr>
<tr>
<td>Units of meaning</td>
<td>Meaning</td>
<td>Category</td>
<td>Emergent Themes</td>
</tr>
<tr>
<td>------------------</td>
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</tr>
<tr>
<td>our sources.</td>
<td>When the faculty began using ESSAonline the students were an average of 4 points below the State average in all test areas</td>
<td>Analysis – student learning</td>
<td>as a resource within the faculty</td>
</tr>
<tr>
<td>Overall our performance was very, very poor. Essentially, I've just got here roughly, the state average was about 43 per cent. Our school was below 39 per cent across all of the areas.</td>
<td>The faculty began using the ESSAonline data to identify their areas of weakness and choose Working Scientifically as the area to address first.</td>
<td>Analysis – faculty</td>
<td>Student learning was below the State average 5 years ago</td>
</tr>
<tr>
<td>So as a team we looked at all the areas, and it was impossible to improve everything. We targeted initially working scientifically, because that was by far the poorest of them all, and then we thought we'd see how we go and target an area every year.</td>
<td>ESSAonline is a great way of identifying the areas that the faculty is doing well in and the areas that need to be addressed.</td>
<td>Analysis - faculty</td>
<td>Faculty used ESSAonline to identify areas of weakness</td>
</tr>
<tr>
<td>Absolutely. It's helping to inform us so it's a great way of informing us of you know what we've done well and what we maybe need to tweak or improve or rethink completely.</td>
<td></td>
<td></td>
<td>The faculty developed specific interventions targeting the students skills in working scientifically</td>
</tr>
</tbody>
</table>

Figure 4.14 on the following page summarises the categories identified by the analysis of the two coordinators’ responses and the theme focuses that emerged.
ESSAonline is used extensively because

- questions
  - have an integrated structure
  - multiple choice are well developed and contain similar options
  - extended response are well developed
  - are used as a resource within the faculty
- student responses
  - provide insight into student learning needs
- analysis
  - can be used to identify the strengths and weaknesses at many levels: individual student, class, cohort or faculty
  - helps the faculty monitor student learning relative to the state
  - analysis and sharing of ESSA data is very time consuming
- feedback
  - is provided to both the students and the faculty
- intervention
  - can be developed to target specific areas e.g. working scientifically

Figure 4.14  Theme focuses identifying why coordinators made extensive use of ESSAonline data

The themes identified in Figure 4.14 are for a single, individual question as answered by the two coordinators who made extensive use of ESSAonline. Hence, they do not constitute themes that have emerged from across the entire set of interviews. As in the previous section, the themes identified were further refined, in an attempt to achieve a more insightful perspective. Consequently, the themes identified from the analysis of each question were referred to as theme focuses. Themes will be the term used to describe the refined theme focuses at the end of each data source analysis.

The theme outcomes were compared and contrasted within each of the three cases and then across the cases. The themes were then combined into one figure with two main sections. The top half of the figure identified the themes found to be common to coordinators with the lower half identifying differences between the three cases.
The responses from the six coordinators were organised to address the five research subsidiary questions as stated below.

- What are coordinator beliefs about the value of ESSAonline as a formative assessment tool?
- How are ESSAonline data accessed, shared and analysed within the faculty?
- How is SMART II used by teachers within the faculty, what feedback has been provided to students and how have they responded?
- What interventions have been developed in response to ESSAonline and how have they impacted the performance of subsequent cohorts sitting ESSAonline?
- Should the Catholic Education Office Sydney continue to invest in ESSAonline as a formative assessment tool?

### 4.3.3 What are coordinator beliefs about the value of ESSAonline as a formative assessment tool?

<table>
<thead>
<tr>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Common areas of agreement</strong></td>
</tr>
<tr>
<td>- it is formative, the questions are well developed and integrate content from across the course</td>
</tr>
<tr>
<td>- analysis of data provides feedback to the faculty about the strengths and weaknesses of the students relative to the State at individual, class and cohort level</td>
</tr>
<tr>
<td>- provides teachers data to identify faculty strengths and weakness, thus empowering them to develop specific interventions to improve student learning outcomes</td>
</tr>
<tr>
<td>- ESSAonline has its limitations as it cannot assess all aspects of the syllabus</td>
</tr>
<tr>
<td>- use of ESSAonline places additional demands on teacher time</td>
</tr>
<tr>
<td>- SOLO can provide deep insight into student learning and identification of misconceptions, though it is not well understood or used by all teachers</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Areas of difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordinators who make some use of ESSAonline believe:</td>
</tr>
<tr>
<td>- there is not enough time to develop and entrench interventions into faculty practice</td>
</tr>
</tbody>
</table>
• feedback provided by ESSAonline is of little benefit to students as it arrives too late: about one term after the test
• as most schools have completed their own assessment program, ESSAonline is run at time when students are not interested in doing another exam

Coordinators who do not use ESSAonline believe
• it does not achieve its purpose of raising the profile of science
• it is redundant within a faculty that already has an effective assessment program
• since being online, technical issue have rendered the data invalid

Figure 4.15 Theme outcomes for: What are coordinator beliefs about the value of ESSAonline as a formative assessment tool?

There were similarities between themes expressed by coordinators. They believed that ESSAonline data provided opportunities to analyse the academic performance within the faculty at three key levels: the individual student, the class and the cohort. When analysed, the ESSAonline data was used to identify the strengths and weaknesses in student learning when compared to other students in the State.

The coordinators believed the test was a good formative tool that incorporated well developed multiple choice and extended response items which integrated content from across the syllabus. Through the use of SOLO along with close analysis of student responses, the data provided an insight into student learning and facilitated the identification of misconceptions.

As an example of formative assessment, all six coordinators agreed that ESSA whether pen and paper or online was very good. Coordinator CCC said:

Yeah, as an ongoing form of assessment, I think it's brilliant. It's the adage that you test - you find out what the students don't know and then reteach. (3/9/13)
Coordinators were unified in their belief that ESSAonline provided good feedback not only about the strengths and weaknesses of individual students, classes and the cohort but also about the teaching programs within the faculty.

Some key differences existed in the themes expressed by coordinators. Coordinator EEE did not use ESSAonline data as she believed she already had a strong assessment program operating within her school. She also believed she knew what was happening in her classrooms and believed that the use of ESSAonline, whilst it may be a good diagnostic tool, was totally redundant within her department. Coordinator FFF on the other hand, believed that since ESSAonline, went online it encountered significant technical issues at either CEO or DEC level and no longer provide valid and reliable data.

Time was another factor of concern amongst coordinators. Some coordinators believed that the proper analysis of data was time consuming and if interventions were to be developed and implemented, schools needed to make time available to teachers.

Coordinator CCC raised a concern about the value of ESSAonline feedback to students:

I think directly to the students, I don't think they - kids, look at the actual formative results, no. It comes back too late. They do it one year; it comes back the following year. I don't believe the data is formative for the children, I think it's useless. (3/9/13)

CCC’s position is in agreement with Shute (2008) who believes that to be of value, feedback must be provided in a timely fashion. Another important concern raised by both CCC and AAA was the timing of the test. Both coordinators believed that as most schools have completed their yearly school-based assessment program prior to sitting ESSAonline, positioning the task so late in the year, early to mid-November, renders the data unreliable as the students lack motivation and fail to apply themselves to the task.

Some coordinators were concerned that not all teachers fully understood the SOLO taxonomy and were unable to apply the holistic marking process.
### 4.3.4 How are ESSAonline data accessed, shared and analysed within the faculty?

<table>
<thead>
<tr>
<th>Common areas of agreement</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESSAonline data are shared by the coordinator with the teachers through either printed reports or by projecting the data live from SMART II.</td>
<td></td>
</tr>
<tr>
<td>Data may be analysed by the coordinator before being shared as a written report. In most schools science teachers are invited to take part in the analysis of the data.</td>
<td></td>
</tr>
<tr>
<td>Teachers attempt to identify the strengths and weaknesses of the students:</td>
<td></td>
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<tr>
<td>- firstly as a cohort, by comparing school data with that of the State</td>
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<tr>
<td>- on a class by class basis, either that of the Year 8 class from the previous year or for the current Year 9 class.</td>
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<tr>
<td>- on an individual student basis.</td>
<td></td>
</tr>
<tr>
<td>Analysis is undertaken in all five test reporting areas: Science Overall, Extended Response, Knowing and Understanding, Communicating Scientifically, Working Scientifically.</td>
<td></td>
</tr>
<tr>
<td>Teachers attempt to identify trends in cohort data. Identify areas of improvement or areas that the students may have performed weaker than in previous testing. Some schools undertake analysis on a gender basis.</td>
<td></td>
</tr>
<tr>
<td>Teachers use ESSAonline data to compare the performance of individual students with school data e.g. identifying, special needs students, top performers and those who may be underperforming at school. Teachers review student placement in specific classes. Some schools use the data to review student subject selection for Year 11.</td>
<td></td>
</tr>
<tr>
<td>Faculties review data to reflect on the performance of the faculty as a whole to identify strengths and weaknesses in their own programming and teaching. Some teachers use the data to engage in reflective practice by reviewing the performance of the students in their Year 8 class from the</td>
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</table>
previous year.
- Once analysed student performance is reported to: the Year 9 cohort, principal, whole school staff and the parent community.
- Top performing students may be given special awards at school assemblies.
- Teachers develop school-based interventions based on the needs of the students and faculty as revealed by the analysis.
- Teachers report that the analysis and development of school-based interventions is very time consuming and that some staff are reluctant to engage in the process.

<table>
<thead>
<tr>
<th>Areas of difference</th>
<th>Coordinators who do not use ESSAonline believe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Data are not shared with the teachers, principal, school staff or parents</td>
</tr>
<tr>
<td></td>
<td>No analysis of the data is undertaken</td>
</tr>
</tbody>
</table>

Figure 4.16  *Theme outcomes for: How are ESSAonline data accessed, shared and analysed within the faculty?*

The processes of data sharing and analysis within schools were highly variable. However, some commonalities did exist. The four coordinators interviewed that made some or extensive use of data shared it. They shared it as either a report or by using live data from SMART II, or they used a mixture of both mediums. Some coordinators undertook either a partial or complete analysis before sharing data with faculty members. Irrespective of whether or not preliminary analysis was undertaken, some discussion and analysis of the data did take place with faculty members during faculty meetings. All faculty members were given the opportunity to view the data and have some input into its analysis.

When analysing data, teachers looked at them from either a student or faculty perspective. When analysed from a student perspective teachers sought a number of or all the following:
- performance at either the individual student, class or cohort level;
• strengths and weaknesses in all five test reporting areas: Science Overall, Extended Response, Knowing and Understanding, Communicating Scientifically, Working Scientifically when compared with the State;
• areas of improvement or decline in performance;
• long term trends;
• identification of students underperforming in either ESSAonline or school tasks;
• top and low performing students;
• identification of students who may be placed in inappropriate classes;
• selection of Stage 6 courses of study; and
• student misconceptions.

When analysed from a faculty perspective, teachers attempt to identify:
• strengths and weaknesses in faculty programming;
• interventions which may benefit student learning and hence performance in external testing; and
• aspects of teaching practice that could be further developed.

Once analysed, schools reported performance in ESSAonline to a variety of audiences. Many schools held Year assemblies and reported the ESSAonline performance praising students for their efforts. Some schools presented special certificates to students who achieved Level 6. Formal presentations were made at either a Year assembly or a whole school assembly. Most coordinators were required to report ESSAonline analysis to the school principal and other members of the executive. Some coordinators shared ESSAonline data at whole school staff meetings and with the parent body through the school newsletter.

Coordinators worked with teachers to develop school-based interventions to address the needs as perceived through either student or faculty analysis. Some coordinators said the analysis process and development of school-based interventions was very time consuming. Consequently, they cited the reluctance of some staff to engage in the process.

In schools that made no use of the data, data was not shared or analysed.
4.3.5 How is SMART II used by teachers within the faculty, what feedback has been provided to students and how have they responded?

<table>
<thead>
<tr>
<th>Common areas of agreement</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• All schools make use of SMART II.</td>
</tr>
<tr>
<td></td>
<td>• The level of training provided to teachers in the use of SMART II varies from school to school.</td>
</tr>
<tr>
<td></td>
<td>• Not all teachers have a login or password to access data on SMART II.</td>
</tr>
<tr>
<td></td>
<td>• The level of use made by teachers of SMART II is highly variable. Many teachers do not make any use of this analytical tool.</td>
</tr>
<tr>
<td></td>
<td>• A small number of teachers set up their current Year 9 class in SMART II analysing what it is that their students can or can’t do. Teachers identify items in which the students achieved the biggest positive or negative discrepancies as compared with the State. Equipped with this data teachers attempt to meet the individual needs of the students. Apart from the individual reports received by the student little individual feedback is provided by the teachers to their students about their performance in ESSAonline. Teachers use this data in a variety of ways e.g. pairing students in class, strong students to mentor weaker students, to affirm students, to encourage students to maintain the level of work he/she demonstrated in the test. Teachers also attempt to identify students: underachieving in either their school work or the test, incorrectly placed in their current class, or selecting inappropriate courses in Stage 6.</td>
</tr>
<tr>
<td></td>
<td>• Some teachers set up their Year 8 class from the previous year reflecting on their students’ performance in the test and their own teaching successes / issues. Teachers use this reflective practice to develop new teaching strategies and program modifications designed to address the learning needs of their students and the issues they identified in their own teaching practice.</td>
</tr>
</tbody>
</table>
One coordinator completes a full report using ESSAonline and then sets up the Year 8 classes from the previous year for their teachers to access and reflect upon. Whilst some teachers make good use of this data others are reluctant to use the information.

One coordinator provides reports listing detailed information about all students in each current Year 9 class. The report details the students’ performance in all 5 areas of the test and what the students can and cannot do and any misconceptions identified in SMART II. Most teachers make very little use of this data.

Students respond in a positive way when they receive feedback based on their performance in ESSAonline.

Areas of difference

<table>
<thead>
<tr>
<th>Coordinators who make some use of ESSAonline believe:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Teachers should not be expected or encouraged to access SMART II or engage in deep reflection.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Coordinators who do not use ESSAonline believe</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Teachers do not have a login to access data on SMART II</td>
</tr>
</tbody>
</table>

Figure 4.17 Theme outcomes for: How is SMART II used by teachers within the faculty, what feedback has been provided to students and how have they responded?

Teacher training in the use of SMART II varied across schools although most teachers in the six case study schools were provided with some training and a login and password over the past five years. At the time data were collected not all teacher logins were current.

Teachers who had access to SMART II data made use of the data in one or more of the following ways:

• Set up their current Year 9 class and reviewed the performance of their current students in the test. Equipped with this data, teachers were able to meet the learning needs of their students and address any misconceptions revealed by the data. Teachers who reviewed the performance of their Year 9 students were able
to provide feedback to students about their performance in the test. Students who received this feedback did so in a positive manner.

- Some teachers set up their Year 8 class from the previous year and reviewed the performance of their students. In doing so teachers were able to engage in reflective practice evaluating the impact of their teaching methods on the performance of their students. In one school, the teachers shared their findings using them to inform the development of school-based interventions such as the revision of current teaching programs.

In one school the coordinator provided teachers with both the performance data of students from the teacher’s previous Year 8 class and the teachers’ current Year 9 class. In both instances the coordinator reflected that teachers were reluctant to use the data. Coordinators from the schools which made some use of ESSAonline data reported they did not encourage / expect teachers to individually use the data available on SMART II. Coordinators from the schools that made no use of ESSAonline data did not use the data available to them nor did they provide feedback to the students about their performance in the test.

4.3.6 What interventions have been developed in response to ESSAonline and how have they impacted on the performance of subsequent cohorts sitting ESSAonline?

<table>
<thead>
<tr>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common areas of agreement</td>
</tr>
<tr>
<td>- Coordinators have instigated many school-based interventions designed to address weaknesses identified either within the cohort or the faculty. Examples of these interventions included:</td>
</tr>
<tr>
<td>- program modification / redevelopment</td>
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<tr>
<td>- greater emphasis on students planning their own investigations</td>
</tr>
<tr>
<td>- misconceptions identified through SMART II were directly addressed e.g. direction of food web arrows, particle size, magnetic poles</td>
</tr>
<tr>
<td>- students required to use appropriate technical language</td>
</tr>
</tbody>
</table>
when answering problems and completing assessment tasks
- coordinator developing working scientifically PowerPoint and distributing a copy to each student and making it available to parents via the school website
- students completing two research projects each year: a practice and final project
- purchasing a new textbook that addresses the literacy needs of the students
- purchase of Science workbook in Years 7 & 8
- teachers teaching the meaning of the Board of Studies list of verbs
- teachers teaching students how to write cause and effect relationships
- introduction of formative assessment program based on regular quizzes
- introduction of Year 7 subject matter into Year 8 half yearly and end of year exams
- implementation of a study skills program
- coordinator developing working scientifically scaffolds
- faculty developing working scientifically assessment task
- students completing school developed ESSAonline style test prior to ESSAonline trial exam.
- focus on developing student skills in writing extended response

- Many of the interventions were found to have a positive impact on student learning e.g. parents were able to support students by using working scientifically PowerPoint in the home, students in Years 9 & 10 were found to become independent learners, top students were extended, students developed their use of technical language, students better recalled the content they were expected to learn
- Whilst some coordinators believed they had no real evidence
to show that their school’s involvement in ESSAonline had any direct impact on student learning and performance in external testing, others did and listed the evidence as:
- improvement in ESSAonline data 2008 – 2012
- improvements in ESSAonline Working Scientifically
- improvements in student marks for extended response questions in summative tasks
- improvements in mean marks for the Extended Response and Communicating Scientifically components of the ESSAonline
- the standard of work presented by Year 10 students had improved
- ESSAonline weaknesses addressed in class, use of the same questions as a post-test showing improvement
- students demonstrating a massive improvement in their student research project as they completed 8 research projects over 4 years

<table>
<thead>
<tr>
<th>Areas of difference</th>
<th>Coordinators who made some use of ESSAonline believed:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Unfortunately the process of developing school-based interventions was so time consuming many never actually came to fruition or became entrenched in faculty practice</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Coordinators who did not use ESSA believed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• No interventions were developed</td>
</tr>
<tr>
<td></td>
<td>• No evidence of improvement in student performance was evident in external testing</td>
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</tbody>
</table>

Figure 4.18  Theme outcomes for: What interventions have been developed in response to ESSAonline and how have they impacted on the performance of subsequent cohorts sitting ESSAonline?
The study revealed that across the four schools a range of school-based interventions had been developed and implemented. Interventions that were commonly implemented were:

- teaching program modification / redevelopment;
- greater emphasis on students’ planning their own investigations;
- addressing student misconceptions;
- students required to use appropriate technical language;
- increased focus on working scientifically skills;
- development of literacy-based activities;
- teaching the meaning of Board of Studies list of verbs;
- teaching students how to write cause and effect relationships;
- introduction of formative assessment strategies;
- introduction of Year 7 subject matter into Year 8 half yearly and end of year exams;
- incorporation of ESSAonline style test questions into school examinations and tests, and
- focus on developing student skills in writing extended responses.

Whilst some coordinators believed they had no concrete evidence to show that these interventions had an impact on student performance in external testing, others were able to report a variety of forms of evidence citing both improvements in ESSAonline data and other anecdotal school-based evidence. Some coordinators suggested that these interventions contributed to substantial improvements in external test performance.

The two coordinators who made some use of ESSAonline data both reported that in some instances their interventions were never implemented let alone incorporated in faculty practise. Coordinator DDD stated:

I had Jess going through and looking at the high achievers across the board and the low achievers. So we were trying to look at some low achievers. So we're doing that. Then we started - and as you can see we just didn't get it finished.

The schools that made no use of ESSAonline data have not attempted to develop or implement any strategies to improve student results in external testing.
4.3.7 Should the Catholic Education Office Sydney continue to invest in ESSAonline as a formative assessment tool?

| Themes |
|-----------------|--------------------------------------------------|
| Common areas of agreement | Yes, as: |
| | - it has been a good guiding tool for teachers which has led to improvements in student learning |
| | - it has boosted student confidence by achieving good results in an external test |
| | - is has been a good tool telling teachers what their students don’t know |
| | - we need to continue tracking student performance |
| | It is vital that the technology works. |

<table>
<thead>
<tr>
<th>Areas of difference</th>
<th>Coordinators who do not use ESSA believe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
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</table>

Figure 4.19 Theme outcomes for: Should the Catholic Education Office Sydney continue to invest in ESSAonline as a formative assessment tool?

Five coordinators were in agreement that the Catholic Education Office should maintain its commitment to the use of ESSAonline as a form of formative assessment. Coordinators reported that it had been a valuable tool:

a) identifying what their students don’t know;

b) guiding teachers in the adoption of strategies which have led to significant improvements in student learning.

Coordinators argued that it is essential the technology used for ESSAonline work correctly.

4.3.8 Summary of key findings - Phase 2

An overview of the six schools shows that all have a range of teachers with various lengths of teaching experience. A total of 45 teachers worked across the six faculties with only one teacher working outside his / her trained subject area. As teaching experience
increased, fewer teachers remained classroom teachers. School A had the greatest number of teachers with the least experience whilst school E has the greatest number of teachers with the greatest experience.

What are coordinator beliefs about the value of ESSAonline as a formative assessment tool?

Coordinators that used ESSAonline believed the test is a good formative tool incorporating well developed multiple choice and extended response items which integrate content from across the syllabus. Through the use of SOLO taxonomy, along with close analysis of student responses, the data can provide deep insights into student learning and facilitate identification of misconceptions. Some coordinators believed that substantial data analysis is time consuming and if teachers are to develop interventions then schools should make time available to teachers.

Another important concern raised by both CCC and AAA was the timing of the ESSAonline test. Both coordinators believed that as most schools have completed their yearly school-based assessment program prior to sitting ESSAonline, the assessment is too late in the year. This causes problems such as lack of student motivation and the failure of students to apply themselves to the task. CCC also believed that to be of value, feedback must be provided in a timely fashion rather than being provided the next year. Some coordinators were concerned that many teachers did not fully understand the SOLO taxonomy and were unable to apply the holistic marking process.

How are ESSAonline data accessed, shared and analysed within the faculty?

The processes of data sharing and analysis within schools were highly variable. However, some commonalities did exist. Data are either shared as a written report, by using live data from SMART II or a mixture of both mediums. Discussion and analysis of data often took place with faculty members during faculty meetings.

When analysing data, teachers looked at it from either a student or faculty perspective. When analysed from a student perspective, teachers tried to identify a number of different forms of information. Examples included:

- performance at either the individual student, class or cohort levels;
• strengths and weaknesses in all five test reporting areas: Science Overall, Extended Response, Knowing and Understanding, Communicating Scientifically, Working Scientifically compared with the State; and
• areas of improvement or decline in performance.

When analysed from a faculty perspective, teachers attempted to identify many different forms of information. Examples included:
• strengths and weaknesses of faculty programming; and
• identification of interventions which may benefit student learning and hence performance in external testing.

Once analysed, coordinators reported performance in ESSAonline to a variety of audiences.

**How is SMART II used by teachers within the faculty, what feedback has been provided to students and how have they responded?**

Teacher training in the use of SMART II varied across schools. Not all teachers had access to SMART II online.

Teachers who accessed SMART II made use of data in one or more of the following ways:
• Set up their current Year 9 class and reviewed the performance of their current students in the test.
• Set up their Year 8 class from the previous, review the performance of their students and thus reflect on the effectiveness of their teaching practice. Teachers were able to identify class weaknesses and review the strategies they used to teach the content or skill.

Some Year 8 and Year 9 teachers were reluctant to use the data. Coordinators from the schools which made some use of ESSAonline data reported that they did not encourage / expect teachers to individually use the data available on SMART II.

Coordinators from the schools that made no use of ESSAonline data did not use the data available to them nor did they provide feedback to students about their performance in the test.
What interventions have been developed in response to ESSAonline and how have they impacted on the performance of subsequent cohorts sitting ESSAonline?

The study revealed that across the four schools that used ESSAonline data, a range of school-based interventions were developed and implemented. The interventions commonly implemented were:

- teaching program modification / redevelopment;
- greater emphasis on students’ planning their own investigations;
- addressing student misconceptions; and
- faculty literacy-based programs targeted at: student use of technical language and use of the languages of description and explanation.

Whilst some coordinators believed they had no concrete evidence to demonstrate that interventions had an impact on student performance in external testing, others were able to report evidence of improvements in student learning. Such interventions were accredited with making substantial improvements in the performance of subsequent cohorts sitting ESSAonline.

The two coordinators who made some use of ESSA data both reported that, in many cases, their interventions were never implemented or became entrenched in faculty practise.

Schools that made no use of ESSA did not attempt to develop or implement strategies to improve student results in external testing.

Should the Catholic Education Office Sydney continue to invest in ESSAonline as a formative assessment tool?

Five of the six coordinators were in agreement that the Catholic Education Office should maintain its commitment to the use of ESSAonline as a form of formative assessment. Coordinators argued that it was essential that the technology used for ESSAonline work correctly.

4.4 Phase 3 data: ESSAonline data for the six elected schools from 2008 to 2012

In an attempt to identify the impact ESSAonline had on student performance in external testing, data for the period 2008 – 2012 was aggregated. As ESSA changed from a pen
and paper test to an online test in 2011, statisticians at the Department of Education and Community recommend that levels of achievement in the pen and paper test should not be compared with levels of achievement in the online test. Hence, two set of figures were included. When reading these figures, comparisons should only be made within a single figure. The five reportable areas of the test are: Science Overall, Extended Response, Knowing and Understanding, Communicating Scientifically and Working Scientifically.

A set of figures has also been incorporated tracking the difference in means (School – State) for 2008 – 2012. The numerical data for 2011 and 2012 has been shaded as the test was online for these two years.

4.4.1 Making valid comparisons between schools

In an attempt to facilitate fair and valid discussion of the ESSAonline data for the six schools involved in this study the ICSEA values for each school has been accessed from the My School website and listed below. The Index of Community Socio-educational Advantage is a scale that represents levels of educational advantage and is based on the measurement of key factors that have been deemed to impact on a student’s ability to achieve at school.

ICSEA was developed to enable fair and meaningful comparisons of student performance in NAPLAN testing. Calculation of ICSEA is based on student family background data which statistical modelling has shown to have the greatest impact on student performance. ICSEA values are recorded in Table 4.13.

ACARA (2013, p. 3) reports:

ICSEA values are calculated on a scale which has a median of 1000 and a standard deviation of 100. ICSEA values range from around 500 (representing extremely educationally disadvantaged backgrounds) to about 1300 (representing schools with students with very educationally advantaged backgrounds).

Table 4.13 on the following page lists the ICSEA values for the six schools included in the study.
Table 4.13  \textit{ICSEA values for the six schools included in the study}

<table>
<thead>
<tr>
<th>School</th>
<th>ICSEA Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1018</td>
</tr>
<tr>
<td>B</td>
<td>1057</td>
</tr>
<tr>
<td>C</td>
<td>997</td>
</tr>
<tr>
<td>D</td>
<td>999</td>
</tr>
<tr>
<td>E</td>
<td>1093</td>
</tr>
<tr>
<td>F</td>
<td>1067</td>
</tr>
</tbody>
</table>

Comparison of the ICSEA values show there is considerable variation in educational
disadvantage between schools. School E had a considerably higher advantage compared
with schools C and D. Schools A, B and F had ICSEA values higher than the median and
approximately mid-way between E and C. Whilst this comparison should be noted, the
focus of this section is not on comparing schools but on the growth made by successive
cohorts of students in the different reportable areas of the test.

The following figures review two sets of data for each school. The first set includes two
figures showing student performance in Levels in Science Overall from 2008 to 2012.
The second set records State and school means, standard deviations and the difference
(School – State means) for each reportable area of the test. Data from the table displaying
the difference, School – State means, is then displayed as a figure showing the trends
across the five years for each of the five reportable test areas.

4.4.2  \textbf{Aggregated data for the three case studies}

This section reports in detail the aggregated data for the two sub-units within each of the
three cases:

- schools that make extensive use of ESSAonline data
- schools that make some use of ESSAonline data
- schools that make no use of ESSAonline data

4.4.2.1  \textbf{Case: Schools which make extensive use of ESSAonline data}

In this section, the performances of the students from the two schools that form the sub-
units of this case are considered. The two schools have mid-level ICSEA values which
are less than those for schools E and F but greater than for schools C and D. Both
Coordinators claimed to make extensive use of ESSA data. School A had the greatest number of young teachers compared with the other five schools.

4.4.2.1 School A

Science Overall

2008 – 2010 Pen and Paper Test

![Figure 4.20](Percentage in Levels for ESSA 2008 - 2010 Science Overall: School A)

2011 – 2012 ESSAonline

![Figure 4.21](Percentage in Levels for ESSAonline 2011 - 2012 Science Overall: School A)

The two figures above show that for all five years of reported testing, students within this school (ICSEA 1018) have been achieving above State average. For the period 2008 to 2010 performances were strongest in Levels 2 and 4 with students achieving well below...
and well above the state average for these levels respectively. Variations across the years were noted and can be explained in terms of the ability level of the cohorts. In the years 2011 to 2012 results showed strong improvements in Levels 2, 5 and 6. The improvement in Level 5 was particularly interesting because it was against the trends both within the CEO and the State. No student achieved at Level 1 across the five years examined.

**Means and Standard Deviations**

Table 4.14  *School A: Means and Standard Deviations ESSAonline 2008 - 2012*

<table>
<thead>
<tr>
<th>Reportable Test Area</th>
<th>Science overall</th>
<th>State (All Students)</th>
<th>School (All students)</th>
<th>Difference: School – State Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Science Overall</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td>84.6</td>
<td>8.1</td>
<td>87.3</td>
</tr>
<tr>
<td>2009</td>
<td></td>
<td>85.7</td>
<td>7.9</td>
<td>86.2</td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td>84.5</td>
<td>8.9</td>
<td>87.1</td>
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<tr>
<td>2011</td>
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<td>9.9</td>
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<td>2012</td>
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<td>85.0</td>
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<tr>
<td>Extended Response</td>
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<td></td>
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<td>84.6</td>
<td>9.7</td>
<td>88.3</td>
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<td>2009</td>
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<td>9.9</td>
<td>87.2</td>
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<td>86.6</td>
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<td>12.1</td>
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</tr>
<tr>
<td>Knowing and Understanding</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td>84.8</td>
<td>8.5</td>
<td>86.8</td>
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<td>10.8</td>
<td>88.4</td>
</tr>
<tr>
<td>2012</td>
<td></td>
<td>85.0</td>
<td>11.2</td>
<td>87.5</td>
</tr>
<tr>
<td>Communicating Scientifically</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td>84.9</td>
<td>11.0</td>
<td>87.1</td>
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<td></td>
<td>85.2</td>
<td>11.7</td>
<td>86.5</td>
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</table>
Figure 4.22 plots the trend in the difference: School – State mean, in each of the five reportable areas 2008 to 2011.

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<tr>
<th>Year</th>
<th>School</th>
<th>State</th>
<th>Science</th>
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<th>Math</th>
<th>Science</th>
<th>Math</th>
<th>Science</th>
<th>Math</th>
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<td>12.1</td>
<td>90.0</td>
<td>12.2</td>
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<td></td>
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</tr>
<tr>
<td>2009</td>
<td>86.0</td>
<td>9.7</td>
<td>86.0</td>
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<td>2.9</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4.22 shows a significant drop in means for each reportable area from 2008 to 2009. This was quite disappointing given the coordinator said she used ESSA online data extensively to inform teaching and learning. In an attempt to identify reasons for this change the researcher returned to the original data to explain this significant change as well as why it took a further four years to return to higher levels of achievement. The evidence indicates that the original science coordinator for the College was promoted within the school to the position of Curriculum Coordinator in 2006. The current Science Coordinator took on the role of science coordinator in that year. Across the three years from 2006 to 2009 the College population increased necessitating an influx of new teachers. It is possible that because the original coordinator taught less science classes and the school grew, the cumulative effect was responsible for the decline in 2009. For
the years 2009 to 2012, despite minor variations in some areas, the figure shows a clear positive gradient for each trend line across the five areas.

Another significant trend highlighted by the data analysis is the performance of students in Extended Response questions. Figure 4.22 shows that after the initial fall from 2008 to 2009, student performance continued to improve over the following four years. Over this same time period, Table 4.14 shows that trends across the State were negative. The interview with coordinator AAA revealed that the college focussed strongly on literacy skills over this time. The growth rate for Extended Response clearly aligns with that for Communicating Scientifically. A further trend identified is the decline in student performance for Working Scientifically. Following the fall from 2008 to 2009, student performance has still not returned to its original level.

4.4.2.1.2 School B

Science Overall

2008 – 2010 Pen and Paper Test

![Figure 4.23](image.png)

Figure 4.23 Percentage in Levels for ESSA 2008 - 2010 Science Overall: School B
Figure 4.24 Percentage in Levels for ESSAonline 2011 - 2012 Science Overall: School B

Figure 4.23 demonstrates exceptional growth in performance across the three years of testing from 2008 to 2010. At Levels 2 and 3, the percentage of students within the school decreased relative to the percentage of students across both CEO schools and across the State. During this time achievement at Level 4 grew dramatically whilst there was also improvement at Level 5 from 2009 to 2010. From 2011 to 2012, as shown in Figure 4.24, there was significant improvement in student performance. Achievement in Science Overall was above state average as confirmed by the means shown in the Table 4.15. In 2012 whilst students at School B followed the same trends as those in CEO schools and across the State, their performance declined at Level 5. Nevertheless, the percentage at Level 5 was still considerably above State average. At Level 3, whilst the percentage of students achieving at this level across the State rose, achievement at this level for School B fell. Overall, this was very positive as it resulted from a significant increase in achievement at Level 4 and a minor increase at Level 2.
### Means and Standard Deviations

**School B: Means and Standard Deviations ESSAonline 2008 - 2012**

<table>
<thead>
<tr>
<th>Reportable Test Area</th>
<th>Science overall</th>
<th>State (All Students)</th>
<th>School (All students)</th>
<th>Mean School – State Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td><strong>Science Overall</strong></td>
<td>2008</td>
<td>84.6</td>
<td>8.1</td>
<td>84.1</td>
</tr>
<tr>
<td></td>
<td>2009</td>
<td>84.8</td>
<td>9.3</td>
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<tr>
<td></td>
<td>2010</td>
<td>84.5</td>
<td>8.9</td>
<td>88.0</td>
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<tr>
<td></td>
<td>2011</td>
<td>85.0</td>
<td>9.9</td>
<td>89.8</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>85.0</td>
<td>10.2</td>
<td>90.0</td>
</tr>
<tr>
<td><strong>Extended Response</strong></td>
<td>2008</td>
<td>84.6</td>
<td>9.7</td>
<td>82.6</td>
</tr>
<tr>
<td></td>
<td>2009</td>
<td>84.3</td>
<td>11.6</td>
<td>84.9</td>
</tr>
<tr>
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<td>84.2</td>
<td>11.3</td>
<td>87.3</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>84.3</td>
<td>12.6</td>
<td>94.5</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>85.0</td>
<td>12.1</td>
<td>91.9</td>
</tr>
<tr>
<td><strong>Knowing and Understanding</strong></td>
<td>2008</td>
<td>84.8</td>
<td>8.5</td>
<td>84.9</td>
</tr>
<tr>
<td></td>
<td>2009</td>
<td>85.0</td>
<td>9.9</td>
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<td>84.6</td>
<td>9.2</td>
<td>87.9</td>
</tr>
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<td></td>
<td>2011</td>
<td>85.1</td>
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<td>85.0</td>
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<td>89.4</td>
</tr>
<tr>
<td><strong>Communicating Scientifically</strong></td>
<td>2008</td>
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<td>11.0</td>
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<tr>
<td></td>
<td>2009</td>
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<td>14.1</td>
<td>89.2</td>
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<td>85.2</td>
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<td><strong>Working Scientifically</strong></td>
<td>2008</td>
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<td>84.9</td>
<td>11.0</td>
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<td>2010</td>
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<td>12.3</td>
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</tr>
<tr>
<td></td>
<td>2011</td>
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<td>14.1</td>
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</tr>
<tr>
<td></td>
<td>2012</td>
<td>85.1</td>
<td>12.9</td>
<td>92.1</td>
</tr>
</tbody>
</table>

Figure 4.25 plots the trend in the difference: School – State mean, in each of the five reportable areas 2008 to 2012.
Again, nearly all the trends for school B shown in Figure 4.25 have a positive gradient indicating the performance of students in this school, relative to the State, has improved. There were only two exceptions. The first is the decline in the performance by students in ‘Working Scientifically’ for 2011 and the second is the decline in performance by students in the Extended Response category. Both declines were relative to the performance of the State in 2012. This said, the performance of students in both categories is still very strong despite the decline. These declines were both disappointing for the coordinator and teachers. This is because the science faculty had a very strong focus on both these categories over the five year period. Across the five years depicted in Figure 4.25, the overall trend was for positive growth in all five reportable areas.

### 4.4.2.1.3 Summary of findings for the case: Schools which make extensive use of ESSAonline data

Despite the initial decline in student performance from 2008 to 2009 for school A, the overall trend for both schools clearly demonstrates that extensive use of ESSAonline data can improve the performance of subsequent student cohorts. Schools keen to improve student performance need to identify student / cohort weakness, reflect on pedagogy and programming and implement well considered school-based interventions to address identified issues.
4.4.2.2. Case: Schools which make some use of ESSAonline data

In this section, the performance of the students from the two schools that form the sub-units of this case is considered. The two schools, C and D, have lower ICSEA values than for the other 4 schools; therefore students experience a greater educational disadvantage. Both coordinators claimed to make some use of ESSAonline data, but as identified earlier in this chapter, often failed to complete the interventions or embed them in faculty practice.

4.4.2.2.1. School C

Science Overall

2008 – 2010 Pen and Paper Test

![Graph 1](image1)

Figure 4.26 Percentage in Levels for ESSA 2008 - 2010 Science Overall: School C

2011 – 2012 ESSAonline

![Graph 2](image2)

Figure 4.27 Percentage in Levels for ESSAonline 2011 - 2012 Science Overall: School C
Figures 4.26 and 4.27 show that students in school C generally improved their ESSAonline performance from 2008 to 2011. Student performance at Level 3 fell from where student performance was significantly above both State and CEO average to being on a par with students across the State by 2011. During the same period student performance at Level 4 increased so that it was greater than both the State and CEO average. At the same time student achievement at Level 5 also increased although it remained below that of both the State and CEO average. In 2012, performance at Levels 4 and 5 declined pushing student representation higher at Level 3.

**Means and Standard Deviations**

Table 4.16  
*School C: Means and Standard Deviations ESSAonline 2008 - 2012*

<table>
<thead>
<tr>
<th>Reportable Test Area</th>
<th>Science overall</th>
<th>State (All Students)</th>
<th>School (All students)</th>
<th>Mean School – State Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td>Mean</td>
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<td>2012</td>
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Figure 4.28 plots the trend in the difference: School – State mean, in each of the five reportable areas 2008 to 2012.

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<td>80.7</td>
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</tbody>
</table>

From 2008 to 2010 trends in student performance in all categories were positive. Having all commenced at a point below the State average, students showed improvement from one cohort to the next. During this period the coordinator reported a strong focus within the faculty on developing student skills in both literacy and working scientifically. Unfortunately, from 2010 student performance fell in all areas except the Extended Response category which rose sharply for another year and then fell even more
dramatically. In 2012, student performance in Working Scientifically, Science Overall and Communicating Scientifically were all below 2008 levels. The significant variations that occurred in both Extended Response and Working Scientifically may be accounted for by the small number of questions in these areas.

4.4.2.2 School D

Science Overall

2008 – 2010 Pen and Paper Test

![Graph](image1.png)

**Figure 4.29 Percentage in Levels for ESSA 2008 - 2010 Science Overall: School D**

2011 – 2012 ESSAonline

![Graph](image2.png)

**Figure 4.30 Percentage in Levels for ESSAonline 2011 - 2012 Science Overall: School D**

Figures 4.29 and 4.30 do not reveal any easily identified patterns in performance. Student levels of achievement vary from cohort to cohort with no sustained trend in either a positive or negative direction. An example of this can be seen when comparing 2011 with 2012. Whilst student achievement at Level 4 appears to have been consistent and
accompanied by an improvement in performance at Level 2, a greater change occurred at the other end of the cohort which showed a fall in student achievement at Levels 5 and 6. In 2012 the student body was over represented at Level 3. In summary, whilst some improvement was made by weaker students, the more capable students failed to maintain their 2011 position.

**Means and Standard Deviations**

Table 4.17  School D: Means and Standard Deviations ESSAonline 2008 - 2012

<table>
<thead>
<tr>
<th>Reportable Test Area</th>
<th>Science overall</th>
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<td>School (All students)</td>
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<tr>
<td></td>
<td>Science Overall</td>
<td>Extended Response</td>
<td>Knowing and Understanding</td>
<td>Communicating Scientifically</td>
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<td>2008</td>
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<td>124</td>
<td>-1.7</td>
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</tbody>
</table>

159
Figure 4.31 plots the trend in the difference: School – State mean, in each of the five reportable areas 2008 to 2012.

As stated previously there is no real pattern in performance from one cohort to the next. This said, Figure 4.31 shows a negative trend for all categories. Once again, the greatest variations occur for the Working Scientifically and the Extended Response categories. In 2008 students performed five points above the State average in Working Scientifically, but by 2012 this had fallen to 3 points below the State average. In 2008 achievement in all categories was equal to or better than the State average except in Communicating Scientifically. In 2012 achievement in all categories was at least 1 point below State average.
4.4.2.2 Summary of findings for case: Schools which make some use of ESSA
There is no strong evidence to suggest that schools which made some use of ESSA reaped any long-term benefit. Whilst there was some evidence that students in school C improved from one cohort to the next from 2008 to 2010 this trend was not sustained. Students from school D showed a decline in performance over the five year period.

4.4.2.3 Case: Schools which make no use of ESSA
In this section, the performances of students from the two schools that form the sub-units of this case are considered. The two schools, E and F, have the highest ICSEA values of the six schools with E having the greatest educational advantage. Both coordinators claimed to make no use of ESSA data. Coordinator EEE claimed that the data was redundant as she fully understood the ability and needs of her students, whilst FFF claimed that since ESSA became an online test the data was no longer valid or reliable.

4.4.2.3.1 School E
Science Overall
2008 – 2010 Pen and Paper Test

Figure 4.32 Percentage in Levels for ESSA 2008 - 2010 Science Overall: School E
Figures 4.32 and 4.33 show that students in School E consistently performed above State average. At Levels 1, 2 and 3 student representation is either not present or well below averages for both the Catholic Education Office and the State. At Levels 4, 5 and 6, in all but two instances student representation is above average for both the CEO and the State. Achievement appears to have been consistent for this five year period except for natural variations between cohorts.

**Means and Standard Deviations**

Table 4.18  
*School E: Means and Standard Deviations ESSAonline 2008 - 2012*

<table>
<thead>
<tr>
<th>Reportable Test Area</th>
<th>Science overall</th>
<th>State (All Students)</th>
<th>School (All students)</th>
<th>Mean School – State Difference</th>
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<td>Knowing and Understanding</td>
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Figure 4.34 plots the trend in the difference: School – State mean, in each of the five reportable areas 2008 to 2012.
Data presented in Figure 4.34 appears to complement the findings drawn from Figures 4.32 and 4.33. That is, achievement by students at School E has remained consistent across the five years, apart from cohort variations in different aspects of the test. One trend worth noting is that performance in Knowing and Understanding increased from 2008 to 2009 and then remained at approximately 6 points above the State average. This represents a high level of achievement. Performance in Extended Response peaked in 2011 rising to seven points above the State average, but then fell back to the level achieved from 2008 to 2010. This trend appeared to be the reverse of that for Communicating Scientifically. In 2011 Communicating Scientifically fell two points below achievement in previous years, rising only slightly in 2012. Achievement in Science Overall increased from 3.8 points above the State average in 2008 to 5.2 in 2009 and then maintained an average performance of 5.3 points above the State average through to 2012.

See next page for data relating to School F.
4.4.2.3.2 School F

Science Overall

2008 – 2010 Pen and Paper Test

The trend indicated by Figures 4.35 and 4.36 demonstrates an overall consistent level of performance. The figures reveal minor variations from one cohort to the next. The only variation worthy of note is shown in Figure 4.35 at Levels 2, 3 and 4 in 2008. In this year student performance was stronger than other years with a very high level of student representation at Level 4.

See Table 4.19 on the following page for Means and Standard Deviations ESSAonline 2008 - 2012

Figure 4.35 Percentage in Levels for ESSA 2008 - 2010 Science Overall: School F

Figure 4.36 Percentage in Levels for ESSAonline 2011 - 2012 Science Overall: School F
### Means and Standard Deviations

Table 4.19  **School F: Means and Standard Deviations ESSAonline 2008 - 2012**

<table>
<thead>
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Figure 4.37 plots the trend in the difference: School – State mean, in each of the five reportable areas 2008 to 2012.
Data for Science Overall compares with data from Figures 4.35 and 4.36 and shows minor variations each year from 2008 to 2012. The highest level of achievement occurred in 2008 with student performance at 2.6 points above the State average. However, considerable variation did occur within the different categories across the five year period. Performance in Extended Response showed the greatest variation, commencing at 1.2 points above the State average in 2008, falling to 0.4 points below the State average in 2010 and finally rising to 3.6 points above the State average in 2012. Performance in Knowing and Understanding was another category which showed considerable variation across the five years falling to its lowest level in 2009.

4.4.2.3 Summary of findings for case: Schools which make no use of ESSA.

Students in both schools maintained a consistently high level of achievement across the five years in which data were collected. The mean performance in Science Overall for students at school E was 5.3 points above the State average from 2009 to 2012 whilst for students in school F the mean was 2.2 points above the State average from 2008 to 2012.

There were no consistent positive or negative trends in student achievement levels in either school across the five year period. Achievement levels in Extended Response questions varied widely over the five years and can be accounted for by the small number of questions in this category in the test.
4.5 Conclusion
Chapter 4 reported the analysis of both Phase 1 and 2 qualitative data and Phase 3 ESSAonline quantitative data. The following is a summary of the key findings as they relate to each of the subsidiary questions.

Finding 1  What are coordinator beliefs about the value of ESSAonline as a formative assessment tool?
All schools that took part in the questionnaire sat the test at least five times and all schools have a range of teachers with various lengths of teaching experience. School A has the greatest number of teachers with the least experience whilst school E has the greatest number of teachers with the greatest experience. Coordinators believe the test is a good formative tool incorporating well developed multiple choice and extended response items which integrate content from across the syllabus.

Finding 2  How are ESSAonline data accessed, shared and analysed within the faculty?
Sharing of ESSAonline data within faculties is controlled by the coordinator. When shared at faculty meetings the data is discussed and teachers are invited to contribute to the analysis. Whilst ESSAonline data is provided to schools via SMART II, not all schools provide teacher access to the package or training. Coordinators reported that thorough analysis of the data is time consuming and if interventions are to be developed and implemented, schools need to make time available to teachers.

Finding 3  How is SMART II used by teachers within the faculty, what feedback is provided to students and how have they responded?
In 25% of schools most teachers of the previous year’s Year 8 cohort engage in reflective analysis of the ESSAonline data. Many teachers review their teaching programs and pedagogy in an attempt to address student weaknesses identified in the data. Programming changes may lead to a review of the pedagogy teachers’ use in the classroom. Most Year 9 teachers don’t access data to build an awareness of the strengths and weaknesses of their current students. Year 9 teachers are not likely to provide specific feedback to students based on ESSAonline data. Teachers analyse data mainly at a cohort / faculty level.
Concerns were raised about the timing of the test as most schools have completed their yearly school-based assessment program before sitting ESSAonline. Hence, it occurs too late in the year, causing lack of student motivation. Coordinators also believe that to be of value, feedback must be provided in a timely fashion – not the next year!

Finding 4  What interventions have been developed in response to ESSAonline and how have they impacted on the performance of subsequent cohorts sitting ESSAonline?

Coordinators in many schools claim that involvement in ESSAonline led to improvements in student performance in subsequent cohorts sitting ESSAonline. Schools are able to point to overall improvements in data as reported in SMART II.

Phase 3 quantitative data revealed that schools which make extensive use of ESSAonline data have shown growth in the performance of subsequent cohorts in ESSAonline testing. Schools which make some use of ESSAonline have shown no sustained growth and in one school negative growth resulted. Schools which make no use of ESSAonline have shown no positive or negative growth.

Finding 5  Should the Sydney Catholic Education Office Sydney continue to invest in ESSAonline as a formative assessment tool?

Five out of six coordinators interviewed agreed that CEO Sydney should continue investing in ESSAonline on the assumption that the technology works correctly.

Chapter 5 will discuss the findings in relation to the research questions and research propositions. It will use the quantitative data to validate the claims made in the qualitative data. The discussion will be undertaken in the context of existing literature to explore student learning and assessment more fully.
Chapter 5 DISCUSSION OF FINDINGS

5.1 Introduction
This chapter discusses the study findings and conceptualises them in terms of how they answer the research questions and link to the research propositions. Throughout this process, findings are integrated and discussed in terms of the relevant literature. The discussion attempts to relate findings to the achievement-based learning conceptual framework developed in Chapter 2. Data from all three phases of the study are integrated into the discussion.

5.2 Research Question
The study attempts to answer the following question:

How have teachers, in Sydney Catholic systemic schools, used data from Essential Secondary Science Assessment online (ESSAonline) and what have been the impacts of their use on the performance of subsequent cohorts sitting ESSAonline?

In using the findings to respond to this question and to evaluate the use of ESSAonline as a diagnostic tool the discussion will be focussed by the five subsidiary questions and the five propositions stated in the research design. The study findings will be contextualised and interpreted in terms of the literature underpinning the achievement-based learning conceptual framework outlined in Chapter 2.

5.2.1 Subsidiary questions
The subsidiary questions are:

- What are coordinator beliefs about the value of ESSAonline as a formative assessment tool?
- How are ESSAonline data accessed, shared and analysed within the faculty?
- How is SMART II used by teachers within the faculty, what feedback has been provided to students and how have they responded?
- What interventions have been developed in response to ESSAonline and how have they impacted on the performance of subsequent cohorts sitting ESSAonline?
- Should the Catholic Education Office Sydney continue to invest in ESSAonline as a formative assessment tool?
As stated in Chapter 3, the following propositions were identified based on the research question. Subsidiary questions and associated literature guided the development of these propositions. These propositions will now be linked directly with the subsidiary questions to guide the discussion of the findings within the context of the achievement-based learning framework developed in Chapter 2. The subsidiary questions and propositions will also inform the formulation of the conclusion. The propositions were:

- Schools predominantly use a constructivist paradigm of learning.
- Formative and summative assessment can, when used appropriately, improve student learning.
- Formative and summative assessment data provides the information needed by teachers to evaluate student learning against a set of standards.
- Following evaluation, teachers should provide timely feedback to students.
- Teachers should provide guidance to and opportunities for students to respond to feedback.

5.2.2 ‘Closing the gap’

Phase 3 quantitative data for students from the six selected schools, as reported in Chapter 4, shows three trends. The first is that ESSA data, when used extensively, can have a positive impact on the performance of subsequent cohorts of students sitting ESSA. The second is, when some use is made of ESSA data, student performance stays the same or may even regresses. Finally, when ESSA data is not used at all, allowing for minor variations between cohorts, student performance stays the same.

In Chapter 2 the literature clearly showed that when used appropriately, formative assessment can have positive impacts on student learning (Black & Wiliam, 1998; Black et al., 2004; Taras, 2005; Wiliam, 2011). Based on this evidence, the question to be answered is, ‘Why isn’t the use of ESSA within CEO Sydney systemic schools having the desired effect of ‘closing the gap’ between student performance and expected achievement standards for all students?’ This question will be explored throughout this chapter.
5.3 Finding 1: What are coordinator beliefs about the value of ESSAonline as a formative assessment tool?

There was very little disagreement amongst coordinators that ESSAonline has the potential to be a very good formative assessment tool. Coordinators considered that the test contained well developed questions that have been trialled and validated by experienced academics. This position had been previously supported during an interview with Joanne Sim, test developer with EMSAD (now known as the High Performance Directorate) (personal communication, August 10, 2012). Coordinators engaged in the testing process because they believed it provided extensive data about student learning and can provide insights into student misconceptions. Coordinators also believed ESSAonline data provided them with the opportunity to engage in reflective thinking about student strengths and weakness. Such insights empowered them to develop specific interventions to improve student learning outcomes.

Only two of the 20 coordinators who responded to the initial questionnaire reported that they were not prepared to use the data. Of these, one coordinator had ceased using the data as she believed that since moving to an online format, the data was no longer valid or reliable. She argued that, because the technology was not able to cope with the demands of the test, the results did not accurately report student knowledge and skill development. The other coordinator refused to use the test because she claimed she already had deep knowledge and understanding of her students and their learning needs. Neither coordinator had any issues with the content of the test and believed it was a good assessment tool.

Some coordinators believed that ESSAonline, as a single 90 minute test conducted at the end of Stage 4, had significant limitations. The main limitation was that it only tested a small amount of the content taught over the two year period leading up to the test. Whilst the test incorporated a practical based extended response question, it failed to adequately test student investigation skills. The test only provided a snapshot of student knowledge and skills at one small point in time.

Concerns were also raised that the real potential of the test was not being fully realised because many staff did not fully understand SOLO taxonomy and hence could not fully interpret the data. Consequently, the data is under-interpreted by many teachers.
Whilst ESSAonline was intended to provide formative feedback to students, parents and teachers at the end of Stage 4, it was clear from the findings that the timing of the test was inappropriate from three perspectives.

- At the time of testing, mid-November, many students had already completed school examinations and knowing the test results will not be available until the following year, they fail to perceive its relevance and apply themselves. Despite the intention of the test being to identity what students know and can do, its potential benefit was lost on students and failed to provide valid data.

- The results of the ESSAonline test were not available until midway through Term 1 the following year. Shute (2008) argues that for feedback to be effective it must be timely. Consequently, it can be argued that a delay of 16 weeks in providing feedback cannot be considered timely. This delay in providing test results coupled with the fact that many students have new teachers, meant the data lost some of its significance for both learners and teachers.

- Black and Wiliam (2009) argued that for feedback to be formative it must be “used by the students, peers or their teachers to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have taken in the absence of the evidence that was elicited”. The general consensus amongst coordinators was that little feedback is provided to students as teachers received the data so late that they had new classes, did not know the students well and had begun new programs. This meant that little, if any, feedback was provided directly to students.

Whilst some minor elements of these findings from Phase 1 and 2 may raise issues about the value of ESSAonline to teachers, schools and the system, when considered in context of Phase 3 findings the evidence clearly shows, that when used appropriately, ESSAonline can lead to positive growth in the performance of subsequent cohorts of students – see Section 4.4.2.1.

5.3.1 A dilemma

Another question to be explored is what happened in schools that made some use of ESSAonline when compared with those that made extensive use of ESSAonline? Why is it that schools that made extensive use of ESSAonline showed growth in student performance and schools that made no use of ESSAonline maintain steady student
performance, whilst students in schools that made some use of data showed negative growth. This dilemma will be considered in the contexts of schools C and D (coordinators claim to have made some use of ESSAonline).

Comparisons of the four schools that composed the two cases: those that made extensive use of ESSAonline and those that made some use of ESSAonline, revealed some differences in demographics. Considering the mean value for ICSEA is 1000, the two schools that made extensive use of ESSAonline had ICSEA values in excess of 1018 indicating no real educational disadvantage compared with those that made some use of ESSAonline with ICSEA values of 997 and 999 respectively. The schools in the second case revealed some disadvantage which could impact student learning both at home and at school. While the difference in ICSEA values may account for the difference in achievement, it is unlikely this difference alone accounted for the failure of schools that made some use of ESSAonline to foster growth in student performance.

A review of teacher experience showed that school A had the highest concentration of young teachers with less than five years of teaching experience. School B has more experienced teachers than A and schools C and D had a mix of both young and experienced teachers. Despite the high concentration of young teachers in school A the findings showed growth in student performance after an initial fall in performance following the loss of a highly experienced and accomplished teacher. The findings also showed that regardless of teacher experience, the use of ESSAonline data can lead to improvements in the performance of subsequent student cohorts.

Overall, the findings showed that the use of ESSAonline as a formative assessment tool can have positive impacts when used appropriately. Benefits were evident for schools that had no educational disadvantage and were not limited by teacher experience.

5.3.2 Implication of the findings for subsidiary question 1 and proposition 1
The implications of the findings for subsidiary question 1 will now be considered within the context of proposition 1 which was developed within the framework of subsidiary question 1, the literature review of current understandings of assessment and evaluation, and ESSAonline testing.
• What are coordinator beliefs about the value of ESSAonline as a formative assessment tool?
• Schools operate predominantly out of a constructivist paradigm of learning.

The findings show that coordinators are in agreement that ESSAonline is a good formative tool and can provide a firm basis upon which to develop and implement interventions which can lead to growth in student performance in subsequent cohorts. Growth may be dependent upon ICSEA value but more likely is not limited by ICSEA value or teacher experience.

The place of ESSAonline in the achievement-based learning framework, as shown in Figure 5.1, needs to be carefully identified to fully assess its benefits. If used as a formative assessment tool within the context of the Stage 4, science teachers should use data formatively within the context of the two year course and attempt to develop interventions designed to assist students achieve all outcomes before moving onto Stage 5. However, as discussed previously, given the problems associated with the timing of the test and when schools received results, it is not possible to develop interventions and implement these before students commenced Stage 5 science. Hence, ESSAonline operating as a formative tool in Stage 4 is not possible.
Pedagogy

Constructivist paradigm
Facilitates higher order thinking
Students’ make their own meaning

Instructional design
- student centred
- content knowledge
- PCK
- teacher as facilitator of learning

Teacher
- professional knowledge
  of curriculum and standards.
- sets expectation of learning environment

Teacher planning
- Development of teaching / learning sequence within context

Pre-assessment
- Teacher identifies student learning needs

Teacher / students
- Develop and share learning goals and standards to be achieved

Teacher delivery and management of learning sequence

Student achievement of outcome
No  Yes

Feedback
- Teacher and peer

Teacher evaluation
- Teacher compares student performance against expected standards and formulates appropriate feedback

Student response to feedback
Achievement of outcome
Yes  No

Move onto new concept within current module
Module complete?
Yes  No

Summative assessment
Teacher collects data then uses task formatively
Students work until they achieve the outcome
Outcome achieved?  Yes

Formative assessment
- All classroom activities assume a formative role
- Teacher collects data

Teacher planning
Selection of outcome’s

Teacher
- professional knowledge
  of curriculum and standards.
- sets expectation of learning environment

Teacher planning
Development of teaching / learning sequence within context

Teacher / students
Develop and share learning goals and standards to be achieved

Teacher delivery and management of learning sequence

Student achievement of outcome
No  Yes

Teacher planning
Selection of outcome’s

Teacher / students
- Develop and share learning goals and standards to be achieved

Teacher delivery and management of learning sequence

Student achievement of outcome
No  Yes

Feedback
- Teacher and peer

Student response to feedback
Achievement of outcome
Yes  No

Move onto new concept within current module
Module complete?
Yes  No

Summative assessment
Teacher collects data then uses task formatively
Students work until they achieve the outcome
Outcome achieved?  Yes

Figure 5.1  Conceptual framework – achievement based learning
ESSAonline could however, be considered as operating as summative assessment at the end of Stage 4 and hence used to identify what students know and can do. Within the limitations of a 90 minute test ESSAonline achieves this purpose well. However, as results were not received before the commencement of Stage 5 it is of little value to students and parents. Its use in this context is again limited by timing.

It appears that ESSAonline is best used as a form of pre-assessment at the end of Stage 4 before moving into Stage 5. Being armed with data about what students know and can do provides teachers with the opportunity to address identified learning needs of students as they move through Year 9. A key finding of the study is that little use is made of the test data in this way. Whilst this study was unable to identify the impact of the use of ESSAonline in schools that did use data this way, it appears that much of the potential available through ESSAonline is being under-utilized.

In light of the proposition that schools operate from a constructivist paradigm of education, teachers should use the following list of instructional design features previously discussed in Chapter 2 to inform their practice as student move into Stage 5. Armed with the knowledge of what students know and can do, teachers must work through the steps outlined in the *achievement-based learning* framework to assist students achieve the desired Stage 4 outcomes before commencing Stage 5 (or when revisiting the concepts during Stage 5). Teachers should use their professional skills in selecting from the appropriate constructivist strategies listed below to help ‘close the gap’ in student learning. As they do so, teachers must provide students with appropriate feedback and provide opportunities and structures for them to respond to the feedback until they have achieved the desired outcomes at the expected standard. The features of instructional design, within a constructivist paradigm, to be used to facilitate student achievement of outcomes not demonstrated in ESSAonline include:

- ascertaining schemata from which students operate;
- identifying and teaching within authentic real world contexts in which content and skills can be learnt and applied;
- creating a supportive climate in which students feel safe to reveal their conceptions and engage in social negotiation about learning;
- establishing a teacher–pupil relationship, where the teacher is seen as guide in the process of the learner constructing his / her own knowledge;
• presenting information in a variety of different ways, for example, revisiting content at different times and in rearranged contexts;
• providing opportunities for students to use problem solving skills that allow them to go beyond the information given; and
• using formative teaching practices designed to facilitate student achievement of outcomes.

(Adams, 2000; Brown, 2004; Ertmer & Newby, 2008).

5.4 Finding 2: How are ESSAonline data accessed, shared and analysed within the faculty?

The processes of data access, sharing and analysis vary across schools. Teachers attempt to identify the strengths and weaknesses of students: firstly, as a cohort by comparing school data with that of the State; secondly, on a class by class basis, either that of the Year 8 class from the previous year or for the current Year 9 class and finally on an individual student basis. Faculties reflect on the performance of the faculty as a whole by attempting to establish links between their programming and pedagogy with the strengths and weaknesses in the performance of their students. Analysis is undertaken in all five test reporting areas: Science Overall, Extended Response, Knowing and Understanding, Communicating Scientifically and Working Scientifically. Teachers attempt to identify, longitudinal trends in cohort data, class data and, the emergence of new areas of improvement or weaknesses. Teachers use the data to engage in reflective practice by reviewing the performance of students in their Year 8 class from the previous year.

5.4.1 Accessing and sharing data

All coordinators made use of SMART II to access student ESSAonline data as this is the only method available to schools. The level of usage of SMART II by coordinators and teachers across the schools was highly variable and in many cases dependent on the attitude of the school Executive to the use of data and the level of access they provided to teachers. Whilst many coordinators undertook a review of data at faculty meetings using live data from SMART II other coordinators relied on printing a full report package from SMART II, and then undertake analysis of data before presenting a report to the faculty. The printing of full report packages from SMART II is inconsistent with the reasons for its development. The use of hard copy to analyse data has the potential to slow the process of analysis and make it more complex than it need be. SMART II was developed
to empower teachers to engage online with the rich data from ESSAonline thus providing opportunities for teachers to improve student learning outcomes in a time efficient way (Bruniges, 2014).

5.4.2 Analysing data
Responses elicited in both the questionnaire and the interviews revealed significant differences in the amount of ESSAonline data analysis conducted and the level at which it was analysed.

- **School A** attempted to use the data in two key ways. Firstly, to identify the strengths and weaknesses of Year 8 students and to use this knowledge to review faculty Stage 4 pedagogy and programming. Secondly, to build profiles of Year 9 students and use these to address their learning needs.

- **School B** focused on reviewing the performance of Year 8 students and used this information to review Stage 4 programs and develop whole school interventions designed to address identified issues.

- **School C** focussed on the performance of Year 8 students and developed interventions to address identified needs.

- **School D** focused on developing deep knowledge of current Year 9 students and attempting to address their needs on an individual basis.

In schools A and B where performance growth had occurred, coordinators and teachers took different approaches to analysing data and developing interventions. In School A the coordinator undertook the bulk of analysis and analysed the data at student, class and cohort levels. Following analysis, the teachers reflected on the performance of the Year 8 cohort and amended teaching programs and pedagogy. Teachers were also given data about students in their Year 9 classes. However, little use was made of this information.

In school B the coordinator and teachers engaged in an in-depth analysis of the performance of each of their classes from the previous year to identify the strengths and weaknesses of students in their class. This analysis was then used to inform programming and teaching in Stage 4 over the following years. Whilst little attention was paid to the performance of Year 9 students, some tracking was made of students who achieved anomalous levels of performance in ESSAonline. The coordinator and teachers
also developed whole school interventions including the development of whole school approaches to develop both student literacy and working scientifically skills.

When comparing the strategies used across both Schools A and B it appears there was only one key area that both schools / coordinators had in common to promote potential growth in student performance. The common strategy used was that both schools had a strong focus on the performance of their students in Stage 4 and then engaged in reflective practise leading to new ways of approaching teaching and learning in Stage 4.

In school C, the coordinator and teachers focussed primarily on the performance of Year 8 students and developed interventions to address issues in Stage 4 pedagogy and programming. Teachers in school D focussed on developing deep knowledge of their current Year 9 students and attempting to address their needs on an individual basis.

Phase 3 findings show that the interventions developed in schools A and B worked well, whilst the interventions used in C and D lead to no or negative performance growth. The impact of the Year 9 strategies used in both schools A and D are not able to be evaluated by this study because School Certificate testing no longer exists and no other instrument is available to track the long term impacts on students. Whilst performance data for the students from school C remained relatively constant the interventions developed did not achieve the same level of growth as for school A which had a younger and less experienced staff. The strategy used in School D did not reap any benefits that could be measured by this study. Performance growth data for schools C and D needs to be considered within the context that both coordinators reported that interventions developed were either not completed or embedded in practice.

Whilst it is difficult to attribute any particular change in practice to improved performance in ESSAonline testing, it appears interventions that focus on reviewing and developing Stage 4 pedagogy and programming will, most likely, result in improved performance in subsequent cohorts of students. In this study it is not possible to identify the benefits of any interventions designed to address the learning needs of Stage 5 students as no longitudinal tracking of student performance has been possible. Consequently, the benefits of interventions designed to meet the individual learning
needs of Year 9 students are difficult to identify, quantify and assess. Further study needs to be undertaken to identify the benefits of such interventions.

5.4.3 Reporting ESSAonline
Student performance in ESSAonline is reported to various forums, for example the principal, school executive, year group, whole staff and parents. Reporting is a very important process especially when it comes to the impact it can have on student performance. Emerson et al, (2012) report that parental involvement can have up to 60% impact on student performance. Hence, maintaining good communication practices with the parent body is an excellent way to build partnerships. Coordinator B reported that she actually listed students achieving at the highest level in the school newsletter and provided special achievement awards for those achieving at Level 6. The process of providing special achievement awards can also have positive impacts on student efficacy. This can lead to further growth in student improvement.

Many parents seek ways of working with their child which can have a very positive impact on student attitude (Emerson et al., 2012). The literature demonstrated that parents in particular look for transparent reporting and accountability. It is worth noting that as a system, the Catholic Education Office prepares an annual report detailing the performance of the system in the ESSAonline test. However, there is no complementary process imposed on schools to encourage the use of ESSAonline data, the development of school-based interventions or the reporting of ESSAonline data.

5.4.4 Implications for subsidiary question 2 and proposition 2
The implications of the findings for subsidiary question 2 will now be considered within the context of proposition 2 which was developed within the framework of subsidiary question 2, the literature review of current understandings of assessment and evaluation, and ESSAonline testing.

- *How are ESSAonline data accessed, shared and analysed within the faculty?*
- *Formative and summative assessment can, when used appropriately, improve student learning.*
Whilst coordinators expressed concerns about the untimely receipt of ESSAonline data this should not preclude its use by teachers. Teachers should be encouraged to collaboratively analyse and reflect on the performance data of the previous Year 8 students. As reported in Chapter 1, knowledge about the strengths and weaknesses of student learning can be used in two different ways. The first is that teachers review, evaluate and develop Stage 4 pedagogy and programing. In this way, subsequent cohorts of Year 8 students will benefit from an enhanced teaching and learning program. The second is to review the performance of each current Year 9 student, identify their learning needs and develop individual learning programs. Through this second process, the knowledge and skill gaps of each student can be identified and dealt with. It is clear from this study that further research needs to be undertaken to track student longitudinal growth so that the impact of ESSAonline as a formative tool can be maximised. According to the *achievement-based learning* framework, students must be given feedback and the opportunity to continue working at achieving outcomes until they attain the desired standards.

A key tenet underpinning a constructivist approach to learning is that the teacher must fully understand the prior knowledge and schemata from which students operate. ESSAonline has been designed to complement the class work of teachers and assist them in doing so. When providing detailed ESSAonline data to Year 9 teachers about what their current students can and cannot do, teachers should be able to design instructional activities, based on a constructivist view of teaching and learning so they can provide learning opportunities designed to address the particular needs of each student. Such an undertaking is consistent with the *achievement-based learning* framework which forms the conceptual foundation for this study. Feedback from coordinators indicated that not all staff fully understood the purpose of ESSAonline and / or the SOLO taxonomy. Hence, some teachers did not fully comprehend the depth of information about student learning available through SMART II or how it should be used.

As reported earlier much of the potential available from ESSAonline fails to be realised as teachers do not provide direct feedback to Year 9 students nor address their individual learning needs. Further training at the school or system level is needed to overcome this problem. Based on ESSAonline data teachers should be required to provide Year 9 students with student-centred learning activities designed to meet their specific learning
needs. In doing so teachers must follow the *achievement-based learning* framework to carefully assess and evaluate student achievement of desired outcomes. If desired outcomes have not been met, teachers must provide students with timely (Shute, 2008) feedback and provide opportunities to respond to feedback until they have achieved desired outcomes.

5.5 Finding 3 How is SMART II used by teachers within the faculty, what feedback has been provided to students and how have they responded?

At the recent Education World Forum Ministerial Exchange, the current NSW Director-General of Education and Communities, Michele Bruniges (2014) reported:

> We (BOSTES) have designed and delivered a School Measurement, Assessment and Reporting Toolkit (SMART II) – a software package which provides classroom teachers with the tools to examine and craft appropriate responses to student achievement data. It also enables teachers to link relevant data sets to support the evaluation of intervention programs, discuss teaching and learning in the light of curriculum evidence, and make the next set of teaching decisions to progress student learning.

Bruniges (2014) went on to argue that there must be a balance between teacher effort and teacher time. Teachers must be empowered with the right tools to identify where students have made mistakes and how best to rectify them.

5.5.1 Use of SMART II

Whilst this tool exists and is capable of empowering teachers to engage online with the rich data from ESSAonline and to improve student learning outcomes in a time efficient way, the level of use made of it by teachers and coordinators varies enormously across schools. Responses from both the questionnaire and coordinator interviews revealed that whilst some schools made good use of SMART II, serious issues exist in other schools. Although the Catholic Education Office has always strongly encouraged schools to use data to inform teaching and learning and provided funding to purchase relevant access, there appears to be concerns amongst some principals about allowing teachers to use the online data. As many coordinators commented, neither access to or training for teachers in the use of SMART II was provided within their schools. This attitude by some principals was therefore preventing teachers from making the necessary links between related data sets needed to identify the problems being encountered by the their students. Many of the formative benefits available to schools through SMART II were not being
realised. The failure of schools, coordinators and teachers to use SMART II as intended by the Department of Education and Communities has implications for future professional development within the system. Principals need to be made aware that potential growth in student learning can be achieved through training teachers and coordinators in the use of SMART II and that they must provide staff with access to data. Coordinators and teachers need to be supported in developing their skills to maximise the benefits available through this software package.

Potentially, some of the concerns raised by coordinators about the amount of time needed to fully unpack and analyse data could be minimised by schools or the system by insuring better training for both coordinators and teachers in the use of software and providing unfettered access to data. The fact that some coordinators still print hard copy of the data demonstrates that they fail to understand or make good use of the software and benefit from its strengths.

Teachers who do make use of the data do so in one of two ways. They either use SMART II to formulate their current Year 9 class and review what it is that their current Year 9 students know and can / cannot do or they modify what is taught to their current Stage 4 classes based on data from the year before. Teachers who opt for the latter strategy use data in a reflective way to review their programming and teaching strategies. Instead of deep analysis being the sole responsibility of the coordinator, all science teachers should be required to access, analyse and reflect on data for past and current students. Engaging faculty members in these practices would provide opportunities for teacher professional growth and development, minimise the time spent by coordinators in accessing superficial data and provide a starting point for the faculty to come together, share and reflect on findings at a deep level. Responses from both the questionnaire and the interviews showed that some coordinators did not expect teachers to access data.

5.5.2 Feedback to students
SMART II not only provides test data but also contains a substantial section ‘Curriculum Links’ (see sample Appendix 4) designed to help teachers identify student misconceptions and develop teaching strategies to help students achieve desired outcomes.
Only a small number of responses from both the questionnaire and interviews identified this section of SMART II as a resource. Coordinator A reported that Curriculum Links provided good information about the distractors used, what student selection of the particular distractor revealed about student learning, and in particular the existence of misconceptions. Curriculum Links also provides ideas about developing strategies to support student learning. Use of this part of the SMART II package empowers teachers to address student learning needs and also develop new pedagogy and programming for Stage 4.

Findings from the study failed to reveal any strong evidence of feedback being provided to students about what they knew and could do and how they could improve their achievement of outcomes. Coordinators who reported providing feedback to students also reported that students responded in a positive fashion to the feedback. The literature clearly shows that formative assessment can have positive impacts on student learning (Black & Wiliam, 1998; Black et al., 2004; Taras, 2005; Wiliam, 2011). It also shows that for feedback to be formative it must be “used by the students, peers or their teachers to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have taken in the absence of the evidence that was elicited” (Black & Wiliam, 2009). The question must then be asked what can or should be done to improve the effectiveness of ESSAonline as a form of formative assessment?

As stated previously in this Chapter, ESSAonline best fits the role of pre-assessment for Stage 5 Science in the achievement-based learning framework. With this in mind, when then, and how could / should the ESSAonline Curriculum links be used to provide feedback to students to support them in the achievement of the Stage 4 outcomes necessary to be successful in Stage 5? This and the question posed in the previous paragraph will now be explored.

5.5.3 Implications for subsidiary question 3 and propositions 3 and 4

The implications of the findings for subsidiary question 3 will now be considered within the context of propositions 3 and 4, which were developed within the framework of subsidiary question 3, the literature review of current understandings of assessment and evaluation, and ESSAonline testing.
- How is SMART II used by teachers within the faculty, what feedback has been provided to students and how have they responded?
- Formative and summative assessment data provides the information teachers need to evaluate student learning against a set of standards.
- Following evaluation, teachers should provide timely feedback to students.

ESSAonline test results are received by the school and the students mid-Term I, approximately 16 weeks after sitting the test. In light of Shute’s (2008) work, these results cannot be considered timely feedback. During this time, students have been on six weeks holiday, promoted one year, are in new classes, likely to have a new teacher and are well into a new topic of work. It is no surprise that there was very little evidence of teachers providing specific feedback to students. Given the less than favourable conditions for feedback to students, it does not mean that it cannot / should not happen. Schools need to consider options for how feedback could be provided to students to assist them achieve Stage 4 outcomes before moving further into Stage 5.

Reflecting on the work by Hattie and Timperley (2007), they defined the purpose of feedback as reducing discrepancies between current understandings or performance and desired goals. Their model specifies three questions that need to be addressed: Where am I going? How am I going? Where to next? Each feedback question operates at four levels: feedback about the task, feedback about the processing of the task, feedback about self-regulation and feedback about the self as a person. They demonstrate that feedback about self is the least effective form of feedback. Feedback about self-regulation and feedback about processing “are powerful in terms of deep processing and mastery of tasks” (Hattie & Timperley 2007, p. 91) while feedback about the task is powerful when it is used either to improve strategy processing, or for enhancing self-regulation. Within this framework and the package of information contained in Curriculum Links, most feedback to students would need to focus on the task and processing of the task.

According to the achievement-based learning framework, when ESSAonline is considered a form of pre-testing, the feedback should ideally be provided before students encounter the concepts or skills again. In some cases it may be that students may not encounter the learning again in Stage 5. When then should feedback be given to students
providing them with the opportunity to achieve the outcome before moving onto new concepts?

After considering the factors that impact feedback, it appears that a blend of strategies may need to be used. One strategy can be employed to address outcomes which will not be encountered again, while another can be employed for those that will be encountered again in Stage 5. A starting point would be to map the syllabus outcomes in the ESSAonline test against the faculty Stage 5 program to identify when and if the concepts and skills will be encountered again. For those that will be encountered again, strategies based on Hattie and Timperley’s (2007) theories about feedback and the ESSAonline Curriculum Links can be developed and then authentically built into Stage 5 programming. For those outcomes that will not be encountered again, time should be set aside in Year 9 for teachers to work with their current Year 9 class (or maybe their Year 8 class from the previous year) to review the concepts and skills so the desired outcomes can be achieved. According to the achievement-based learning framework time needs to set aside to ensure outcomes are achieved.

One of the limitations of this study was there is no longer a common test which all students sit after Year 8. Consequently, there was no way of tracking the impact of feedback on individual student performance. Hence, it is not possible for this study to evaluate the impact of ESSAonline as a formative assessment tool on the performance of individual students over time.

5.6 Finding 4: What interventions have been developed in response to ESSAonline and how have they impacted on the performance of subsequent cohorts sitting ESSAonline?

All coordinators, apart from the two who did not use ESSAonline, reported the development of some form of school-based interventions. These interventions ranged in scope from interventions targeting individual students who were underachieving at school through to whole school interventions such as a whole faculty focus on using technical language or the process of scientific inquiry.
The interventions developed by coordinators could be divided into three main types. The first, were those that focussed on Stage 4, the second were those that could be applied to both Stages, and the third were those that targeted Stage 5 students. Of the interventions that targeted Stage 4, most were associated with aspects of the course that many students found problematic. An example of this was in school A where the data showed that students did not understand that arrows in food chains indicated the direction of energy flow. Teachers identified parts of the teaching program that taught this and modified the emphasis and pedagogy used to teach the concept. Other interventions focussing on Stage 4 included the development of scaffolds to support student learning. Multifaceted interventions that supported student learning in the classroom and that became embedded in faculty practice were shown, as in School B, to lead to the most improvement.

Another intervention adopted by school B was the development of student study and test skills program. Teachers in this school developed a metacognition program that helped students understand how they learn. The teachers then implemented regular quizzes to identify if students increased their rate of retention. Teachers provided formative feedback to students in the same teaching period. Other schools in this study reported implementing similar programs incorporating practise ESSAonline tests and ESSAonline type questions into existing test programs.

Many interventions focussed on adopting strategies that addressed learning in both Stages 4 and 5 and were implemented in an attempt to improve learning for all students. One key area these interventions were designed to address was working scientifically. In this category strategies ranged from placing a greater emphases on open investigations in which students were required to develop their own experimental procedures through to completing practice and final student research projects each year from Year 7 to Year 10. The coordinator at school B actively worked with parents to develop partnerships which empowered the parents to support their daughter’s learning at home. Resource materials were placed on the school website for access by both students and parents. Emerson et. al. (2012) believed that through building partnership with parents and equipping them with the knowledge and skills they need, parents can and will play an active role in their children’s learning leading to a positive impact on student achievement.
Many coordinators reported implementing whole faculty literacy approaches that incorporated a variety of strategies. These included the use of scaffolds for writing different text types, focussing on writing extended response answers, focussing on the use of technical language and teaching the meaning of the NSW BOSTES key verbs.

Only two coordinators reported implementing strategies which directly impacted Year 9 students only. They were the coordinators from schools A and D. The coordinator from school A reported that teachers attempted to address some misconceptions identified in the test whilst the coordinator from school D reported that teachers were asked to address the learning needs, as identified through ESSAonline of individual students. Both coordinators reported these interventions were not well received by teachers nor were they well implemented.

It is evident from the discussion so far that the main types of interventions developed and implemented across schools focussed on the modification of teaching practices and whole school approaches to the development of student literacy, working scientifically and examination / study skills. Very little work was undertaken in addressing the specific learning needs of individual students. The types of interventions implemented suggest that both coordinators and teachers were working from a teacher-centred pedagogy rather than a constructivist student-centred paradigm.

In terms of the *achievement-based learning* framework, coordinators and teachers failed to evaluate the data available from ESSAonline to implement the loop requiring students to revisit unachieved outcomes until they achieved the achieved the desired standard.

### 5.6.1 Evidence of improvement in student performance

When asked if coordinators had any evidence of interventions leading to improvements, their answers varied from a short negative response, through to some very comprehensive responses in which coordinators were able to note numerous changes in student test performance and behaviour.

Phase 3 test performance data is included at this point to inform the discussion and provide evidence about the future value of ESSAonline as a formative instrument in the overall education strategy of the Catholic Education Office.
5.6.2 Student performance in ESSA testing across the six selected schools

Schools that make **extensive** use of ESSAonline data to inform learning and teaching

![Figure 5.2 ICSEA 1018](image1)

![Figure 5.3 ICSEA 1057](image2)

Schools that make **some** use of ESSAonline data to inform learning and teaching

![Figure 5.4 ICSEA 997](image3)

![Figure 5.5 ICSEA 999](image4)

Schools that make no use of ESSAonline data to inform learning and teaching

![Figure 5.6 ICSEA 1093](image5)

![Figure 5.7 ICSEA 1067](image6)
Analysis of Figures 5.2 to 5.7 reveals that student data from year to year shows variation as different cohorts are compared. Figures 5.2 and 5.3 show data for schools A and B which make extensive use of ESSAonline data. Across the five years, performance is strong in both these schools. The mean value for Science Overall was 2.24 points above the State mean for School A and 2.58 points for School B. It is worth noting that School B has a higher ICSEA value (1057) than School A (1018) and by 2012 student achievement in all five areas for school B was higher than for A. The 2009 data for both schools in the five different test areas commenced at similar levels but over the following three years student performance in these areas improved at a greater rate for School B than for school A.

It is interesting that when asked if there was any evidence that student performance had improved over the years, as a result of school-based interventions, coordinator AAA said – no! This response was very surprising to the researcher given his knowledge of the coordinators level of usage of ESSAonline data. Coordinator BBB listed a wide variety of both qualitative and quantitative evidence to support her view that student performance in School B had improved. Extensive reference was made by Coordinator BBB to numerical data in graphs to show there were significant improvements in the number of students achieving at Levels 5 and 6. She was also able to describe anecdotal evidence of improvements in areas that had been specifically targeted such as working scientifically, writing skills and student use of technical language. Coordinator BBB made specific reference to parents thanking her for posting resources on the school website that empowered them, to assist their children in the completion of student research projects.

Figures 5.4 and 5.5 show data for schools C and D. Both schools showed no or negative achievement growth. Interventions initiated in School C, whilst initially leading to some growth appear to have had no long term impact on student achievement. Interventions initiated in this school focussed on improving pedagogical practice in Stage 4 but as reported by the coordinator did not become entrenched in practice. The trend shown in Figure 5.4 is very similar to those in Figures 5.6 and 5.7. The implication is that unless interventions are fully implemented and followed-up, schools should not expect growth in student performance. The data presented in Figure 5.5 shows negative growth in performance. This is not surprising since teachers in the school focussed on interventions that identified and addressed learning needs of Year 9 students. Consequently, successive
cohorts of Year 8 students experienced the same curriculum and pedagogical practices across the five years rather than benefiting from attempts to improve them.

The decline in student performance for School D seems inconsistent when compared with schools E and F. Both schools E and F made no use of ESSA data yet maintained consistent levels of performance. The successive performances of School D Year 8 cohorts should have been relatively consistent in the same way that it was for schools E and F. Consequently, it is likely that other factors influenced this finding. From personal knowledge, the researcher is able to report that there was significant instability in leadership within the Science Department at this time. Leadership changed three times over the five year period with the coordinator in the middle years falling gravely ill and the department being led by the school’s curriculum coordinator. Whilst the curriculum coordinator was a member of the Science Department it was a less than satisfactory situation because she was being physically and emotionally stretched to her working limits.

Figures 5.6 and 5.7 show trends for schools E and F. These schools made no use of ESSA data and maintained consistent student performance within the limits of changing student cohorts. This trend is not surprising given stability in the demographics of the student populations and the consistency in pedagogy and programming. Students in these schools demonstrated strong performance. This was particularly true for school E with results for Science Overall an average of 5 points above the State for the five year period whilst achievement for students from school F was an average of 2.18 points above the State average for Science Overall across the same period. School E has an ICSEA value of 1093, whilst School F had an ICSEA value of 1067.

5.6.3 Implications for subsidiary question 4 and propositions 2, 3, 4 and 5
The implications of the findings for subsidiary question 4 will now be considered within the context of propositions 2, 3, 4 and 5 which were developed within the framework of the subsidiary question, the literature review of current understandings of assessment and evaluation, and ESSAonline testing.
• What interventions have been developed in response to ESSAonline and how have they impacted on the performance of subsequent cohorts completing ESSAonline?
• Formative and summative assessment can, when used appropriately, improve student learning.
• Formative and summative assessment data provides the information needed by teachers to evaluate student learning against a set of standards.
• Following evaluation, teachers should provide timely feedback to students.
• Teachers should provide guidance to and opportunities for students to respond to feedback.

Finding 4 clearly shows that when ESSAonline data is used appropriately to identify the strengths and weaknesses in student learning its use can have positive impacts on student learning. Given the naturalistic setting of the classroom the degree of impact is dependent on many variables, for example, the level of analysis undertaken, the number and type of interventions developed, the level of completion of the intervention, whether the intervention is embedded in faculty practice and impacts of teacher health and stability of faculty leadership.

The type of interventions developed across the six schools focussed on whole cohort level changes revolving around improvements to programming and pedagogy. There was very little evidence of schools identifying the individual needs of students and addressing these through the provision of feedback and providing opportunities for the students to respond to feedback. Potential for further improvement exists should teachers provide individual feedback to Stage 5 students.

Significant implications flow from these findings should CEO Sydney wish to continue investing in ESSAonline as a formative assessment tool. These include:
• The provision of professional development to equip teachers with the skills need to fully unpack the data and identify the individual learning needs of the students.
• The development of a culture, open to the data provided by ESSAonline, and a willingness to use it to improve student learning.
• The development of an assessment and evaluation tool that can track student learning across both Stages 4 and 5.
• The provision of professional development to equip teachers with the skills to provide appropriate feedback to students and the development of structures to empower students to respond to feedback and close ‘the gap’ between their learning and the desired achievement standards.

5.7 Finding 5: Should the Catholic Education Office Sydney continue to invest in ESSAonline as a formative assessment tool?

All coordinators, except one, were in agreement that the Catholic Education Office should continue to invest in ESSAonline as a formative assessment tool. Coordinator FFF added the condition that the technology work correctly, otherwise the results would not be valid or reliable.

Coordinators were generally very supportive of the test and believed that it was a good assessment tool. Coordinators believed that it provided good feedback, particularly to the faculty, and was in a form that could be used to guide future planning.

5.7.1 Implications for subsidiary question 5

The implications of the findings for subsidiary question 5 will now be considered.

• Should the Catholic Education Office Sydney continue to invest in ESSAonline as a formative assessment tool?

ESSAonline can only bring about improvements in student learning if the data is used by teachers. The findings show that not all teachers and coordinators are committed to its use nor are principals conscientious in overseeing the use of the data in their schools.

Implications for whether CEO should continue to invest in ESSAonline.

• Should CEO continue to invest in ESSAonline and insist that all schools take part in testing then they will need to develop accountability structures which require principals to report on ESSAonline achievement, how the data was analysed and the interventions implemented.

• The CEO could make involvement in ESSAonline open to those schools committed to using the data. In this situation schools wanting to use the data
formatively could do so. Financial resources saved under this model could be used to fund other initiatives designed to raise student performance in Science.

5.8 Response to research question

How have teachers, in Sydney Catholic systemic schools, used data from Essential Secondary Science Assessment online (ESSAonline) and what have been the impacts of their use on the performance of subsequent cohorts sitting ESSAonline?

In summary, many teachers across the system attempted to use ESSAonline data in a positive way to inform learning and teaching. As coordinators have different organisational and leadership skills, the level of use and the quality of interventions developed in response to ESSAonline data varied widely across the system.

When data was used extensively and followed-up by well informed and developed interventions, the results had very positive impacts on the performance of subsequent student cohorts sitting ESSAonline.

A significant finding of this study is that schools do not use ESSAonline data to address the specific learning needs of individual students. Effectively, schools follow a teacher-centred rather than constructivist student-centred view of learning and teaching. The system needs to institute significant professional development to empower coordinators and teachers to fully understand and analyse ESSAonline data, and develop and implement interventions to address individual student needs within a constructivist paradigm of teaching and learning. Such a view of teaching and learning is not desired for its own sake, but to provide a ‘holistic’ perspective on teaching and learning that acts to highlight when teaching and learning practices and processes are less than best practice. Coordinators and teachers need to use the achievement-based learning framework to help students achieve desired student learning outcomes.

The Catholic Education Office, Sydney must decide how best to invest in ESSAonline to maximise growth in science learning.
6.1 Introduction

Black and Wiliam (2009) argue:

Practice in a classroom is formative to the extent that evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers, to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have taken in the absence of the evidence that was elicited (Black & Wiliam, 2009, p. 9).

Within this definition, the effectiveness of formative assessment is seen to be dependent on the participation of both the teacher and the learner. This chapter will further explore the findings of the study within the context of the achievement-based learning framework to determine how teachers and students can best work together to improve the learning outcomes of all students.

The chapter also discusses the implications of the study findings in terms of assessment, curriculum and pedagogy and evaluates the investment of the Catholic Education Office in ESSAonline as a formative assessment tool. The chapter concludes with a set of recommendations directed at CEO Sydney in terms of the continued investment in ESSAonline.

6.2 Response to research question

*How have teachers in Sydney Catholic systemic schools, used data from Essential Secondary Science Assessment online (ESSAonline) and what have been the impacts of their use on the performance of subsequent cohorts sitting ESSAonline?*

Teachers across the CEO system attempt to use ESSAonline data to inform learning and teaching. As coordinators vary in their organisational and leadership skills the use made of ESSAonline data varies widely across the system as do the impacts of its use. Aspects of the Phase 3 quantitative data support the literature reviewed in Chapter 2 and clearly show that when used appropriately, formative assessment can have positive impacts on student learning (Black & Wiliam, 1998; Black et al., 2004; Taras, 2005; Wiliam, 2011).
ESSAonline data, when used extensively, can have a positive impact on the performance of subsequent cohorts of students sitting ESSAonline.

If formative classroom practice “*can help make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have taken in the absence of the evidence*” (Black & Wiliam, 2009) then the analysis of ESSAonline data should be able to not only lead to improved learning outcomes for future cohorts of students but also those moving onto Stage 5. Whilst coordinators and teachers have in the past focussed strongly on their Stage 4 programming and pedagogy and have been able to achieve growth in future cohorts of students sitting ESSAonline, it appears that there is a whole dimension of ESSAonline that remains un-tapped. CEO needs to explore how schools can be encouraged to focus on developing individual learning plans for Stage 5 students. The system also needs a tool to track student achievement across Years 7 to 10.

There are a number of factors existent within the CEO which limit the actions of coordinators, teachers and schools that, in turn, impact the use of ESSAonline data and its ability to improve learning outcomes for students. These include:

- the time available to coordinators and teachers to adequately analyse, develop and implement interventions;
- the level of support provided by school executives to facilitate the effective use of ESSAonline data, including their attitudes towards
  - the use of online data to inform learning and teaching;
  - training teachers in the use of and providing teachers access to SMART II;
- failure by teachers and coordinators to fully understand the purpose of ESSAonline and the operation of both SOLO taxonomy and SMART II;
- the timing of the ESSAonline test and the timely provision of results to students (Shute, 2008); and
- lack of motivation of teachers to provide feedback to their Year 9 students.

Despite these limitations, many of which are beyond the control of the Catholic Education Office, it does not mean that investment by the system should not be pursued. Rather, the system should provide additional support to schools to facilitate continued
and improved use of ESSAonline so that student learning outcomes are improved. Data from schools A and B, have shown that when used appropriately use of ESSAonline data can have a positive impact on the performance of subsequent cohorts sitting the test. This said, the impact the test can have on the performance of students over the long term needs to be further investigated. To ensure effective use of ESSAonline data, structures and processes need to be developed and implemented to facilitate the development of interventions which lead to improved student achievement in both Stages 4 and 5.

6.3 Summary of key findings and their implications

Key findings of the study will now be reviewed within the framework of the Catholic Education Office’s investment in ESSAonline and how that investment can be directed to improve student learning in both Stages 4 and 5.

6.3.1.1 Finding 1

Year 8 students in all schools that participated in this study sat the test at least five times. Each school was also staffed by science teachers with a range of teaching experience. Of the six schools that took part in Phase 2 of the study, School A had the largest number of teachers with the least teaching experience while School E had the largest number of teachers with the greatest teaching experience. Coordinators believed the ESSAonline test is a good formative tool that incorporates well developed multiple choice and extended response questions which integrate content from across the syllabus.

6.3.1.2 Implications of finding 1

Coordinators agreed that ESSAonline is a good formative tool that can provide a firm basis upon which to develop and implement interventions to increase student performance in subsequent cohorts (Black & Wiliam, 1998; Black et al., 2004; Taras, 2005; Wiliam, 2011). Phase 3 data showed a potential relationship between student performance and ICSEA value indicating that ICSEA value may impact the overall performance of students. Evidence from School A data showed that ICSEA value and teacher experience do not prevent growth in student performance.

If this finding is interpreted from the perspective of the achievement-based learning framework, the ESSAonline test functions as a pre-assessment at the end of Stage 4 before students move to Stage 5. Armed with data summarising what students know and
can / can’t do, teachers have the opportunity to address both the teaching programs and pedagogy used in Stage 4 and the identified learning needs of individual students as they move into Year 9.

The study findings confirm that when ESSAonline data are used extensively to modify Stage 4 programming and pedagogy, improvements can be made in the performance of subsequent Year 8 cohorts. However, another key finding was that test data can be used to identify the learning needs of individual Year 9 students and to provide feedback to them to ‘close the gap’ between desired and actual achievement of outcomes. This study was unable to identify the impact of using ESSAonline data in this way because external tests are not conducted in NSW after Year 8. As many coordinators and teachers fail to develop individual learning plans for their Stage 5 students the potential to increase student performance using ESSAonline data is under-utilised. Further study needs to be undertaken to identify the impact of the analysis of ESSAonline data on student learning as they move through Stage 5.

6.3.2.1 Finding 2
Sharing ESSA data within Science Departments is controlled by the coordinator. When shared at faculty meetings, data is discussed and teachers invited to contribute to the analysis. Whilst ESSAonline data is provided to schools via SMART II, not all schools provide training or access for teachers to the package. Teachers analyse data mainly at a cohort or faculty level. Thorough analysis of data is time consuming. Consequently, time needs to be made available to analyse data, develop, implement and embed interventions in faculty practice.

6.3.2.2 Implications of finding 2
ESSAonline data is provided to schools approximately 16 weeks after the test. This makes it difficult for teachers to provide timely feedback to students (Shute 2008). Consequently, the Catholic Education Office, schools, and teachers need to develop and implement structures and processes to ensure best use is made of the data. Teachers need to be encouraged to collaboratively analyse and reflect on the data, for the benefit of subsequent Year 8 cohorts and current Year 9 students. After developing deep knowledge about what students know and can / cannot do, teachers must develop interventions at two levels; reviewing Stage 4 pedagogy and programming, and addressing Year 9 student
It is clear from this study that further research needs to be undertaken to track student academic performance longitudinally to investigate the impact of using ESSAonline data to evaluate student achievement of outcomes. According to the achievement-based learning framework student ESSAonline data must be used formatively to evaluate individual student learning needs (Kizlik, 2012; Watson, 2012), and provide well formulated feedback (Hattie & Timperley, 2007; Havne, 2012) based on a constructivist paradigm of learning. This includes providing opportunities for students to continue working at achieving outcomes until they have ‘closed the gap’ (Black & Wiliam, 2009).

When using data from previous Year 8 students, teachers should reflect on student strengths and weaknesses then review their programming and pedagogy to identify practices which worked well and those that did not. Findings from this review should then be used to inform future practice.

**6.3.3.1 Finding 3**

In 25% of schools most teachers of the previous year’s Year 8 cohort engaged in reflective analysis of ESSAonline data. These teachers reviewed the teaching programs to address the weaknesses identified by the data. Programming changes may also lead to a review of the pedagogy used by teachers in the classroom.

Most teachers of Year 9 did not access data to identify the strengths and weaknesses of their current students. Consequently, Year 9 teachers are not likely to provide specific feedback to students based on analysis of ESSAonline test data.

**6.3.3.2 Implications of finding 3**

ESSAonline test results are received by schools and students mid Term I, approximately 16 weeks after students sit the test. Shute (2008) would argue this cannot be considered timely feedback. Consequently, it is no surprise there is little evidence of teachers providing specific feedback to students. As has already been argued, given the less than favourable conditions for feedback to students it does not mean that feedback cannot or should not be provided (Black & Wiliam, 2009). Schools need to consider options and develop, implement and embed structures and processes to assist students achieve Stage 4 outcomes. The achievement-based learning framework is one way of structuring or
providing a process to facilitate a more successful and comprehensive completion of Stage 5.

Feedback about self-regulation and feedback about processing “are powerful in terms of deep processing and mastery of tasks” (Hattie & Timperley 2007, p. 91). Within the context of this finding and the _achievement-based learning framework_, teachers should be encouraged to use the information contained in Curriculum Links to provide feedback to “the learners, or their peers, to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have taken in the absence of the evidence that was elicited” (Black & Wiliam, 2009, p. 9). Students must be provided feedback and afforded the opportunity to act on the feedback they receive.

The _achievement-based learning_ framework indicates that feedback should be provided before students encounter the concepts or skills a second time or before related concepts are taught. This is particularly the case if the test functions as a pre-test. In the case of ESSAonline feedback, the question arises, when should feedback be provided to ensure students have the opportunity to achieve Stage 4 outcomes before moving onto new concepts encountered in Stage 5?

The findings from this study indicate that feedback may be more efficiently provided using a blend of strategies. It should be noted that one strategy should be used to address outcomes that will not be encountered again and another for those that will be used as a basis for further learning. Consequently, the first step would be to map the concepts in the Stage 5 curriculum against those for which feedback is available. For those that will be re-encountered strategies based on Hattie and Timperley’s (2007) study and Curriculum Links could be developed and authentically embedded in Stage 5 programming. For those that will not be encountered again, time should be set aside in Year 9 for teachers to review the concepts and skills so students will have the opportunity to achieve the desired outcome. Consistent with the _achievement-based learning_ framework, time needs to be allocated or programmed to revisit outcomes that still need to be achieved.

One of the limitations of this study is that because there is no common external test that all students sit after Year 8 there is no way of tracking the impact of feedback on
individual student performance. The only way individual student performance could be assessed would be for schools to implement their own testing program at the end of Stage 5.

6.3.4.1 Finding 4 – Part 1
Concerns were raised about the timing of the ESSAonline test. As ESSAonline is an assessment of Stage 4 student learning outcomes, by necessity it should be sat towards the end of Stage 4 (Panizzon et al., 2006). A consequence of this, however, is most schools have completed their school-based yearly assessment program. Consequently, students lack motivation when they sit ESSAonline and fail to fully commit to the task. Coordinators believe that to be of practical value feedback must be provided in a timely fashion, a view supported by Shute (2008). However, it was found that Term I of the following year made it difficult to use the ESSAonline data effectively for individual students. Consequently, few teachers used the data with most failing to provide any real feedback to students.

6.3.4.2 Implications of finding 4- Part 1
These concerns raise serious questions about the validity and reliability of the test data. Is the data an accurate reflection of what students know and can or cannot do? Also, does the data provide an adequate platform from which to develop school-based interventions? It is argued that ESSAonline data is the best independent form of evidence available to schools to review the performance of both the Science Department and students. However, ESSAonline data should not be used in isolation from school-based assessment and evaluation programs. ESSAonline provides only one set of data in a complex human system. Whilst it can be argued that some students may not have correctly answered particular questions on the test day because they did not apply themselves it may be equally argued that it is unlikely they answered questions correctly by chance. By reviewing ESSAonline data in the context of the whole school and departmental records, teachers should be empowered to develop school-based intervention programs and individual student learning programs to help improve the learning outcomes of students.

Although it is argued that ESSAonline data is received at a less than opportune time it can equally be argued that the timing is appropriate. Schools have resumed for the new school year, teachers have meet their new students and are in the process of identifying
their learning needs (*achievement-based learning* framework). Consequently, ESSAonline can provide timely additional information to assist teachers “link relevant data sets to support the evaluation of intervention programs, discuss teaching and learning in the light of curriculum evidence, and make the next set of teaching decisions to progress student learning” (Bruniges, 2014). The Catholic Education Office, schools and teachers must develop, implement and embed practices to insure the real benefits available through ESSAonline are realised.

6.3.5.1 Finding 4 - Part 2
Phase 3 quantitative data revealed that schools that made extensive use of ESSAonline data showed an increase in the performance of subsequent cohorts sitting ESSAonline. Schools that made some use of ESSAonline data showed no sustained increase in performance and in one school performance regressed. Schools that made no use of ESSAonline data remained consistent in their performance over the years data were analysed. Coordinators in many schools claimed that involvement in ESSAonline increased student performance and were able to identify a range of evidence to support their claims.

6.3.5.2 Implications of finding 4 – Part 2
The extensive use of ESSAonline by some schools has shown that improvements in the performance of subsequent cohorts of students sitting ESSAonline can be realised. This improvement was the result of teachers engaging in reflective practices after data analysis. Teachers were able to cite evidence to support this claim. The science coordinator at School B said better links with parents were achieved by using the school website as a common resource for students and parent when working on research projects. This translated to improvements in ability of students to plan and conduct investigations. Improvements in student performance were evident in the Working Scientifically component of ESSAonline. Students increased their test average from 0.6 points below the State average in 2008 to 3.7 points above the State average in 2012. In a similar way, after developing a faculty-based literacy program, students moved from an average of 0.8 points below the State average in 2008 in Communicating Scientifically to 7 points above the State average in 2012.
In schools that only made some use of ESSAonline data, no increase in student performance was evident. While the two schools studied in this case used ESSAonline data differently, the reason for no increase in student performance was different. The coordinator at School C said that “in the busyness of the school environment it was difficult to embed any changes in practice”. However, after two interventions in School C student performance increased in all areas between 2008 and 2010. The two interventions focused on the development of a science-based literacy strategy and a focus on Working Scientifically. Unfortunately, after 2010 student performance in ESSAonline across all areas declined, except for Extended Response.

In School D, ESSAonline data were used to identify the learning needs of Year 9 students. Unfortunately, the success of this initiative was not able to be assessed because, at the time of commencing this study, no external assessment of student achievement was available at the end of Year 10. The coordinator of School D also reported that much of the intended work associated with this intervention was not completed.

Over the last two years the Department of Education and Communities has developed, piloted and trialed a new Year 10 ESSA Test. School D was part of the trial test in 2014 and ESSAonline provided learning growth data for Year 8 students tested in 2012. Data analysis revealed that of the 115 students tested, 57 achieved a level of growth above that expected in the trial of 5,254 students with 31 students achieving growth within expectations. Ten students achieved no or negative growth. Overall, these results were very positive with 50% of the cohort achieving learning growth for Stage 5 Science above expectation for the trail (see Figure 6.1). This small data set is evidence for the need for further study into the long term impacts of using ESSAonline data to identify and address the learning needs of individual students.
Data for both schools C and D indicate that increased student performance requires ESSAonline data to be used in an extensive and sustained way. Evidence from the new Year 10 Trial ESSAonline test shows that in the future, the previously largely under-utilised potential of ESSAonline to support student learning in Stage 5 could be better used and effectively tracked across Years 7 to 10.

6.3.6.1 Finding 5

Coordinators overwhelmingly supported the ongoing commitment of Catholic Education Office to ESSAonline, especially if available technology is able to successfully support the implementation of the test.

6.3.6.2 Implications of finding 5

Although coordinators were overwhelmingly in favor of the Catholic Education Office continuing its commitment to ESSAonline, the system will need to review the way ESSAonline testing is implemented, there are two main options:
If Catholic Education Office continues to invest in ESSAonline and insist that all schools take part in the testing then they will need to develop accountability structures which require principals to report on ESSAonline achievement, how the data was analysed and the interventions implemented.

Alternatively, Catholic Education Office could make involvement in ESSAonline open to those schools committed to using the data. In this situation schools wanting to use the data formatively will do so. Financial resources saved under this model could be used to fund other initiatives designed to raise student performance in Science.

6.4 Recommendations

According to the achievement-based learning framework for students, teachers, parents, schools and the system to maximise the benefits available from ESSAonline, the following recommendations need to be adopted and implemented:

- ongoing commitment by CEO to ESSAonline testing;
- commitment of additional financial resources by CEO to ESSAonline Year 10 testing;
- ongoing development of CEO computer network to facilitate uninterrupted student access to the test;
- provision of adequate time for coordinators and teachers to complete a thorough analysis of ESSAonline data;
- commitment by the school executive to provide training for all science teachers in SOLO and the use of SMART II;
- provide access to and encourage all science teachers to use SMART II to link data and plan effective teaching and learning strategies to meet the needs of all students;
- provide in-school support through the Catholic Education Office to coordinators and faculties to facilitate data analysis and the development of school-based interventions;
- CEO and school executives encourage coordinators and teachers to willingly commit to analyzing ESSAonline data, developing faculty-based evaluations of current Stage 4 programming and pedagogy, providing feedback to students and developing individualised science learning plans to meet the needs of Stage 5 students.
OR
CEO develop policies which mandate the use of ESSAonline data and the development and implementation of interventions by all schools, coordinators and teachers;

- time be made available within teaching programs for Year 9 students to revisit ESSAonline to identify outcomes that were not achieved and for teachers to provide appropriate feedback and opportunities to facilitate achievement of the outcomes; and

- processes to insure the evaluation and updating of interventions and student learning plans.

6.5 Impacts of the study
The findings of this study clearly show that schools that make extensive use of ESSAonline testing can make significant improvement in the performance of subsequent cohorts sitting the test. Given that these improvements resulted from testing solely in Year 8, when considered within a context that DEC began Year 10 ESSAonline testing as a pilot in 2013 and Year 6 ESSAonline as a pilot in 2014, the potential of a full system commitment to ESSAonline from Year 6 - Year 10 to lead to even greater impacts on student learning is quite compelling.

A consequence of only a small number of faculties using ESSAonline data extensively is that very few schools show significant growth in student performance from one cohort to the next or provide feedback to Stage 5 students.

Given the limited success of ESSAonline and the large financial commitment, the Catholic Education Office has a key decision to make, to either continue using ESSAonline as a formative assessment tool or to use the financial resource in other ways to bring about improvements in student learning in science. Should CEO continue to invest in ESSAonline, as recommended by this study, then it must decide between:

- imposing more stringent controls mandating greater use of ESSAonline data; or
- supporting only those schools that commit to using the data and directing remaining funds at other initiatives.
6.5.1 Students
It has been clearly shown that schools that made extensive use of ESSAonline data had a significant impact on student performance. Hence, it is difficult to see that whichever decision the Catholic Education Office makes in relation to its ongoing investment in ESSAonline that students will benefit from the findings of this study. Should the Catholic Education Office continue with testing through either mandated controls or through the voluntary commitment of schools to the use of data, students will benefit. Should the Catholic Education Office decide to no longer invest in ESSAonline the commitment of the financial resources to other initiatives should have a positive impact on student learning.

6.5.2 Teachers
The McKinsey Report (Barber & Mourshed, 2007) showed that the most effective professional learning occurs when teachers learn from one another. Teachers who make extensive use of ESSAonline data will benefit personally through two avenues:

- observation of the positive learning outcomes for students; and
- development of their professional skills through the analysis of data and the development of interventions and individualised learning plans.

When teacher performance improves, both schools and students benefit.

6.5.3 Schools
The McKinsey report (Barber & Mourshed, 2007) also concluded that effective professional development occurs when teachers learn from one another in a collaborative framework. Schools could benefit from an ongoing commitment to ESSAonline by sharing ideas about the interventions they developed along with the way they supported the learning of Stage 5 students through individualised learning plans.

6.5.4 Parents
Seyfreid and Chung (2002, p.109) report, “Parent involvement and parent expectations are fundamental to academic success.” The findings of this study have implications for parents. When parents are provided with opportunities and mechanisms for involvement
in the education of their children it can lead to increased student performance. Schools which commit to ESSAonline at both Stage 4 and 5, will be able to equip parents with quality information about what their son / daughter can and cannot and be provided with new opportunities to become involved in helping their student achieve improved learning outcomes.

6.5.5 Catholic Education Office, Sydney

Hall and Simeral (2008, p.169) argue that school improvement has always been a priority of systems but can only be achieved by building teacher strengths, abilities and potential. Hence, as a system, the Catholic Education Office Sydney irrespective of which option they pursue can only benefit from increased teacher knowledge and skill development made possible through a continued commitment to ESSAonline or reallocation of resources to other forms of teacher professional learning.

6.6 Areas for future research

A major limitation of this study was that after the NSW Board of Studies ceased School Certificate testing in science, there was no instrument available to track the longitudinal impact of ESSAonline testing on individual students.

Recent developments in the Department of Education and Communities have seen the development of ESSAonline tests in Year 6 and Year 10. The coupling of student data across all three tests can potentially provide tracking of student growth across a five year period.

Two areas for further study include:

- Investigating the impact of the *achievement-based learning* conceptual framework on student learning. This requires structures to be put in place to ensure teachers evaluate student achievement following formative classroom practice. Provide quality feedback to students and provide opportunities for students to respond to feedback.
- Investigating the impact of longitudinal tracking of student performance in external testing on learning growth in science.
6.7 Conclusion

Findings show that very few teachers made extensive use of ESSAonline test data or provided feedback to students about ‘the gap’ between what they know and can do and the expected achievement standard. Without feedback there can be no action by the teacher, students or parents to close ‘the gap’. Teachers who have made extensive use of ESSAonline data have experienced positive growth in the performance of subsequent cohorts sitting ESSAonline. There has been no effective tool to track the impact of individual learning plans developed for Stage 5 students from ESSAonline data.

With the addition of the Year 10 ESSAonline test, the ESSAonline process has been expanded to comprehensively facilitate two distinct but related processes. The Year 8 test provides data that can be used by teachers and faculties to reflect on their practise and improve pedagogy and programming for Stage 4. This same data can be used as a diagnostically to develop individual student learning programs as students move through the Stage 5 curriculum. Although both these processes could be undertaken using data from just the Year 8 test, now the value and effectiveness of the Stage 5 application can be assessed and evaluated.

Within the context of the *achievement-based learning conceptual framework* the full potential of ESSAonline to systemic schools is being under-utilised and the potential for students to gain real and measurable improvements in their learning outcomes is not being realised.
References


ESSAonline is an interactive online science assessment for Year 8 students. In 2014, it was based on content from the NSW Board of Studies Science Years 7–10 Syllabus. The following resource provides materials from ESSAonline 2014 in a print version.

Extended response task 1: Dissolving tablets (6 marks)
Emily read the instructions on a packet of headache tablets. They said to dissolve two tablets in a glass of water but they did not say what temperature the water should be.

Emily wondered, ‘Does temperature make a difference in how quickly the tablets dissolve?’
Write the important steps that Emily should carry out to test her idea.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Explain how Emily’s investigation gives her confidence in her results.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Extended response task 2: I think I can! (6 marks)

A student added a small amount of water to a can. He then placed it over a Bunsen burner until he saw steam.

The following series of photographs come from the video.

![Photograph 1](image1)

![Photograph 2](image2)

![Photograph 3](image3)

![Photograph 4](image4)

![Photograph 5](image5)

Describe what is happening in the video.

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

In terms of particle theory, explain how physical changes and air pressure contribute to the changes in the can.

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________
Extended response task 3: Nicolaus Copernicus (6 marks)

Nicolaus Copernicus was a Polish scholar and astronomer who lived from 1473 to 1543. Here is a diagram that accurately shows what Copernicus thought the positions, sizes and distances were for objects in space.

Nicolaus Copernicus

2. What are two similarities between Copernicus’s model and the model of our solar system that we use today?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Why do scientists change the model of our solar system?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Read the following article then complete items 1 to 8.

**Burn for you**

Devon and Cynthia wanted to find out how much energy is in food. They had seen the labels on food packaging and wondered how scientists had measured the values.

They read some articles on the internet that described appropriate investigations. The basic idea of these investigations was to burn food and use the energy to heat some water. The temperature change of the water was then measured.

Devon and Cynthia found an investigation which suggested using peanuts. They decided to change the investigation because Cynthia has a life-threatening allergy (anaphylaxis) to all nuts. They decided to use chips instead of peanuts.

---

1. Devon and Cynthia changed the investigation to improve safety and reduce the risks by removing a hazard.
   - What was the hazard?
     - chips
     - peanuts
     - the internet
     - safety glasses

2. The role of the photo in the stimulus is to show
   - the equipment required
   - the experiment procedure
   - the setup of the equipment
   - the way to collect the results

3. What is the name of this piece of equipment?
   - beaker
   - test tube
   - conical flask
   - measuring cylinder

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4 What is the scientific understanding that this investigation is based upon?
- Burning food produces energy.
- Water boils when it reaches 100°C.
- Chemical reactions produce new substances.
- Peanuts can cause allergic reactions in some people.

5 Draw lines to match each investigation stage with its feature.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Stage of Investigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controlling the variables</td>
<td>Background research</td>
</tr>
<tr>
<td>Reading articles on the internet</td>
<td>Method</td>
</tr>
<tr>
<td>Deciding to use chips instead of nuts</td>
<td>Results</td>
</tr>
<tr>
<td>Collecting the data during the investigation</td>
<td>Risk assessment</td>
</tr>
</tbody>
</table>

6 Think about the variables that would affect Cynthia and Devon’s investigation.
Which is the independent (changed) variable in this investigation?
- type of chip
- mass of the chip
- volume of water used
- temperature of water after heating

7 How could Devon and Cynthia improve reliability of their investigation?
- use different brands of chips
- use a greater mass of each chip
- increase the number of different types of chips
- test more than one sample of each type of chip

8 Devon and Cynthia will write a report on their investigation.
What will Devon and Cynthia include in their bibliography?
- the equipment list
- the list of references they used
- their discussion and conclusion
- the background notes (information) they collected
Why use a pool cover?

A pool cover is a great investment. Over a whole year, a pool can lose up to 5 mm of water each day. By using a pool cover, the water loss is reduced by about 95%.

Pool covers also extend the swimming season by increasing the pool’s water temperature by up to 8°C.

A well-fitted pool cover keeps dirt, leaves and insects out of the pool. This also helps the cleaning equipment to keep the water suitable for swimming.
9. Choose yes or no for each reason to answer the following question:
   According to the article, what are the reasons that a pool cover is a great investment?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>prevents water loss</td>
<td></td>
</tr>
<tr>
<td>saves energy</td>
<td></td>
</tr>
<tr>
<td>keeps the pool cleaner</td>
<td></td>
</tr>
<tr>
<td>extends use of the pool</td>
<td></td>
</tr>
</tbody>
</table>

10. Using a net to remove leaves and insects from a pool is an example of:
   - chromatography
   - filtration
   - sedimentation

11. Swimming pools would lose most water during:
   - cool and cloudy days
   - cool and windy days
   - warm and cloudy nights
   - warm and windy days

12. On a hot day, the water on the surface of a pool would most likely undergo:
   - a physical change
   - a chemical change
   - no change

13. Gaseous water is less dense than liquid water because particles in gaseous water are:
   - closer together
   - further apart
   - smaller in size
   - larger in size

14. On hot days, water particles in the pool collide into each other more often because the water particles:
   - have more energy
   - have less energy
   - get larger as the pool warms up
   - are made as the pool warms up

15. What is one environmental impact of covering a pool?
   - Australia would have fewer droughts.
   - There would be more water in dams.
   - People could swim for more months in the year.
   - Swimming pools would stay clean and leaf-free.

16. Pure water has the chemical formula H₂O.
    What type of chemical substance is pure water?
    - compound
    - element
    - mixture
Spray-on skin cells

Dr Fiona Wood is a leading Australian plastic surgeon. She has developed a product called ReCell, which is an aerosol spray that spreads skin cells over a wound. ReCell is an important invention for the treatment of burns.

Burns are serious injuries because they can damage large areas of skin. The burns need to be covered quickly to reduce infections and encourage growth of new cells for healing. This also helps patients feel better and reduces the amount of scar tissue that forms on the burnt skin.

In the past, it took about 21 days to make enough skin cells to cover a major burn. However, ReCell can be applied at the bedside in about 30 minutes. Dr Wood’s skin cell spray helps heal the wound quickly and is now used by surgeons around the world.

Dr Fiona Wood was named Australian of the Year in 2005 for her ground-breaking work. She is considered to be a ‘living treasure and biotechnology innovator’.
17. Choose true or false for each answer to the following question:

Why is ReCell a technology?

<table>
<thead>
<tr>
<th>True</th>
<th>False</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scar tissue forms when ReCell is used.</td>
<td></td>
</tr>
<tr>
<td>ReCell is easy to apply to wounds.</td>
<td></td>
</tr>
<tr>
<td>ReCell reduces the chance that harmful bacteria can enter through the skin.</td>
<td></td>
</tr>
<tr>
<td>ReCell improves the lives of burns patients.</td>
<td></td>
</tr>
</tbody>
</table>

20. Which statement is correct?
- Cells are made up of organs.
- Cells are made up of tissues.
- Tissues are made up of cells.
- Tissues are made up of organs.

21. Choose yes or no for each purpose to answer the following question:

What are the purposes of this article?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>to show how improvements in technology impact on society</td>
<td></td>
</tr>
<tr>
<td>to give reasons why society should support scientific research</td>
<td></td>
</tr>
<tr>
<td>to show that scientific arguments are different from legal ones</td>
<td></td>
</tr>
<tr>
<td>to explain the advantage of using models in science to explain phenomenon</td>
<td></td>
</tr>
</tbody>
</table>

18. Skin is part of the excretory system. Therefore, one role of the skin is
- to break down food
- to spread oxygen around the body
- to remove wastes from the body
- to let people move

19. Here is a diagram of a skin cell.

What is the role of the part labelled X?
- to store food for the cell
- to control the functioning of the cell
- to store chemicals that make food for the cell
- to control the movement of substances into and out of the cell
Popcorn bounce!

Katie and Martin had loads of fun when they conducted an investigation to see if uncooked popcorn could be made to "bounce" up and down.

Katie knew that vinegar reacts with bicarbonate of soda to make carbon dioxide. So, they dropped some uncooked popcorn into some vinegar, sprinkled in some bicarbonate of soda and watched what happened.

Katie and Martin were so pleased with the results that they decided to repeat the experiment. This time, they doubled the amount of bicarbonate of soda, which produced more bubbles.

The series of photographs comes from a video of Katie and Martin's investigation.
22 Katie and Martin gathered their data by making
  ○ inferences
  ○ predictions
  ○ explanations
  ○ observations

23 What equipment should be used to measure 220 mL of vinegar?
  ○ beaker
  ○ measuring spoon
  ○ measuring cylinder

24 When Katie and Martin combined the vinegar and popcorn, they made
  ○ a compound
  ○ an element
  ○ a mixture
  ○ a pure substance

25 Number each box to show the order of the observations from the experiment.
   Begin with '1' for the first observation in the sequence.
   □ The popcorn travels to the top of the beaker.
   □ Bubbles form on the popcorn at the bottom of the beaker.
   □ Gas forms when bicarbonate of soda is added to vinegar.
   □ Gas bubbles on the popcorn burst.
   □ The popcorn sinks to the bottom of the beaker.

26 Look at the diagram.

What will happen to the popcorn labelled A?
  ○ It will float to the top of the beaker.
  ○ It will sink to the bottom of the beaker.
  ○ It will float in the middle of the beaker.
Expanding joints
When objects get hot, they expand. Expansion joints are spaces that allow expansion to occur without causing damage. There are expansion joints in many places. To stop railway lines buckling, they have spaces between each length of rail. When builders lay concrete over large areas, they leave small gaps between each section of a slab. This stops the concrete cracking. Pipes carrying hot substances also expand so rubber rings are placed between each length of pipe. Bridges usually have expansion joints made from metal.
27 Look at the photograph of the railway tracks.

What would happen if the weather got colder?
- There would be no change.
- The rails would start to buckle.
- The gap between the rails would get larger.
- The gap between the rails would get smaller.

28 Roads, concrete and railway lines use air-filled gaps in their expansion joints because air particles
- change their shape
- can be compressed together
- get smaller when heated
- have less energy when heated

29 The diagrams show particles in a gas, a solid and a liquid.
Which diagram represents a solid?

30 Choose true or false for each answer to the following question:
What usually happens when a solid gets warmer?

<table>
<thead>
<tr>
<th>Statement</th>
<th>True</th>
<th>False</th>
</tr>
</thead>
<tbody>
<tr>
<td>It gets bigger.</td>
<td></td>
<td>☐</td>
</tr>
<tr>
<td>It changes shape.</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>It increases in temperature.</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>It gains energy.</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
What does your heart do?

Ancient Egyptians thought the heart was where emotions and thoughts occurred. The ancient Greeks believed the heart contained the soul or spirit. Traditional Chinese culture relates the heart to happiness. What do you think your heart does?

William Harvey was the first person to scientifically describe the heart as the pump that moves blood around and around the body.

Dr Harvey collected information about the heart and blood while working at St Bartholomew’s Hospital in London. He tested his ideas by dissecting many animals, such as molluscs, insects, reptiles, fish, birds and mammals, including dead humans.

He published his results in 1628 but many other doctors and scientists rejected his explanations. Harvey thought that experiments, such as the one in his drawing, showed that blood vessels from the heart (called arteries) must join up with blood vessels returning to the heart (called veins).

When Harvey died in 1657, aged 79, his ideas still had not been accepted. This changed when, in 1661, Marcello Malpighi used a microscope to discover capillaries in a frog’s lung. Capillaries are tiny tubes that join arteries and veins.
31. The main function of the human heart is to
   ○ make blood for the body
   ○ pump blood around the body
   ○ join the arteries and veins together

32. Use information from the article to label the following diagram.
   Use the words artery, vein and capillary as your labels.

33. “Can you find it in your heart to love me?”
   This question uses ideas about the heart that are most similar to
   ○ scientific ideas
   ○ ancient Egyptian ideas
   ○ ancient Greek ideas
   ○ Harvey’s ideas

34. William Harvey did not discover capillaries because
   ○ the technology to see them was not available
   ○ he did not study the right types of animals
   ○ other doctors and scientists rejected his ideas
   ○ he spent too much time looking at other animals and not enough time investigating humans

35. Calculate the number of years between Harvey publishing his ideas and Malpighi finding evidence to support Harvey’s ideas.
   Type your response in the box. Use numbers (not words).
   ________ years

36. Choose yes or no for each answer to the following question:
   What means the same as ‘your heart’s job’ or ‘what your heart does’?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>your heart’s function</td>
<td></td>
<td></td>
</tr>
<tr>
<td>your heart’s properties</td>
<td></td>
<td></td>
</tr>
<tr>
<td>your heart’s characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>your heart’s role</td>
<td></td>
<td></td>
</tr>
<tr>
<td>your heart’s structure</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
37 Which milk provides more energy per serve?
- full cream milk
- reduced fat milk

38 What is the size of a serve of reduced fat milk?
- 113 mg
- 250 mL
- 315 mg
- 458 kilojoules

39 How much more fat does one serving of full cream milk have than one serving of reduced fat milk?
- 4.5g
- 6.5g
- 7.5g
- 11.5g

40 The fat content of milk is measured and published to encourage people to
- drink more milk
- exercise more frequently
- make informed choices about milk
- avoid drinking milk that contains fat

41 The nutritional information about milk is presented in a table. One advantage of presenting data like this is that the tables
- explain cause and effect
- allow comparisons to be made
- make information more accurate
- demonstrate how quickly things change

42 What are the two elements listed in the nutritional information table?
- protein and fat
- sugars and sodium
- sodium and calcium
- sugars and calcium

43 The body system that breaks down milk is the
- circulatory system
- digestive system
- respiratory system
- skeletal system
Look at the following photo then complete items 44 to 49.

**Kata Tjuta**

Kata Tjuta, also known as the Olgas, is a rock formation located in the Northern Territory. It is of great importance to the Anangu Aboriginal people who own the land.

The name, Kata Tjuta, means 'many heads'. This name comes from the 32 rock domes that are spread across an area of just over 20 kilometres. This landmark is made of conglomerate rock that has eroded over a long period of time, leaving the formations that are seen today.
44 When the Anangu describe how Kata Tjuta formed, it is an example of
- a cultural account
- a historical account
- a scientific account

Use this food chain from the Kata Tjuta ecosystem to answer items 45 and 46.

45 In a food chain, a consumer gets its energy by
- making its own food
- eating other living things
- breaking down rotting material

46 What will happen to the number of red foxes if a drought causes a shorter grass growing season?
- It would increase.
- It would decrease.
- It would stay the same.

47 Kata Tjuta is composed of conglomerate rock. What type of rock is conglomerate?
- igneous
- metamorphic
- sedimentary

48 Kata Tjuta is red in colour due to the substance Fe₂O₃.
   The substance Fe₂O₃ is an example of
   - a mixture
   - an element
   - a compound

49 What elements are present in Fe₂O₃?
   Indicate yes or no for each element.

<table>
<thead>
<tr>
<th>Element</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>copper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>flourine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iron</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mercury</td>
<td></td>
<td></td>
</tr>
<tr>
<td>osmium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>oxygen</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Catherine Wardrop - the plant illustrator

Catherine Wardrop's job is to draw plants with absolute accuracy.

Compare the photo of the Acacia pubescens plant to Catherine's illustration. Her illustration accurately shows in detail, the appearance of the plant. Look how precisely she has drawn the leaves and the flowers.

Acacia pubescens drawn by Catherine Wardrop

Photograph of the Acacia pubescens
50. If Catherine Wardrop produced an illustration of this small fern, the scale she would use would be in
   - centimetres
   - kilometres
   - metres

51. What instrument is used to look at the finer detail of plants?
   - binoculars
   - computer
   - microscope
   - telescope

52. Catherine Wardrop is a plant illustrator who works with botanists. What scientific field do botanists work in?
   - biology
   - chemistry
   - geology
   - physics

53. What would cause the plant samples to rot?
   - The sample is replacing its nutrients.
   - Sunlight can no longer reach the sample.
   - Microorganisms breaking down the sample.
   - The sample no longer able to obtain oxygen.

54. A paramecium is classified as an animal. Which cell structures would be found in both paramecium and plant cells? Draw lines to match each part of the plant to its role.

<table>
<thead>
<tr>
<th>Role</th>
<th>Part</th>
</tr>
</thead>
<tbody>
<tr>
<td>to carry out photosynthesis</td>
<td>leaves</td>
</tr>
<tr>
<td>to absorb water and</td>
<td>root</td>
</tr>
<tr>
<td>nutrients from the soil</td>
<td></td>
</tr>
<tr>
<td>to support the leaves</td>
<td>stem</td>
</tr>
</tbody>
</table>

55. What feature does a scientist use to classify plants?
   - the plants’ habitat
   - the plants’ locations
   - the plants’ scientific names
   - the plants’ structural features

56. What materials are required for photosynthesis?
   - water and glucose
   - oxygen and glucose
   - water and carbon dioxide
   - carbon dioxide and oxygen

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Read the following article then complete items 57 to 65

Earth’s ‘cosy blanket’

The atmosphere contains a number of gases, often in tiny amounts, which trap the heat given out by the Earth.

The balance of these gases in the atmosphere helps to maintain the Earth’s temperature.

57. This model shows the Sun as a source of
   - life
   - energy
   - the atmosphere
   - greenhouse gases

58. The arrows in this model represent
   - heat
   - particles
   - air currents

59. What are two limitations of this model?

<table>
<thead>
<tr>
<th>Limitation</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Sun is shown as being very close to the Earth.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The model shows that heat can travel through space.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The model suggests that the atmosphere is made of particles.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The atmosphere is shown as an uniform layer that doesn’t change.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
60 Heat energy moves through space by
- conduction
- convection
- radiation

61 Which of the following are greenhouse gases?
Choose yes or no for each gas.

<table>
<thead>
<tr>
<th>Gas</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>carbon dioxide</td>
<td></td>
<td></td>
</tr>
<tr>
<td>methane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>nitrogen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>oxygen</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

62 What will happen if there is more
greenhouse gas in the atmosphere?
- Less heat will escape into space.
- More heat will escape into space.
- Earth’s surface will receive less energy from the Sun.
- Earth’s surface will receive more energy from the Sun.

63 The oxygen in the atmosphere comes from
- animals
- plants
- rainfall
- volcanoes

64 Pie charts are used to represent this type
of information because
- it is the most accurate graph
- it shows the proportion of gases
- the gases all have different amounts
- each graph has different information

65 Use the following gases to add labels to
the pie chart to identify the gases in the
atmosphere.
Nitrogen
Other gases
Oxygen
Read the following article then complete items 66 to 72.

Wind turbines produce water

In Australia, wind turbines are used to make electricity. Recently, scientists have developed a special type of wind turbine called an Eco turbine that can also extract the water vapour from the air. A prototype located in the dry desert of Abu Dhabi has been extracting between 500 and 800 litres of clean, fresh water every day from the air.

66 Which branch of science must be studied by the engineers who design wind turbines?
- astronomy
- biology
- geology
- physics

67 What wind speed produces the most efficiency in the wind turbine?
- 1 m/s
- 8 m/s
- 12 m/s
- 26 m/s
68. The wind turbines are not 100% efficient. This is because:
   - Energy is given off as light.
   - Wind energy turns the turbine blades.
   - Energy is 'lost' as heat through friction.
   - The energy converts carbon dioxide from the atmosphere.

69. What is the maximum power generated by the wind turbine?

70. Which of these is an advantage of wind power over solar power?
   - The energy is free.
   - Electricity can be generated at night.
   - Wind power releases less greenhouse gases.
   - Wind power can have fossil fuels as backup.

71. Use economic, legal, or scientific to classify each argument about using turbines.

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>One modern wind turbine</td>
<td>Saves over 2000 tonnes of carbon dioxide emissions each year.</td>
</tr>
<tr>
<td>The NSW Government</td>
<td>Requires that 20% of electricity must come from renewable sources by</td>
</tr>
<tr>
<td></td>
<td>2020.</td>
</tr>
<tr>
<td>Farmers can earn extra income</td>
<td>By having wind turbines on their land.</td>
</tr>
</tbody>
</table>

72. Why do Australians need to use electricity that comes from renewable resources?
   - Wind farms are cheap to build.
   - Australia has a shortage of coal.
   - Renewable energy sources are more efficient.
   - Burning coal emits large amounts of greenhouse gases.
Look at the following photos then complete items 73 to 78.

Coal mine explosion

Image 1  Image 2

Image 3  Image 4

Image 5  Image 6

QLD Resources Council: Coal Peat Energy Harvest

stockpile  crusher  furnace

electricity  generator  turbine

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73 Why is coal classified as a sedimentary rock?

- It is made from dead plants.
- It contains black mineral crystals.
- It is made up of layers compacted together.
- It forms when plants are heated and then cooled.

74 Why is coal a non-renewable resource?

- It is in constant supply.
- It can be easily replaced.
- It takes a long time to form.
- It is made from plant material.

75 A scientific argument for planting more trees in the environment is

- People prefer to live among trees.
- Trees can be grown and sold as timber.
- Trees absorb carbon dioxide emission from coal power stations.
- Governments legislate that mining companies must reforest the land.

76 Number each box to show the order of steps that occur in the coal fired energy plant.

- Steam moves from the furnace to the turbine which then turns the shaft.
- Coal moves into the crusher from the stockpile.
- Electricity travels along power lines to your home.
- Cold water heated inside the furnace.
- Electricity is made inside the generator.

77 Draw lines to identify a type of energy present in different parts of the power plant.

<table>
<thead>
<tr>
<th>Part of the power plant</th>
<th>Type of energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>in the furnace</td>
<td>heat</td>
</tr>
<tr>
<td>the shaft of the turbine</td>
<td>electrical</td>
</tr>
<tr>
<td>leaving the generator</td>
<td>kinetic</td>
</tr>
</tbody>
</table>

78 What would be one impact if people stopped burning fossil fuels?

- Less oxygen available for plants.
- Less oxygen for animals to breathe.
- Less carbon dioxide released by plants.
- Less carbon dioxide released into the air.
Read the following article then complete items 79 to 82.

Bungeeeee!

Brett wanted to go bungee jumping during the holidays.

However, he was worried about how far the rubber band would stretch before it snapped.

Brett wondered how the width of a rubber band would affect how far it stretches.

He set up the following apparatus to investigate this idea.
79. The name of this piece of equipment
- clamp
- retort stand
- boss head
- metre stick

80. Brett measured the unstretched rubber band to be 8.1 centimetres.
   How many millimetres is this?
   - 0.8
   - 8.1
   - 81
   - 810

81. How can the trend in the graph above be described?
   - As the rubber band stretches it causes the mass to increase.
   - As the rubber band stretches it causes the mass to decrease.
   - As the mass is increased it causes the rubber band to stretch.
   - As the mass is increased it causes the rubber band to contract.

82. How many millimetres will the rubber band stretch if a total of 600 g were placed on it?
   Write your answer into the box.
ESSA 2014 student survey

We would like to know what you think about this science test and about science. This survey is not a test and there are no right or wrong answers. Your responses will be kept confidential so please answer as honestly as you can.

Complete this survey about science

I am interested in science.

I know about many careers that are based on science.

I want to study a science subject in Years 11 and 12.

Our knowledge about science is constantly changing.

Science helps me to make decisions about things in my life.

Science impacts on many aspects of my everyday life.

Protecting the environment for the future is my responsibility.

Science provides information about today’s important issues.

Science helps me to understand the world around me.

Complete this survey about the test and science lessons

The test was about what I learn in science class.

The test was easier than I expected.

I enjoyed doing the test.

Literacy is important in learning science.

It is important that all students learn science in Years 7 to 10.

Science is the hardest subject that I learn.

In primary school, I enjoyed lessons that were about science.

In secondary school, I enjoy science lessons.

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Which part of the test did you like best? Choose one.
- Dissolving tablets
- I think I can!
- Nicolaus Copernicus
- Burn for you
- Why use a pool cover?
- Spray-on skin cells
- Popcorn bounce!
- Expanding joints
- What does your heart do?
- Have you had your milk today?
- Kata Tjuta
- Wind turbines produce water
- Earth's cosy blanket
- Coal
- Bungeeeee!

Why did you like this part? Choose one reason.
- It was interesting.
- It was easy to understand.
- It was about a familiar topic.
- The test items were easy.
- I liked the pictures in this part.
- I learnt something new.

Complete this survey about your school subjects

My three favourite school subjects are
- Aboriginal Education
- Agriculture
- Dance
- Design and technology subjects
- Drama
- English
- Geography
- History
- Language studies
- Mathematics
- Music
- PDMPE
- Science
- Visual arts subjects
- Any other subjects

The three school subjects I think I learn most in are
- Aboriginal Education
- Agriculture
- Dance
- Design and technology subjects
- Drama
- English
- Geography
- History
- Language studies
- Mathematics
- Music
- PDMPE
- Science
- Visual arts subjects
- Any other subjects
### Framework strands and syllabus outcomes

This framework has been developed using the SOLO Taxonomy to reflect a developmental learning process as demonstrated by student responses. It refers to the content for Stages 3, 4 and 5 of the NSW Board of Studies Science K-10 Syllabus and this section “Physical World” is related to the following outcomes. Stage 2 content has been placed in the Ikonic Mode without further differentiation into levels.

<table>
<thead>
<tr>
<th>Stage 2</th>
<th>Stage 3</th>
<th>Stage 4</th>
<th>Stage 5</th>
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</thead>
<tbody>
<tr>
<td>ST2-6PW identifies ways heat is produced and that heat moves from one object to another</td>
<td>ST3-6PW describes how scientific understanding about the sources, transfer and transformation of electricity is related to making decisions about its use</td>
<td>SC4-10PW describes the action of unbalanced forces in everyday situations</td>
<td>SC5-10PW applies models, theories and laws to explain situations involving energy, force and motion</td>
</tr>
<tr>
<td>ST2-7PW describes everyday interactions between objects that result from contact and non-contact forces</td>
<td>ST3-7PW uses scientific knowledge about the transfer of light to solve problems that directly affect people’s lives</td>
<td>SC4-11PW discusses how scientific understanding and technological developments have contributed to finding solutions to problems involving energy transfers and transformations</td>
<td>SC5-11PW explains how scientific understanding about energy conservation, transfers and transformations is applied in system</td>
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</tbody>
</table>

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251
<table>
<thead>
<tr>
<th>Contact Forces and Motion</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
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<tbody>
<tr>
<td>describe the effect of forces on the behaviour of objects CT</td>
<td>identify a change caused by a force e.g. change in speed, direction or shape</td>
<td>predict the effect of forces acting in everyday situations</td>
<td>identify changes that take place when particular forces are acting PW1a.</td>
<td>identify that a change occurs when forces are unbalanced</td>
<td>identify a situation where balanced forces are acting e.g. standing still</td>
<td>describe one of Newton’s laws</td>
<td>predict the effect of unbalanced forces acting in everyday situations PW1b.</td>
<td>analyse qualitatively everyday situations involving motion in terms of Newton’s laws CT PW2d.</td>
</tr>
<tr>
<td>identify a technological development, e.g. for car safety or in footwear design</td>
<td>identify solutions for reducing impacts of forces in everyday life</td>
<td>describe some examples of technological developments that have contributed to finding solutions to reduce the impact of forces in everyday life CT, ICT, KA</td>
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<td><strong>PW1c</strong>.</td>
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<td>describe acceleration as a change in speed</td>
<td>describe qualitatively the relationship between force, mass and acceleration <strong>PW2a</strong>.</td>
<td>relate acceleration qualitatively to a change in speed and/or direction as a result of a force <strong>PW2c</strong>.</td>
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<tr>
<td>identify everyday situations where the direct contact force (friction) affects the movement of objects on</td>
<td>identify that friction produces heat</td>
<td>identifies factors that influence the size and effect of frictional forces</td>
<td>analyse some everyday common situations where friction operates to oppose motion</td>
<td>describes how a specific factor can influence the size or effect of frictional forces</td>
<td>describes how specific factors influence the size and effect of frictional forces</td>
<td>investigate factors that influence the size and effect of frictional forces <strong>PW1e</strong>.</td>
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<tr>
<td>different surfaces, eg a bike or skateboard</td>
<td>and produce heat N PW1d.</td>
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<td>analyse the influence of different factors on the size and effect of frictional forces</td>
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<tr>
<td><strong>Fields and non-contact forces</strong></td>
<td><strong>identify the way gravity pulls objects towards the Earth, eg dropping objects from different heights</strong></td>
<td><strong>identify that the Earth’s gravity pulls objects towards it</strong></td>
<td><strong>identify that the Earth’s gravity pulls objects towards the centre of the Earth</strong> (ACSSU118) PW2e. <strong>describe everyday situations where gravity acts as an unbalanced force PW2f.</strong></td>
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<td><strong>describe mass as the amount of matter in an object</strong></td>
<td><strong>distinguish between the terms “mass” and “weight”</strong></td>
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<td>PW2g.</td>
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</table>

**carry out tests to investigate the forces of attraction between magnets**
- identify that magnets have different ends
- identify a device that has a magnet
- describe the behaviour of magnets when they are brought close together
- links greater force between magnets to them being closer together
- identify a device that has an electro magnet
- label magnets as having North and South poles
- **describe the behaviour of magnetic poles when they are brought close together** PW2h.
- investigate/describe how magnets and electromagnets are used in some everyday devices or technologies used in everyday life CT PW2i.

- identifies a “field” is present for forces acting at a distance
- identify a diagram of a magnetic field
- draw a diagram to represent a field
- use the term “field” in describing forces acting at a distance L PW2a.
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<th>Level 3</th>
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</thead>
<tbody>
<tr>
<td>identify an effect of static electricity</td>
<td>identifies that rubbing an object can produce static electricity</td>
<td>describe that friction can produce static electricity</td>
<td>describe an everyday situation where static electricity can be observed</td>
<td>identify that friction causes objects to acquire electrostatic charge</td>
<td>identify ways/situations in which objects acquire electrostatic charge PW2b.</td>
<td>describe the behaviour of charged objects when they are brought close to each other PW2c.</td>
<td>investigate everyday situations where the effects of electrostatic forces can be observed CT PW2d.</td>
</tr>
</tbody>
</table>

<p>| Electricity generation and impacts | describe how people use scientific knowledge in their work and everyday life to control the movement of heat from one | identify electrical devices | identify different forms of energy | observe and describe how some devices transform (change) electricity to heat energy, light, sound or movement eg hair dryers, | identify objects that possess energy because of their motion (kinetic) or because of other properties (potential) PW3a. | investigate some everyday energy transformations that cause change within systems including motion, | apply the law of conservation of energy to account for the total energy involved in energy transfers and transformations |</p>
<table>
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</thead>
<tbody>
<tr>
<td>object to another eg a pot holder, insulated bags or thermos</td>
<td>light globes, bells and fans L, CT PW1d.</td>
<td>state the law of conservation of energy</td>
<td>electricity, heat, sound and light eg within power plants, electricity grid, cars</td>
<td>PW4a.</td>
<td>identify different ways electricity can be generated L</td>
<td>identify that most energy conversions are inefficient and lead to the production of heat energy eg in light bulbs CT PW4a.</td>
<td>identify that efficiency is a comparison of output and input energies</td>
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<tr>
<td><strong>Electricity generation and impacts</strong></td>
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<td>identify potential risks and demonstrate safe use when using electrical circuits</td>
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<td><strong>PW1a.</strong></td>
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<td>identify an environmental consequence of electricity generation</td>
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<tr>
<td>identify a personal or societal consequence of electricity generation</td>
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<td><strong>KA</strong></td>
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<tr>
<td>describe how scientific knowledge can be used to inform personal and community decisions about the use and conservation of sustainable sources of energy</td>
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<td><strong>(ACSHE217, ACSHE220)</strong></td>
<td>L, CT, KA</td>
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<td>identify an implication on society or the environment if energy conversions are made more efficient</td>
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<tr>
<td><strong>identify values and needs and wants of societal groups associated with using electricity</strong></td>
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<tr>
<td>describe possible implications for society and the environment if energy conversions are made more efficient</td>
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<td>discuss the implications for society and the environment of some solutions to increase the efficiency of energy conversions by reducing the production of heat energy</td>
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<td>discuss, using examples, how the values and needs of contemporary society can influence the focus of scientific research in the area of increasing efficiency of the use of electricity by individuals and society</td>
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<td>identify sustainable sources of research and present ideas about the use of non-</td>
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<td><strong>discuss viewpoints and choices that</strong></td>
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<td>energy</td>
<td>different ways electricity can be generated, eg burning coal or natural gas; hydroelectric, geothermal, wind and wave-generated electricity L PW2a.</td>
<td>renewable energy resources</td>
<td>need to be considered in making decisions about the use of non-renewable energy resources CT, KA PW4d.</td>
<td></td>
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</tbody>
</table>

**Use of electricity in circuits**

- identify the components of a simple circuit
- construct simple circuits incorporating devices, eg switches and light globes PW1c.
- demonstrate the need for a circuit to be complete to allow the transfer (flow) of electricity PW1b.
- draw circuit diagrams containing a number of components
- label circuit diagrams to show transfer of electricity
- identify a series circuit
- identify a parallel circuit
- construct and draw circuits containing a number of components to show a transfer of electricity PW3d.
- construct a circuit from a diagram
- construct parallel circuits
- compare the characteristics and applications of series and parallel electrical circuits PW3c.
<table>
<thead>
<tr>
<th>Level 3</th>
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<td></td>
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<td></td>
<td>construct a series circuit</td>
<td>characteristics of series and parallel circuits</td>
<td>compare the applications of series and parallel circuits</td>
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<td>describe current in terms of energy carried around a circuit</td>
<td>describe voltage in terms of change in potential energy</td>
<td>describe voltage, current and resistance in terms of energy applied, carried and dissipated</td>
<td>describe qualitatively the relationship between voltage, resistance and current</td>
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<td>relate electricity with energy transfer in a simple circuit PW3c.</td>
<td>describe resistance in terms of energy dissipated</td>
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<tr>
<td>Heat energy</td>
<td>Light and sound waves</td>
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<tr>
<td>identify in their environment some different ways in which heat is produced, eg by electricity, burning (chemical) and friction (motion)</td>
<td>identify a shadow</td>
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<tr>
<td>observe the effects of heat moving from one object to another, eg the feeling when hands are placed in warm or cold water</td>
<td>identify materials which block light to form shadows</td>
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<tr>
<td>identify a situation involving radiation</td>
<td>describe the transfer of heat energy by conduction, convection and radiation, including situations in which each occurs PW3b.</td>
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<tr>
<td>identify a situation involving conduction</td>
<td>describe a convection current</td>
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<td>identify a situation involving convection</td>
<td>Light and sound waves</td>
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<tr>
<td>explain, in terms of the particle model, the processes underlying conduction of heat energy PW1a. (part)</td>
<td>explain, in terms of the particle model, the processes underlying convection of heat energy PW1a. (part)</td>
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<td>Light and sound waves</td>
<td>Identify waves as carriers of energy</td>
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<td>identify situations where waves transfer energy PW1b.</td>
<td>Identify situations where waves transfer energy PW1b.</td>
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<td>identify that light either passes through, is absorbed, reflected or scattered by materials</td>
<td>opaque or translucent, based on whether light passes through them, is absorbed, reflected or scattered</td>
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<td>predict how light travels through a range of materials</td>
<td>observe and describe how the absorption of light by materials and objects forms shadows eg building shading</td>
<td>label wavelength of a wave diagram</td>
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<td>describe qualitatively using the wave model, the features of waves, including wavelength, frequency and speed</td>
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<td>identify an optical instrument</td>
<td>identify a technology (optical instrument) that depends on reflection and/or refraction of light</td>
<td>describe the occurrence and some applications of absorption, reflection and refraction in everyday situations CT PW1f.</td>
<td>research, using secondary sources to gather information about science understandings, discoveries and/or inventions that depend on the reflection and refraction of light</td>
<td>describe the properties of radiation in the electromagnetic spectrum</td>
<td>describe uses of different parts of the electromagnetic spectrum in communication and other</td>
<td>relate the properties of different types of radiation in the electromagnetic spectrum to their uses in everyday life including communication technology CT PW1e.</td>
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<td>light and how these are used to solve problems that directly affect people’s lives, eg mirrors, magnifiers, spectacles and prisms CT, SHE, ICT, KA PW2a.</td>
<td>technologies</td>
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<td>identify that sound needs a medium to travel through</td>
<td>describe that sound waves transmit energy via particle collisions</td>
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<td>explain using the particle model, the transmission of sound in different mediums PW1d.</td>
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Appendix 3     Phase 1 Questionnaire

School Name: ________________________________  (You may choose to remain anonymous)

Q1. a) How many times have students from your college sat ESSA either as a pen and paper test or online?

b) In which years did your students sit the test?

<table>
<thead>
<tr>
<th>Year</th>
<th>Please tick</th>
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<tbody>
<tr>
<td>2005 (pilot)</td>
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<tr>
<td>2006 (trial)</td>
<td></td>
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<tr>
<td>2007 (trial)</td>
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<td>2008</td>
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<td>2009</td>
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<td>2010</td>
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<td>2011</td>
<td></td>
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<tr>
<td>2012</td>
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</table>

c) During which of these years were you the coordinator of the faculty?

Q2. a) Do you personally oversee the running of ESSA or do you delegate this responsibility?

b) If you delegate the responsibility who runs ESSA?

Q3. Briefly describe how the ESSA results are shared within the faculty?

Q4. a) To what extent is ESSA data used to inform learning and teaching within the faculty?

No use      Some use made of data    Extensive
b) Do you personally oversee the analysis of ESSA results or do you delegate this responsibility?

c) If you delegate the responsibility, who completes the analysis?

d) Briefly describe who within the faculty contributes to the data analysis and how it is completed.

Q5. a) Have your faculty members been trained in the use of SMART II database?

b) How many Year 8 classes would your school have in any given year?

c) i What percentage of teachers who taught a Year 8 class in any given year be likely to access the ESSA results the following year?

ii How would these teachers use the results?

d) i What percentage of teachers who teach a Year 9 class in any given year be likely to access the ESSA results for their students?

ii How would these teachers use the results?

Q6. a) Do you believe that ESSA has led to improvements in teaching and learning in your faculty?

No                      Some improvement       Yes, definitely

b) If Yes or Some improvement, what evidence do you have to support the claim?

Q7. Have you ever provided feedback about a cohort’s performance in ESSA to any of the following groups and how was the feedback provided?

<table>
<thead>
<tr>
<th>Group</th>
<th>Method of providing feedback</th>
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<tr>
<td>Year 9 Cohort</td>
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<tr>
<td>College Executive</td>
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<tr>
<td>Whole school staff meeting</td>
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<td>Parent Body</td>
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<td>Other (please specify)</td>
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</table>
Q8. a) Are you prepared to be interviewed for 50 – 60 minutes to discuss either:

   i the ways ESSA data is used in your faculty; or

   ii why ESSA data is not used in your faculty?

   No ☐       Yes ☐

   c) If Yes, Name: _____________________
Appendix 4 ESSAonline Curriculum Link
Appendix 5 Information sheet

INFORMATION SHEET

Dear Colleague,

Early in Semester 1 2012, I enrolled in a M. Phil course at The University of Notre Dame Australia and am currently conducting research into the CEO’s use of ESSA Online.

The title of the project is Evaluation of the use of data from Essential Secondary Science Assessment Online and its ability to improve student performance in formal science testing.

The purpose of the study is to find out: if teachers are using the ESSA data; how it is being used; what feedback is being provided to students and how they are responding to it; and if there is any evidence of improvement in student performance in formal testing?

Participants will initially be invited to respond to an online survey designed to identify the level of usage made of ESSA data. This survey can be completed in one of two ways: a) anonymously or b) by identifying that the coordinator would be willing to take part in a subsequent interview. For those coordinators prepared to be interviewed an Informed Consent form will be provided.

After analysis of the online survey, eight coordinators will be invited to take part in a 50-60 minute audio-recorded interview. Information collected during the interview will be strictly confidential and will not be used in any way against the participant in the course of his / her employment. This confidence will only be broken in the instance of legal requirements such as court subpoenas, freedom of information requests or mandated reporting by some professionals. To protect the anonymity of the participant, a code will be ascribed to each of the participants to minimise the risk of identification.

The protocol adopted by the University of Notre Dame Australia Human Research Ethics Committee for the protection of privacy will be adhered to and relevant sections of the Privacy Act are available at http://www.nhmrc.gov.au/

Coordinators who volunteer to be interviewed will be asked to sign a consent form before the interview. Participants may withdraw from the project at any time before the data is analysed.

Interviewees will be offered a transcript of the interview, and asked to validate that the transcript is a true representation of the interview.

Data collected will be stored securely by the Catholic Education Office for five years, after which it will be destroyed. No identifying information will be used and the results from the study will be made available to all participants.
Data collected by the study may be used to review the CEO’s involvement in ESSA. Funding of $3000 has been provided by CEO to help cover the costs of the study.

The Human Research Ethics Committee of the University of Notre Dame Australia has approved this study. If you have any concerns or complaints regarding the way this research has been conducted, you can contact the Human Research Ethics Committee, Research Office, The University of Notre Dame Australia on (08) 9433 0964; fax (08) 9433 0544 or email research@nd.edu.au

I thank you for your consideration and hope you will agree to participate in this research project.

Yours sincerely,
Gary Carey
Tel: 0458 230 991 Email: gary.carey@syd.catholic.edu.au

If participants have any complaint regarding the manner in which a research project is conducted, it should be directed to the Executive Officer of the Human Research Ethics Committee, Research Office, The University of Notre Dame Australia, PO Box 1225 Fremantle WA 6959, phone (08) 9433 0943, research@nd.edu.au
Appendix 6 Consent forms

Evaluation of the use of data from Essential Secondary Science Assessment Online and its ability to improve student performance in formal science testing.

INFORMED CONSENT FORM

I, (participant’s name) _________________________________ hereby agree to being a participant in the above research project.

- I have read and understood the Information Sheet about this project and any questions have been answered to my satisfaction.
- I understand that I may withdraw from participating in the project at any time without prejudice.
- I understand that all information gathered by the researcher will be treated as strictly confidential, except in instances of legal requirements such as court subpoenas, freedom of information requests, or mandated reporting by some professionals.
- I understand that the protocol adopted by the University Of Notre Dame Australia Human Research Ethics Committee for the protection of privacy will be adhered to and relevant sections of the Privacy Act are available at http://www.nhmrc.gov.au/
- I agree that any research data gathered for the study may be published provided my name or other identifying information is not disclosed.
- I understand that I will be audio-taped.

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<th>PARTICIPANT'S SIGNATURE:</th>
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<tr>
<th>RESEARCHER’S FULL NAME:</th>
<th>ASSOC. PROF. KEVIN WATSON GARY EDWARD CAREY</th>
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<tbody>
<tr>
<td>RESEARCHER’S SIGNATURE:</td>
<td>DATE:</td>
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</table>

If participants have any complaint regarding the manner in which a research project is conducted, it should be directed to the Executive Officer of the Human Research Ethics Committee, Research Office, The University of Notre Dame Australia, PO Box 1225 Fremantle WA 6959, phone (08) 9433 0943, research@nd.edu.au
10 December 2012

Associate Professor Kevin Watson
School of Education
The University of Notre Dame Australia
Sydney Campus

Dear Kevin,

Reference Number: 012100S
Project Title: “Evaluation of the use of data from ESSA online and its ability to improve student performance in formal science testing.”

Your response to the conditions imposed by a sub-committee of the university’s Human Research Ethics Committee, has been reviewed and based on the information provided has been assessed as meeting all the requirements as mentioned in the National Statement on Ethical Conduct in Human Research (2007). Therefore, I am pleased to advise that ethical clearance has been granted for this proposed study.

All research projects are approved subject to standard conditions of approval. Please read the attached document for details of these conditions.

On behalf of the Human Research Ethics Committee, I wish you well with what promises to be a most interesting and valuable study.

Yours sincerely,

Dr Natalie Giles
Executive Officer, Human Research Ethics Committee
Research Office
Appendix 8 CEO Ethics Approval

Catholic Education Office Sydney
www.ceosyd.catholic.edu.au

21 December 2012

Ref: Research Application 824

Gary Carey
12 Dacey Place
DOONSIDE NSW 2767

Dear Gary

RE: RESEARCH APPLICATION REF: 824 — LETTER OF APPROVAL

Thank you for the submission of your application to conduct research in Archdiocesan Catholic Schools under the jurisdiction of the Catholic Education Office (CEO) Sydney. Approval is given by CEO Sydney to conduct this study. This approval is granted subject to full compliance with NSW Child Protection and Commonwealth Privacy Act legislation. It is the prerogative of any Principal or staff member whom you might approach to decline your invitation to be involved in this study or to withdraw from involvement at any time.

Permission is given for you to approach the Principals of the schools nominated, listed below, requesting participants for your study: “Evaluation of the use of data from Essential Secondary Science Assessment Online and its ability to improve student performance in formal testing”;

Permission to approach 33 Secondary schools as required.

COMMONWEALTH PRIVACY ACT
The privacy of the school and that of any school personnel or students involved in your study must, of course, be preserved at all times and comply with requirements under the Commonwealth Privacy Amendment (Private Sector) Act 2000. In complying with this legislation, the CEO Sydney has decided that, for the purposes of research applications, students are not to be identified by anything other than age and/or gender.

NSW CHILD PROTECTION REQUIREMENTS
It is noted that your proposed study methodology does not involve direct unsupervised contact with students. Approval to conduct this research study in Sydney Archdiocesan Catholic Schools under the jurisdiction of the CEO Sydney is granted subject to the researcher’s full compliance with the ‘Commission for Children and Young People Act 1998’.
FURTHER REQUIREMENTS
When you have established your participating schools, please complete the attached form and return it to this office.

It is a condition of approval that when your research has been completed you will forward a summary report of the findings and/or recommendations to this office as soon as practicable after results are to hand.

All correspondence relating to this Research should note ‘Ref: Research Application 824.’

Please contact me at this office if there is any further information you require. I wish you well in this undertaking and look forward to learning about your findings.

Yours sincerely

[Signature]

Dr Katarina Tuinamuana
Coordinator of Research
E: katarina.tuinamuana@syd.catholic.edu.au