Teaching secondary science with data loggers: the NSW experience

Kenneth R. Silburn
University of Wollongong


This paper is posted at Research Online.
NOTE

This online version of the thesis may have different page formatting and pagination from the paper copy held in the University of Wollongong Library.

UNIVERSITY OF WOLLONGONG

COPYRIGHT WARNING

You may print or download ONE copy of this document for the purpose of your own research or study. The University does not authorise you to copy, communicate or otherwise make available electronically to any other person any copyright material contained on this site. You are reminded of the following:

Copyright owners are entitled to take legal action against persons who infringe their copyright. A reproduction of material that is protected by copyright may be a copyright infringement. A court may impose penalties and award damages in relation to offences and infringements relating to copyright material. Higher penalties may apply, and higher damages may be awarded, for offences and infringements involving the conversion of material into digital or electronic form.
Teaching secondary science with data loggers: the NSW experience

A thesis submitted in partial fulfillment of the Requirements for the award of the degree

Doctor of Education

from

University of Wollongong

by

Kenneth Raymond Silburn
BSc (Macquarie), Grad Dip Ed (Sydney CAE), MEd (UWS)

Faculty of Education

2008
Teaching secondary science with data loggers: the
NSW experience

Candidate : Ken Silburn
Student number:  9838639
University of Wollongong
Research Thesis for the Doctor of Education Degree

Supervisors : Dr. Brian Ferry
Dr. Sue Bennett

Date of Submission: 8 October 2008
Research Thesis for Doctor of Education degree

Teaching secondary science with data loggers: the NSW experience

Candidate: Ken Silburn
Student number: 9838639
University of Wollongong
Table of Contents

Declaration.......................................................................................................................... 11
Acknowledgements........................................................................................................... 12
Abstract............................................................................................................................ 13
List of tables....................................................................................................................... 15
List of figures..................................................................................................................... 16
Chapter One: Introduction to the study ................................................................. 18
  1.1 Introduction............................................................................................................. 18
  1.2 Background to the study ....................................................................................... 19
  1.3 Purpose statement ............................................................................................... 21
  1.4 Research questions ............................................................................................. 21
  1.5 Research strategy and context ............................................................................. 21
  1.6 Conceptual framework ......................................................................................... 21
  1.7 Significance and limitations of the study ............................................................ 23
  1.8 Intended Outcomes ............................................................................................. 24
  1.9 An autobiographical note .................................................................................... 25
  1.10 Structure of the thesis ......................................................................................... 25
Chapter Two: Literature review........................................................................... 28
  2.1 Introduction ............................................................................................................ 28
  2.2 Current issues in science teaching ....................................................................... 29
    2.2.1 Science enrolments ......................................................................................... 30
    2.2.2 Teaching science at school ............................................................................ 36
  2.3 Practical work ........................................................................................................ 40
  2.4 Data loggers ........................................................................................................... 47
  2.5 Teaching and Learning with Data loggers ............................................................ 48
  2.6 Student motivation and engagement ...................................................................... 54
  2.7 Barriers to uptaking technology ........................................................................... 56
    2.7.1 Inservice training .......................................................................................... 57
    2.7.2 Preservice training ......................................................................................... 58
    2.7.3 Practical issues in implementation ................................................................. 59
  2.8 Summary and relevance of literature to this study ............................................. 61
Chapter Three: Research methodology ...................................................... 64
  3.1 Introduction ............................................................................................................. 64
  Research questions ....................................................................................................... 64
  3.2 The Research approach ....................................................................................... 65
  3.3 The Design of this Study ..................................................................................... 66
  3.4 Pilot study – data collection and results ............................................................... 68
    3.4.1 First student questionnaire ............................................................................. 69
    3.4.2 Second student questionnaire ....................................................................... 69
    3.4.3 Teacher pilot questionnaire .......................................................................... 70
    3.4.4 Findings from the pilot study applied to the main study ......................... 70
  3.5 Main Study – Data collection and analysis procedures ..................................... 71
    3.5.1 Teacher surveys ............................................................................................ 72
      3.5.1.1 Participants .............................................................................................. 72
      3.5.1.2 Procedures .............................................................................................. 73
      3.5.1.3 Data analysis .......................................................................................... 74
    3.5.2 Teacher interviews .......................................................................................... 74
      3.5.2.1 Participants .............................................................................................. 75
      3.5.2.2 Procedure ............................................................................................... 77
      3.5.2.3 Data analysis .......................................................................................... 77
    3.5.3 Student surveys ............................................................................................... 78
      3.5.3.1 Participants .............................................................................................. 78
      3.5.3.2 Procedure ............................................................................................... 78
      3.5.3.3 Data analysis .......................................................................................... 78
    3.5.4 Student Focus Groups .................................................................................... 79
      3.5.4.1 Participants .............................................................................................. 80
7.2.1 How do teachers currently use data loggers with their students in physics classrooms?

Current usage rates ................................................................. 207
Impact of types of data loggers ......................................................... 209
Rationale for using data loggers .......................................................... 209
Perceived benefits of data loggers ......................................................... 211
Impact on student learning ................................................................. 211
Teachers’ attitudes ........................................................................ 215
Students’ attitudes ........................................................................ 215

7.2.2 What factors influence teachers’ use of data loggers? .............. 217
New technology and complexity ...................................................... 217
Syllabus issues ............................................................................. 218
Teacher confidence ......................................................................... 218
Professional development and teacher training ................................ 218
TILT training .................................................................................. 220
DET Consultants .......................................................................... 221
Teacher experience (community of practice) ................................ 222
Workload and time ......................................................................... 221
Equipment and classroom management issues .......................... 222

7.2.3 What are the implications for integrating data loggers into the science curriculum? 224
Providing adequate resources ......................................................... 225
Type of data logger and purchasing ................................................... 227
Teacher professional development .................................................... 227
Policy .......................................................................................... 228

7.3 Suggestions for further research .............................................. 229

7.4 Conclusions and implications for practice .............................. 229

References ............................................................................... 231

Appendix 1: Pilot study student survey ........................................ 240
Appendix 2: Results of pilot student survey ..................................... 241
Appendix 3: Student survey modification and application .................. 243
Appendix 4: Modified student survey ............................................. 245
Appendix 5: Pilot study teacher survey ........................................... 247
Appendix 6: Elaboration of pilot teacher survey .............................. 249
Appendix 7: Modified teacher survey .............................................. 251
Appendix 8: Teacher survey ............................................................ 253
Appendix 9: Teacher interview questions ....................................... 256
Appendix 10: Student interview questions ..................................... 257
Appendix 11: Business interview questions .................................... 258
Appendix 12: Observation protocol ................................................ 259
Appendix 13: DET ethics request .................................................... 260
Appendix 14: DET ethics approval ................................................... 261
Appendix 15: UOW ethics approval .................................................. 262
Appendix 16: Information sheet principal ....................................... 263
Appendix 17: Consent form principal .............................................. 265
Appendix 18: Information sheet teacher ......................................... 266
Appendix 19: Consent form teacher ............................................... 267
Appendix 20: Information sheet student ......................................... 268
Appendix 21: Consent form student ............................................... 269
Appendix 22: Information sheet parent ......................................... 270
Appendix 23: Information sheet Marker (surveys) .......................... 271
Declaration

I, Kenneth Raymond Silburn, declare that this thesis, submitted in partial fulfilment of the requirements for the award of Doctor of Education, in the Faculty of Education, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other institution.

Ken Silburn
Date 8 October 2008


Acknowledgements

The completion of this thesis would not have been possible without the assistance of a number of people. It is not something that could have been accomplished in isolation.

I am deeply indebted to my supervisors, Professor Brian Ferry and Doctor Susan Bennett whose expert guidance, clear direction, and thoughtful encouragement I have benefited from throughout the course of my doctoral undertaking.

My thanks, too, go to my colleagues who teach science in the classrooms of western Sydney, without whose responses to the surveys, interviews, classroom visits and myriad conversations, this thesis would not have been possible.

I would also like to thank Bernie Fitzpatrick for his assistance in reviewing the draft of this thesis.

To my parents, Ted and Hazel, who have always been interested in what I do and supportive of my love for learning: thank you for the many sacrifices that are now clear to me, and also for instilling in me the value of knowledge and a passion for excellence.

Last, but certainly not least, I wish to thank my family, Jan, Jacqui, Alan, David and Bradley for putting up with the constant distraction of study and the long periods of time that I spent adhered to the computer.
Abstract

Many countries have identified an urgent need to revitalise the way science is taught in secondary schools in an endeavour to increase the number of students electing to study science at senior school and continuing into science-related study at university.

Recent changes to the New South Wales Higher School Certificate Stage 6 Science syllabuses have resulted in a shift towards the use of data acquisition and analysis technology in the science laboratory. Combined with the increase in technology available to schools and the decrease in cost associated with its use, data acquisition equipment and analysis software, such as data loggers, are now seen as an essential part of the science curriculum.

The recent introduction of data loggers into the education system has been implemented despite a lack of empirical research into their effective use. This study addresses this gap in literature by investigating the implementation and use of data loggers in the secondary science classroom from the viewpoint of both students and teachers.

The purpose of the study was to describe how teachers use data acquisition and analysis technology to support student learning in secondary physics. The study also sought to develop descriptions of effective practice in the use of data loggers in secondary physics teaching and also identified the purposes of the different approaches taken by teachers. An anticipated outcome of this research is an improved understanding of how teachers can better facilitate increased student learning through the use of appropriate technology in the classroom.

The study was guided by three key questions:
(1) What is the current impact of data loggers in secondary school physics classrooms?
(2) What factors influence the ways teachers use data loggers with their classes?
(3) What are the implications for integrating data loggers into the physics curriculum?
A mixed method design combining qualitative and quantitative approaches including a combination of survey, interviews and case study research methods was used. Data were collected by surveys and interviews with students and teachers, and classroom observations. Student focus group interviews were carried out under supervision of an appropriate adult, in consultation with the principal.

The study incorporated the researcher’s own school as well as nine other schools in the Campbelltown and Liverpool School Districts of Sydney, New South Wales. Professional people identified as being leaders in the area of data logging and education also were interviewed to triangulate findings from the schools.

The study found that despite the rhetoric exalting their virtues, the implementation of data logger use in NSW schools has not been effective. Survey results indicated that data loggers were almost only used in the senior years of high school. Even though many teachers could identify the advantages of using data loggers in their classes they were not confident in using this technology, and cited a lack of professional development, the cost and scarcity of equipment, and the complexity and problems associated with classroom management of such equipment.

The study also identified cases of best practice and highlighted strategies used by teachers to use data loggers to extend students’ knowledge. The findings have implications for the future implementation of data loggers in schools and suggest avenues for further research.
List of tables
Table 2-1 Comparison of related search criteria for the period 1990-2004 28
Table 2-2 An elaboration of the 5Es teaching and learning model. (Australian Academy of Science 2007) 46

Table 3-1 Greene, Caracelli and Graham’s List of Purposes for Mixed Research (Greene, Caracelli et al. 1989) as in Johnson and Christensen (Johnson and Christensen 2004). 66
Table 3-2 Sequence and timeline 67
Table 3-3 Teachers interviewed 76
Table 3-4 Data collection techniques used in the study 83
Table 4-1 Teacher survey data . 86
Table 4-2 Analysis of data from Question 1.1 87
Table 4-3 Analysis of data from Question 1.2 88
Table 4-4 Analysis of data from Question 1.3 88
Table 4-5 Summary of data for Question 1.4 89
Table 4-6 Use of data loggers in the senior classes (Years 11 and 12, 2001-2003) 89
Table 4-7 Summary of data for Question 2.1 (n= 61). 89
Table 4-8 Comparison of confidence in using data loggers to previous years 90
Table 4-9 Summary of data for question 2.3 (n= 63) (2003). 92
Table 4-10 Comparison to previous years 92
Table 4-11 Rubric for determining the level of use of data loggers 93
Table 4-12 Selected responses to question 2.3a (2003) 94
Table 4-13 Level of use of data loggers by teachers (2003) 94
Table 4-14 Summary of data collected for question 2.4 96
Table 4-15 Summary of data for Question 3.1 97
Table 4-16 Summary of data for Question 3.3 (N= 47) 100
Table 4-17 Summary of teacher attitude to the use of data loggers (2003) 106
Table 4-18 Summary of data for question 3.2 108
Table 4-19 Summary of data for question 3.3 109
Table 4-20 Results of curriculum consultants workshop 115
Table 5-1 Student survey data 122
Table 5-2 Analysis of Question 3 123
Table 5-3 Analysis of data from Question 3 123
Table 5-4 Analysis of data from Question 4 124
Table 5-5 Analysis of data from Question 5 124
Table 5-6 Analysis of data from Question 9 127
Table 5-7 Analysis of data from Question 10 127
Table 5-8 Analysis of data from Question 11 128
Table 5-9 Analysis of data from Question 12 129
Table 5-10 Analysis of data from Question 13 131
Table 6-1 Characteristics of participating schools 168
List of figures
Figure 2-1: Percentage of students selecting science subjects 1997-2005. Source: NSW Board of studies. (NSW Board of Studies, 2001; NSW Board of Studies, 1998; NSW Board of Studies, 1999; NSW Board of Studies, 1997; NSW Board of Studies, 2002; NSW Board of Studies, 2003; NSW Board of Studies, 2005; NSW Board of Studies, 2000; NSW Board of Studies, 2004) 31
Figure 2-2: Percentage of students selecting physics 1976–2002. Source: Australian Council for Educational Research (Masters, 2006) 32
Figure 2-3: Percentage of students selecting chemistry 1976–2002. Source: Australian Council for Educational Research (Masters, 2006). 33
Figure 2-4: Percentage of students selecting biology 1976–2002. Source: Australian Council for Educational Research (Masters, 2006) 33
Figure 2-5: Student retention rates (Centre for Epidemiology and Research, 2003). 35
Figure 2-6: A diagrammatic representation of the path through a recipe task (Ash & Buchanan, 1998). 44
Figure 2-7: A restructured laboratory task that requires learners to plan, design, evaluate, perform and re-evaluate their work (Ash and Buchanan 1998) 45
Figure 3-1: Schematic overview of the study 68
Figure 3-2: Participants and data collection techniques used 72
Figure 6-1: Example of experimental results collected. 182
Figure 7-1: Visual representation of teacher data logging. 213
Chapter One: Introduction to the study

1.1 Introduction

"We need to re-energise science. Unfortunately, secondary school and university students will not continue to fill our science classes just because we, as teachers, are passionate about our subject matter. We need to provide challenging units of inquiry to our students." (Dr Jim Peacock, Australian Chief Scientist, in Tytler page iii (Tytler, 2007))

The current practices in secondary science teaching deter students from selecting science in senior high school as they see science as old fashioned, taught in an old fashioned way, by teachers who only know science from an out-dated perspective that is no longer relevant to the world (Fensham, 2004; Watters & Diezmann, 2004). This has led to a decline in the number of students completing examinable science subjects at upper secondary schools over the last three decades (Mattick, 2002).

The equipment that students use in the laboratory is often inappropriate to demonstrate the principles of science. It is archaic and represents what might have been done historically, but is disconnected from the current laboratory practices of modern scientists. This has lead to students being disengaged in science and hence not electing to choose science subjects in the senior years of secondary schooling (Goodrum, Hackling & Rennie, 2001). As a result there have been calls for changes in the way science is taught so that it better reflects the way scientists work in the real world. Science, it is argued, needs to be taught so that it is challenging to students through the use of up-to-date equipment and a different way of teaching (Devitt, 1997).

Given the decline in student numbers and the way science is currently taught it is no wonder that concerns are being raised about the future of science and science teaching (Lindahl, 2000; Select Committee on Science and Technology, 2002).

One example of an effective application of modern scientific equipment in the school classroom is through the use of data loggers and ICT. Data loggers are electronic instruments designed to detect, record and store measurements of physical phenomena
over a period of time. They can be used either singularly or in conjunction with a computer or graphics calculator to analyse results.

This study investigates the implementation and use of data loggers from the perspective of the teacher, the student, and the New South Wales (NSW), Australia Department of Education and Training (DET). It focuses on the effects of the introduction of data loggers into the science classrooms in NSW public secondary schools and the identification of teaching strategies to support student use in senior secondary physics practical classes. While physics was the main focus of the study, other subject areas within science such as biology, chemistry and general science were also investigated. Currently there are few, if any, other reported studies into the effects of using data loggers in science classrooms in Australia, except for a limited number of local school-based evaluations to assist in curriculum implementation. The study has implications for teacher training and the way in which teachers teach and students learn with data loggers.

This chapter outlines the purpose and context of this study by explaining and developing the background to the study, the setting in which it was conducted, the research strategy adopted, the questions that guided the inquiry, and the significance and limitations of the findings. The final section provides an overview of the remaining chapters in this thesis.

1.2 Background to the study

Using physics as an example, teaching in the past often relied upon ticker tape timers, strobe photography, metre rules and stopwatches for data recording (Christian & Crossley, 1980). This is an outdated approach and does not reflect how physicists currently work. Such an approach gives students the impression that scientists work with outdated equipment and conduct experiments that are old fashioned and irrelevant. Therefore it is not surprising that students are not taking physics in the numbers that they used to.
In response to the need to make science more relevant to students the new NSW Physics syllabus (NSW Board of Studies, 1999) and the recently amended syllabus requires that students use "appropriate data collection techniques, employing appropriate technologies, including data loggers and sensors" (NSW Board of Studies, 2002).

Recent changes to the New South Wales Higher School Certificate Stage 6 Science syllabuses (NSW Board of Studies, 2002) have resulted in a shift towards the use of data acquisition and analysis technology in the science laboratory. In the past, high speed data acquisition technology was a resource found primarily at university level, however a significant reduction in the cost has made it an affordable tool in schools (Mills, 2000).

In 2000, NSW government secondary schools were each given a tied grant of $4000 (Wasson, 2000) specifically for purchasing equipment and resources required for teaching the science courses as described in the new Higher School Certificate (HSC) syllabuses. Most science faculties invested this money in the purchase of data logging equipment. As a result most of these schools have access to data logging equipment, however a survey of 130 teachers showed that only 48 percent had used data loggers in the classroom (Silburn, 2002). Teachers claimed this was due to inexperience, lack of confidence of staff in the technology and the limited amount of time available for training. Over 60 percent of teachers completing the survey indicated that they were not confident in the use of data loggers. The results of the survey also suggested that there was a need to train staff in appropriate strategies for incorporating the use of new technology. Such results highlight the fact that just purchasing the equipment is not enough. Without effective professional development, teachers will be reluctant to use this equipment and it is likely to gather dust in storerooms. The challenge was to get the equipment out of the storeroom and incorporated into effective teaching and learning in the classroom.
1.3 Purpose statement

The purpose of this study is to investigate how teachers use data acquisition and analysis technology to support student learning in secondary school physics. The study will also identify the purposes of the different approaches taken by teachers. It will also develop descriptions of effective practice in the use of data loggers in secondary school physics teaching.

1.4 Research questions

1. What is the current impact of data loggers in secondary school physics classrooms?
2. What factors influence the ways teachers use data loggers with their classes?
3. What are the implications for integrating data loggers into the physics curriculum?

1.5 Research strategy and context

The study adopted a mixed-method approach using surveys, interviews and observations. This permitted the researcher to triangulate data that came from the different perspectives of students, teachers and outside agencies associated with the introduction of data loggers into the science curriculum.

1.6 Conceptual framework

The conceptual framework of this study is based on the view that cognition is distributed across a variety of resources found within classroom learning environments (Watters & Diezmann, 2004). These resources comprise of social, physical, symbolic and intellectual networks (NSW Board of Studies, 1999; Steketee, 2006). The incorporation of ICT can encourage students to become self-directed, self-motivated and skilful learners (Downes, 2002; Lindahl, 2000) and it is anticipated that the effective use of data loggers should efficiently and effectively produce better learning outcomes for students.
In many Western countries science teaching is often based on a constructivist framework (Tytler, 2007; Watters & Diezmann, 2004). This framework has heavily influenced science education for more than two decades (Skamp, 2004). The constructivist view of learning recognises that each learner has a unique experience of the world and this influences how (s)he organises these experiences into knowledge structures and beliefs (Blackburn & Boyle, 1999; Jonassen, 1998). Much of the early work that supported a constructivist approach to learning recognised that students come to class with preconceived ideas and misconceptions based on their interpretations of experiences (Driver, Squires, Rushworth & Wood-Robinson, 1994).

While the term ‘constructivism’ embraces a diversity of views, there is general agreement between theorists that “learning is an active process of constructing rather than acquiring knowledge” and in turn “instruction is a process of supporting that construction rather than communicating knowledge” (Duffy & Cunningham, 1996, p.171).

In a constructivist approach to teaching, the role of the teacher is not just the facilitator, but also an organiser of challenges and experiences for students at their current knowledge base (Hiscocks, 2000; Hofstein & Lunetta, 2004; Jonassen, 1998). This principle guides the way that science teachers should be engaging with students and practical work to bring about effective learning in the classroom.

The aims of science and science education from a constructivist perspective and hence learning science can be considered as learning new ways of making sense of the world and constructing viable models to fit current understandings and experiences (Tobin, 1990).

The conceptual framework guided the data collection and analyses. Data were collected from classroom teachers, expert teachers, outside agencies and students in order to construct an understanding of how data loggers were used in secondary science classes. The key data were organised into case studies based upon teacher and student interviews, classroom observations and field notes.
1.7 Significance and limitations of the study

The use of data loggers in secondary science classrooms is a very recent innovation and has a poor record of implementation (Roberson, 2004; Tan, Hedberg, Koh & Seah, 2006). There is currently limited research available to assist teachers in effective classroom practice using this technology (Tan, Hedberg et al., 2006). The significance of this study is that it will add to the research about how to assist science teachers to effectively use data loggers to support student learning in the classroom.

The findings from this study on the effects of data loggers in the Australian science classroom combine both teacher and student perceptions. Other studies have predominantly focused on case studies highlighting specific activities in which teachers have identified success in using data loggers with classes for example (Adams, 2000; Albergotti, 1994; Aldis-Wilson, 2000; Atar, 2002; Bridge, 1998; Brown, 2001; Carpenter, 1997; Devitt, 1997; Hecht, 1997; Hunt & Dingley, 2002; Krajcik, Arbor & Layman, 1997; McRobbie & Thomas, 1998; Pitt, 2000; Price, 2001). The use of Information and Communications Technology (ICT) in science teaching has been the focus of broader studies for example Information and Communications Technology in the Science Curriculum: an Australian Study and Science (Tebbutt, 1999) and Computer-based Technologies: Attitudes of Secondary Science Teachers (Ng & Gunstone, 2003). It is anticipated that educators and managers of educational institutions will use the findings of this research to inform the effective implementation of data loggers and similar technologies into the school curriculum. Hopefully this will help students to see school science as relevant and reflecting the way that professional scientists work.

Limitations

While the use of a mixed-method approach using surveys, interviews and observations in the formation of case studies allows the researcher to ‘drill down’ from a large sample to a more focused view of the research, it does incorporate a number of limitations such as the inability to generalise from the findings, and the influence of the researcher’s own subjectiveness and the political and social contexts that are apparent at the time of the research.
Due to the political issues associated with teaching, the implementation of a new syllabus and ethical considerations, the researcher was forced to use a sample population that was not typical of the teachers and students of NSW Government public secondary schools. For example teachers were obviously reluctant to participate or have their students participate if they were not using data loggers and hence not fulfilling syllabus requirements. Some schools contacted the researcher, revealing that they had not used data loggers and were embarrassed by this, and hence did not wish to be included in the study.

Furthermore this study relied upon the professionalism and enthusiasm of teachers to volunteer to have their teaching scrutinised by an outsider. Many teachers had recent negative experiences with surveys and reviews from the DET at district level and hence were wary of any further involvement in an activity that may question their professionalism. It was fortunate that this research was seen of value by many teachers so they volunteered to participate. The fact that these teachers did volunteer suggests that they were highly professional and confident to talk about their experiences with data loggers. This opportunistic sampling however decreases the relevance for the findings to be generalised. Thus the findings of this study may not be able to be generalised as applicable to all science teachers in NSW, but rather reports on the implementation and effective use of data loggers in the classroom within a limited number of schools.

This study focuses on the effective use of data loggers in the secondary physics classrooms in NSW schools. It does not address the use of data loggers at the primary or tertiary levels.

1.8 Intended Outcomes

The completion of this project may result in:

- increased awareness of the use of data loggers in the science curriculum;
- descriptions of examples of effective practice in science teaching;
- an understanding of how data loggers can assist learners to construct knowledge about physics concepts;
• an understanding and promotion of physics as a practical subject, relevant to the real world;
• identification of teaching strategies that allow students to generate an understanding of course material through the use of data loggers; and
• an increase in the professional development of science teachers in the use of appropriate technology in the classroom.

1.9 An autobiographical note

The researcher’s own subjectivity is clearly an important factor in the selection of topic, methodology and explanatory theory. This researcher has a history of providing inservice training to science teachers in Western Sydney through the professional organisation LAZSTA (Metropolitan South West Science Teachers’ Association) and has been a member of its senior executive for several years. As well as this the researcher has close ties with the STANSW (Science Teachers Association of NSW) and has also been appointed as a Science Curriculum Consultant for the Department of Education and Training for an 18 month period. The researcher’s work in the area of technology in science education was recognised by the NSW Department of Education with the awarding of a Minister’s Quality Teaching Award, Minister’s Excellence in the Integration of Information and Communication Technologies Award and a NSW Premier’s Scholarship that allowed the researcher to complete the Modelling Physics Instruction Course at the Arizona State University and the PASCO Institute Summer School on technology in science education. The networking that has resulted, both formally and informally, led to the identification of teachers to participate in this study.

1.10 Structure of the thesis

Following this introductory chapter there are six additional chapters. Chapter Two begins with a literature review about current trends in science teaching in relation to data loggers and data acquisition and analysis. Deliberate emphasis has been placed on more recent literature (1990 onwards) due to the relatively new area of educational
technology and the significant advances that have occurred in the area of data acquisition and analysis at the school level.

Chapter Three presents the methodology used in the study, including the rationale for using a mixed-method approach, an explanation of the data collected and how the data were organised and analysed.

Chapter Four details the results of the data collected from the first stage of the research. It provides a background picture of attitudes, beliefs and practices of teachers in the use of data loggers in the classroom and sets the scene for the more detailed view in the following chapters. The first section (4.1) presents the data collected from surveys of teachers attending HSC (Higher School Certificate) and SC (School Certificate) marking centres giving the general perspective of teacher use of data loggers. The second section (4.2) reports on the results collected from surveys collected from teachers trained as trainers for the Technology in Teaching and Learning (TILT) Data Logging course, giving the perspectives of teachers identified by the NSW Department of Education and Training (NSW DET) as proficient users of data loggers. The final sections (4.3 and 4.4) report on the perspective of outside agencies on the use of data loggers from the data collected from a workshop for NSW DET Science Curriculum Consultants and interviews with representatives from companies distributing data loggers to schools.

Chapter Five follows on from Chapter Four by analysing the data collected from the final stages of the research. The first section (5.1) deals with the data collected from surveys of students attending (HSC) study days, giving a student perspective on the use of data loggers. The second section (5.2) reports on the results collected from teacher interviews.

Chapter Six follows on further, presenting the analysis of data collected from selected classes and presented in the form of case studies. Each case study describes how data loggers were used on a school-by-school basis. Participating schools were invited to take part in the case study investigations by allowing the researcher to interview
Chapter Seven draws together the many themes that have emerged in previous chapters and discusses the outcomes of this study, firstly by presenting a summary of the findings in relation to the research questions posed in Chapter One. This is followed by conclusions derived from these findings and their implications for practice. The final section discusses potential directions for further research. The chapter is then concluded with a brief summary.
Chapter Two: Literature review

2.1 Introduction

This chapter examines the literature that provides a background for this study. The first section outlines the evidence that was collected demonstrating the newness of this area and lack of specific research. The second section provides an overview of the current issues facing science teaching both on an international scale and with specific reference to the Australian educational setting. The uniqueness of science teaching in relation to practical work is outlined in Section Three. Sections Four to Six describe data loggers and their effect on teaching and learning, as well as student motivation. Section Seven outlines the problems that have been reported when data loggers are used in the science classroom. The final section summarises the relevant literature reported and sets this study within that body of literature.

A search of literature was conducted to identify relevant literature focusing on technology in science education using the Educational Resources Information Centre database (ERIC) and other educational databases such as the Australian Education Index and the Expanded Academic (ASAP) database. The results of a literature search using various keywords for the period 1990–2004 are shown in Table 2.1 below.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Science and Education</td>
<td>12833</td>
<td>13603</td>
<td>10352</td>
</tr>
<tr>
<td>Technology and Education</td>
<td>8472</td>
<td>13062</td>
<td>10511</td>
</tr>
<tr>
<td>Science, Technology and Education</td>
<td>2024</td>
<td>2421</td>
<td>1876</td>
</tr>
<tr>
<td>Science, Education and Internet</td>
<td>84</td>
<td>614</td>
<td>509</td>
</tr>
<tr>
<td>Science, Education and World Wide Web</td>
<td>2</td>
<td>250</td>
<td>99</td>
</tr>
<tr>
<td>Science, Education and Data Logging</td>
<td>4</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>Data Logging</td>
<td>4</td>
<td>14</td>
<td>6</td>
</tr>
</tbody>
</table>
This search produced numerous papers on the use of the World Wide Web (WWW) / Internet and science education, but the search results demonstrate the lack of research in the area of data logging in science education as compared to other uses of technology in science education. This may be due in part to the newness of this area and the lack of accepted terminology to describe data acquisition technology (Newton, 2000). Furthermore, the sporadic rate of adoption of data logging technology at the time that these reports were written may also have contributed to the low number of articles. There is a strong link between technology and science, however research on the use of technology in the science laboratory has been generally limited to computer assisted learning programs or use of the Internet to share information (Berger, Lu, Belzer & Voss, 1994; Devitt, 1997).

This review of literature specific to the use of data acquisition and analysis tools in science shows limited research prior to 1990. But even though there has been a recent increase in the research associated with this technology, the Australian content is still limited.

The following section summarises current issues in science education and ends with a discussion on the use and implementation of data loggers in science education.

2.2 Current issues in science teaching

The research report on the Status and Quality of Teaching and Learning of Science in Australian Schools (Goodrum, Hackling et al., 2001), based on a comprehensive survey of over 4000 students ranging from Years 5 to 11, was clear in its findings that students were disengaged with science at the secondary level, resulting in a decrease in the proportion of students electing to study science in the non-compulsory years of schooling. In 1980 students enrolled in an average of 1.3 science subjects. By 1988 this had reduced to an average of 0.86.

Despite these negative findings, the report only focused on enrolments in science subjects and not on its comparison to other subject areas. Hobbs and Moroz (2001) found that of the core subjects (English, mathematics, science and social studies) students selected science as being the most liked for Years 8 and 10, and second most
liked in Year 9. Fensham (2004) speculates that the declining interest of students in science may be partly demonstrated as a rebellion of adolescents against school in general, and not specifically against science. This may be so, but teachers have to manage with this as part of their daily practice.

This decline in the overall proportion of students enrolled in science subjects may also be attributed to the increased opportunity for students to select subjects that they feel are more suited to their particular strengths. However, this is still a worrying trend given the increasing numbers of science professionals and teachers required for an ever-increasingly technology-dependent society (Mattick, 2002).

The decreasing numbers of students studying science at the secondary and tertiary levels has been the focus of recent reports (Ainley, 2006; Select Committee on Science and Technology, 2002; Tytler, 2007; Victorian Mathematics and Science Roundtable, 2007). Australian experts, for example Ainley (2006), have called for an urgent “re-thinking of the way science is taught in Australia arguing that a greater focus on enquiry and reasoning is needed to boost students’ waning interest in science.” (p.15). However, there is a view that this is too simplistic as it ignores some of the findings from cognitive psychology. Kirschner, Sweller and Clark (2006) argue that empirical evidence shows that a focus on inquiry and reasoning that is unguided and ill-structured does not facilitate efficient learning. Thus a greater focus on inquiry and reasoning without teacher guidance about how to effectively employ these approaches to teaching and learning may be counter-productive.

Osborne and Dillon (2008) in a recent report on science education in Europe suggest that the current science curriculum does not meet the needs of the majority of students, who will not progress into scientific careers. They argue that whilst education systems concentrate solely on the supply of future scientists and engineers they fail to “offer an education that develops students’ understanding both of the canon of scientific knowledge and of how science functions.” (p.7)

### 2.2.1 Science enrolments

Figure 2.1 shows the percentage of HSC students studying one or more science
subjects from 1997 to 2005. Science subjects include physics, chemistry, biology, earth and environmental science, and senior science.

In 2000 enrolments in science subjects accounted for 63.7% of all student enrolments for the NSW Higher School Certificate (NSW Board of Studies, 2000). Furthermore the number of science subjects available to students was reduced with the removal of two subjects, the 3/4 Unit Science subject and the science subject developed for students not intending to continue onto tertiary studies, Science For Life. With the changes to the syllabus and a reduction in the number of science courses on offer to students this percentage dropped dramatically to 54.6% in 2002 (NSW Board of Studies, 2002). In the past five years there has been an increase in the proportion of students selecting science subjects, although the current proportion is still far below the proportion prior to 2000.

Figure 2-1: Percentage of students selecting science subjects 1997-2005. Source: NSW Board of studies. (NSW Board of Studies, 2001; NSW Board of Studies, 1998; NSW Board of Studies, 1999; NSW Board of Studies, 1997; NSW Board of Studies, 2002; NSW Board of Studies, 2003; NSW Board of Studies, 2005; NSW Board of Studies, 2000; NSW Board of Studies, 2004)
Figures 2.2 to 2.4 show the proportion of Australian Year 12 students studying specific science subjects (physics, chemistry and biology) for the period 1976-2002.

The graphs indicate a dramatic decline in the proportion of students studying science subjects in Year 12 in the early 1980s to almost half the number in 2002.
In a recent review by Fensham (2004) of students’ attitudes to science it was noted that in three separate international studies in England, Sweden, and Australia, students saw school science as focusing on knowledge transmission of correct answers, comprising irrelevant and boring content, and difficult in comparison to other subjects. Furthermore, students considered science a subject chosen in the senior years of high school only by those committed to a career that required it.

Goodrum and Rennie (2007) in the Australian School Science Education National Action Plan acknowledge that the declining proportion of the student cohort enrolling in science at the senior secondary and tertiary levels is an international phenomenon. Furthermore that there is widespread belief that “declining enrolments are due to students’ lack of interest in school science, its perceived difficulty, and their limited understanding of the range of science-related careers and their importance” p 9

Lyons (2004), in a study comprising 196 15-16 year-olds from six NSW high schools, identified four general characteristics of students’ descriptions of secondary science:

• a subject that focused on facts transmitted from expert sources, such as teachers and texts;
• curriculum content was often presented in a de-contextualised manner;
• physics and chemistry were considered the most difficult of the science courses;
• both physics and chemistry were seen as subjects having strategic value in enhancing university and career options, especially with regard to university entrance.

Many science teachers talk of a decline in the number of students electing to study science in the senior years of high school over the last three decades. However, the statistics shown in the recent DETYA (Department of Education, Training and Youth Affairs) report (Goodrum, Hackling et al., 2001) indicate an increase in the total number of students participating in the senior science subjects although the proportion has changed. In 1980, the number of students sitting science subjects for the Higher
School Certificate was 25613. This increased to 32084 in 1998. More recently in 2005 this figure was 37071 (NSW Board of Studies, 2005).

Figure 2.5 shows the retention rate of students, that is the number of full-time students enrolled in Year 12 in a given year expressed as a percentage of their cohort at the commencement of secondary schooling.

Figure 2.5 indicates a dramatic change in the retention rate of students from approximately 28% in the early 1980s to 70% in 2005. Prior to 1980 many students would cease secondary schooling at the end of Year 10 and enter full-time employment. Students remaining at school to complete the Higher School Certificate were generally interested in continuing on to tertiary studies. As a result, most subjects offered to students were directly linked to further academic study. The change in societal and workplace pressures has now resulted in more students remaining at school. The study of the Higher School Certificate is no longer seen as only for students wishing to go on to university. This has resulted in schools now
offering a greater range of subjects to cater for the extra students, including vocational education, that prepare students for the workforce.

The reduction in the number of students studying physics at the senior secondary level has resulted in subsequent low levels of participation in science studies at tertiary level. This trend has been identified by numerous reports (Fensham, 2004; Goodrum, Hackling et al., 2001; Lyons, 2004; Select Committee on Science and Technology, 2002). Thomson (2005) argues that in moving away from the physical sciences and advanced mathematics courses students are limiting their options for entering higher education. In a study of HSC students completing their studies in 1995 and 1998, she found that around 80% of students studying advanced mathematics and physical science went on to higher education compared to around 60% of the students studying the humanities and social sciences.

This trend away from higher education amongst some groups may also be due in part to the large range of options offered to students in their senior years including Vocational Education and Training (VET), TAFE studies, apprenticeships and traineeships. Thomson (2005) argues that many of these new options limit students’ abilities to take up further education, but are required to cater for the diverse range of students who now decide to stay on for Years 11 and 12.

Another flow-on effect of lower enrolments in science at secondary school is the reduction of students completing university training to become science teachers. The situation is even more critical considering the current and expected shortage of qualified teachers of science (Harper, 2007; Ingersoll, 2003).

2.2.2 Teaching science at school
Mattick (2002) points out that there is currently a significant variation in the quality of science teaching and resources for science in Australian schools, ranging from outstanding programs supported by well-qualified and enthusiastic teachers, through adequate programs supported by minimal resources, to a proportion of schools that have no programs in place at all.
A recent study by the Department of Education, Training and Youth Affairs (DETYA) investigating the current status and quality of teaching and learning in science in Australian primary and secondary schools presented a worrying view of current educational practice (Goodrum, Hackling et al., 2001). The authors reported:

The actual picture of science teaching and learning is one of great variability but, on average, the picture is disappointing. Although the curriculum statements in States/Territories generally provide a framework for a science curriculum focused on developing scientific literacy and helping students progress toward achieving the stated outcomes, the actual curriculum implemented in most schools is different from the intended curriculum. (p viii).

This DETYA report also describes student satisfaction with secondary science as low, attributing this to a lack of relevant or engaging teaching and a lack of connection with students’ interests and experiences. The authors argue that traditional chalk-and-talk teaching, copying of notes, and ‘cookbook’ practical lessons offer little challenge or excitement to students.

In general, the teaching of science is still seen as teaching the content of science rather than process of science. Science is presented to students as a body of knowledge that is unequivocal, uncontested and unquestioned (Ainley, 1995). This situation has led to many students not enjoying studying science and concluding that post-compulsory science studies should be avoided unless needed for some career purpose (Fensham, 2006). This trend has been described by Tytler (2007) as a crisis facing Australia and other post-industrial countries as a diminishing proportion of students in the post-compulsory years undertakes science-related studies, particularly in the physical sciences. Furthermore, Aubusson (2007) contends that the educational challenge facing our school systems should be to produce a population well informed and interested in science, arguing that scientific knowledge is essential if people are to participate in and make decisions in modern democracy.

In a recent report by the Victorian Government (Victorian Mathematics and Science Roundtable, 2007) it was noted that Australian attitudes to science are generally positive, with over 80% of Australians surveyed being interested in scientific
discoveries, new inventions and new technologies. It might be interpreted that students choose to study science out of interest, but this is not always the case. Osborne (2006) argues that this situation is the result of a curriculum that has tended to focus on the development of scientists rather than educating future citizens about science. Therefore, students choose science to enhance future career options rather than interest.

In recent years some small changes in the teaching of science have been reported. For example, in discussing the role of textbooks in science education and practical experiences, Weld (2000) talks of a slow shift to science as something students do, rather than something they hear about. This view is supported by Osborne (2006), who argues that there is a growing recognition that a shift in science education towards ideas, evidence and argument is appropriate to meet the needs of the future citizen and the values of contemporary youth. Similar comments were raised in a report by the Nuffield Foundation in 2008 (Osborne & Dillon, 2008). Some states in Australia have recognised this and attempted to use curriculum change to address this issue. For example in NSW, the Stage 6 science curriculum encourages students to see science as something that people do by adopting a contextual approach designed to bridge the gap between theory and the real world. A similar approach has been adopted by Victorian and Western Australia Science curricula (McKittrick, Mulhall & Gunstone, 1999).

Despite the unpleasant future predicted by these reports it is reassuring to note that in a recent study investigating Year 8 science teaching by the Third International Mathematics and Science Study (TIMMS), Australian Year 8 science teaching was found to resemble a model of ideal science teaching (Lokan, 2006). It was reported that Australian students were provided with good opportunities to achieve curriculum goals and to practise several important scientific enquiry skills, such as the collection and interpretation of scientific data.

Of all the science subjects taught, physics is considered to be the most abstruse and theoretical, and it is perceived to be a subject mainly studied by students who are highly intelligent, mathematically inclined and male (McKittrick, Mulhall et al., 1999). Because teachers of physics focus on developing problem-solving skills, it comes as
little surprise that students see physics as a subject that is about formulae, definitions and problems. Although there has been much emphasis on teaching science as a practical subject, researchers consistently report that the major teaching strategy still in use is textbook and teacher-directed writing activities (Gregson, 2000).

Tytler (2007), argues that we need to re-conceptualise the way we teach science in order to effectively respond to the challenges of new times, new students and new circumstances that have fundamentally changed the social setting within which schools and students operate. He argues that the science content taught in schools has not changed significantly since the 1960s and that this is reflected in the content of science textbooks, to which there has been limited change except for the inclusion of coloured diagrams. This is despite the vast increase in scientific knowledge through research on DNA, viruses, global environmental issues, space exploration and modern materials. This knowledge explosion presents significant challenges to the traditional model of the teacher. This model views the teacher as an expert who delivers significant and stable science concepts to dependent students, but we need to move to a model where a teacher is seen as a facilitator of learning by providing avenues for students to obtain relevant and up-to-date scientific information (Tytler, 2007).

Mattick (2002) asserted that the Commonwealth guidelines for the optimal teaching of science and student outcomes of science education are widely acknowledged as progressive and relevant to the needs of the 21st Century, however they are rarely implemented because of factors such as a lack of resources, classroom management problems, teacher workloads, and lack of training and inservice programs. These factors have contributed to a huge disparity between the intended curriculum and its implementation. Mattick (2002) further points out that, despite the innovative curriculum frameworks, the general picture of teaching and learning in Australian secondary schools is still dominated by traditional practices which are assessment-driven, content-based and focused on system-imposed deadlines. At a recent conference, Masters (2006) argued that science teaching was facing a paradox, in that the very courses that had been designed as a rigorous foundation for future science study appear to turn many science students off science. Not only are these courses not meeting the needs of the majority of students, they are also not
producing significant numbers of students wanting to pursue science as a career. This has translated into a substantial decline in the proportion of university students studying physical and materials science at university, resulting in a fall of more than 31% between 1989 and 2002 (Masters, 2006). Furthermore Masters (2006) reported that in 2001, only 1% of tertiary graduates in Australia had specialised in the physical sciences compared with 5.2% in the UK and 2.6% in the OECD nations.

Ferry (2008) argues that although there has been a focus on the learner, mainly brought about by the constructivist movement, there also needs to be an appropriate level of teacher-organised instruction for effective learning to take place. Ferry believes that approaches that focus on the development of expertise that mirrors that of scientists who are experts in their field imposes extra mental work on students (who are non-experts) making learning more difficult. This is supported by other researchers (Kirschner, Sweller et al., 2006) who claim that the process of teaching a discipline using the inquiry method does not work because the practice of experts cannot be effectively mirrored in ways that ensure that novices learn the complex procedures of professionals who are experts in their field.

2.3 Practical work

Laboratory work is firmly enshrined in science curriculum documents throughout Australia, ensuring that direct experience plays at least some role in student learning (Woolnough, 2005). The NSW science curriculum emphasizes the importance of science as a practical subject. The most recent New South Wales Stage 4-5 syllabus (Years 7-10) mandates that practical experiences must occupy a minimum of 50% of allocated course time for students (NSW Board of Studies, 1998). Information and communication technologies are embedded in the content of the draft-amended Science Stage 4-5 syllabus (NSW Board of Studies, 2002) as “using computer-controlled devices such as data loggers to measure, record and test hypotheses and to report findings”. (p. 22) The use of data loggers is also identified as an essential component with the syllabus stating that students "use a range of appropriate technologies [including data loggers] or strategies for collecting data or gathering information". (p. 33)
Laboratory work is seen as an integral part of most science courses and offers an environment different in many ways from that of the ‘traditional’ classroom setting (Henderson & Fisher, 1998) in which teachers typically use didactic methods such as demonstrations and direct instruction. This is usually done by a ‘chalk-and-talk’ method of instruction whereby the teacher is the provider of knowledge and interprets information from a textbook. In the laboratory setting, students are normally broken up into groups in which they carry out recipe-type investigations that illustrate a concept or enable them to test their own theories.

Ash and Buchanan (1998) describe four objectives of science practical work. Practical activities can:

- develop conceptual understanding;
- enhance student motivation and positive attitudes to the subject;
- build manipulative skills; and
- engage students in processes associated with a scientific approach to questions.

The inquiry method using investigations can take many forms and laboratory work may be one of these. The National (US) Science Education Standards (National Research Council, 2000) identifies the following general features of inquiry-based learning in science:

- learners are engaged by scientifically oriented questions;
- learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions;
- learners formulate explanations from evidence to address science oriented questions;
- learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding; and
- learners communicate and justify their proposed explanations. (p 25).

Haury (2001) clarifies that “although in many cases inquiry-based teaching strategies engage students in investigations, it is not the physical activity that defines inquiry. Teaching through inquiry is distinguished by its emphasis on a questioning attitude, 
gathering data, reasoning from evidence, and communicating explanations that can be justified by available data” (pp 2-3).

Rodrigues and colleagues (Rodrigues, Pearce & Livett, 2001) report that the critics of laboratory work argue that:

- it provides a poor ‘return of knowledge’ given the amount of time put in;
- it involves trivial experiments, which supposedly merely verify what students already know;
- when it does use non-trivial experiments these overwhelm the student; and
- students think practical exercises are isolated activities not related to previous work (p 32).

With the many international reports and reviews on science education we are now in a new era of reform, in which both the content and pedagogy of science learning and teaching are being scrutinized (Hofstein & Lunetta, 2004).

Discussions about the effectiveness of science instruction and the value of laboratory investigations are not new. Lazarowitz and Tamir (1994) discuss a text from over 200 years ago addressing the distinctive role and unique potential of the laboratory and the difficulty in obtaining convincing data on the complexity of factors related to the use of practical work. The article by Edgeworth and Edgeworth (1801) discusses the effectiveness of laboratory investigations:

“...The great difficulty which has been found in attempts to instruct children in science has, we apprehend, arisen from the theoretic manner in which preceptors have proceeded. The knowledge that cannot be immediately applied is quickly forgotten and nothing but disgust connected with useless labor remains in the pupil’s mind ... (Pupils’) senses should be exercised in experiments, and these experiments should be simple, distinct and applicable to some object in which the pupils are immediately interested”. (p 294).

The claims by Edgeworth and Edgeworth (1801) that science teaching should be interesting and relevant are still valid today. So what makes a good science learning
environment? Henderson and Fisher (1998) identify five dimensions of student attitudes to the laboratory learning environment and laboratory work as:

1. cohesiveness - the extent to which students help and are supportive to one another;
2. open-endedness - the extent to which the laboratory activities emphasise an open-ended, divergent approach to experimentation;
3. integration - the extent to which the laboratory activities are integrated with non-laboratory and theory classes;
4. rule clarity - the extent to which behaviour in the laboratory is guided by formal rules; and
5. material environment - the extent to which the laboratory equipment and materials are adequate. (p 58).

The effectiveness of science learning environments can be gauged by student attitudes to learning. Henderson and Fisher’s study of students’ attitudes to the laboratory learning environment and laboratory work in 1998 showed that students scored a negative correlation between ‘open-mindedness’ and ‘cognitive outcomes’, which they suggested may be due to the fact that in the minds of HSC students the final examination for university entrance is predominantly content-driven.

There is debate as to the meaning and extent of ‘openness’ (Mills, 2000), with the term ‘openness’ described as having different meanings in different resources. For example, ‘openness’ as described by Lock (1990) refers to the outcome of an investigation and to whether more than one solution or result is possible. However Simon and Jones (1992) argue that ‘openness’ could occur to a varied extent in each of three phases of a practical task:

1. defining the problem;
2. choosing the method; and
3. arriving at solutions.
Many authors (Ash & Buchanan, 1998; Colburn, 2000; Hiscocks, 2000; Jonassen, 1998; McKittrick, Mulhall et al., 1999) describe a move away from the traditional 'recipe task' format of experiments in which students follow a set procedure to obtain the 'correct' result that illustrates a concept or relationship. Shown in Figure 2.6 is a traditional linear approach of introducing the experiment, explaining the purpose, and presenting the instructions or recipe that students follow and obtain a result. If the results are wrong then the experiment is repeated or the teacher explains the correct result for the experiment.

Under this approach, students can acquire the basic skills to manipulate apparatus, but there is little opportunity provided for them to plan, design, evaluate, perform and re-evaluate their own work (Ash & Buchanan, 1998). Yip (2005) contends that the 'cookbook' format of many laboratory manuals is not conducive to the development of skills involved in the process of scientific enquiry as students are too closely guided in what to do, resulting in limited mental engagement and conditioning students to look for the 'right' answer.
A more progressive approach is to require students to plan, design, evaluate, perform, and re-evaluate experiments as depicted in Figure 2.7.

![Diagram](image)

Figure 2-7: A restructured laboratory task that requires learners to plan, design, evaluate, perform and re-evaluate their work (Ash and Buchanan 1998).

This approach is supported by Colburn (2000) who describes a constructivist approach to science teaching: "If students are simply following set procedure, they are not required to use or test their previous knowledge. Their ideas are not challenged" (p 12). Coburn further suggests that students require a classroom where students are engaged occasionally in open-ended activity in which they try using their previous knowledge to answer questions.

However, as Bybee (2006) asserts, the approaches recommended by Ash and Buchanan (1998) require a certain amount of conceptual understanding and basic knowledge. Bybee (2006) further reinforced this view when he argued that in order for students to develop competence in an area of inquiry, they must have a deep foundation of factual knowledge, understand facts and ideas in the context of a conceptual framework, and be able to organise knowledge in ways that facilitate
retrieval and application. In this situation laboratory experiences are interwoven with other types of science learning activities including lectures, reading and discussion. Bybee (2006) supports the Biological Sciences Curriculum Study (BSCS) five phase instructional model comprising engagement, exploration, explanation, elaboration and evaluation. This five phase instructional model is endorsed by the Australian Academy of Science as the preferred instructional model for its Primary Connections Program (Australian Academy of Science, 2007) that promotes an integrated investigative approach to teaching science that connects science to the lives of the students. This is elaborated in Table 2.2. In this process students use their prior knowledge to develop explanations for themselves over time through a variety of learning experiences structured by the teacher. The Academy claims that students use their prior knowledge to make sense of these observations and experiences to make connections between new information and their prior knowledge.

Table 2-2: An elaboration of the 5Es teaching and learning model (Australian Academy of Science 2007).

<table>
<thead>
<tr>
<th>Phase</th>
<th>Purpose</th>
<th>Role of teaching and learning activity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Engage</strong></td>
<td>Create interest and stimulate curiosity. Set learning within a meaningful context. Raise questions for inquiry. Reveal students’ ideas and beliefs, compare students’ ideas.</td>
<td>Activity or multi-modal text used to set context and establish topicality and relevance. Motivating/discrepant experience to create interest and raise questions. Open questions, individual student writing, drawing, acting out understandings, and discussion to reveal students’ existing ideas and beliefs so that teachers are aware of current conceptions and can plan to extend and challenge as appropriate – a form of diagnostic assessment.</td>
</tr>
<tr>
<td><strong>Explore</strong></td>
<td>Provide experience of the phenomenon or concept. Explore and inquire into students’ questions and test their ideas. Investigate and solve problems.</td>
<td>Open investigations to experience the phenomenon, collect evidence through observation and measurement, test ideas and try to answer questions. Investigation of text-based materials (e.g. newspaper articles, web-based articles) with consideration given to aspects of critical literacy, including making judgements about the reliability of the sources or the scientific claims made in the texts.</td>
</tr>
<tr>
<td><strong>Explain</strong></td>
<td>Introduce conceptual tools that can be used to interpret the evidence and construct explanations of the phenomenon. Construct multi-modal explanations and justify claims</td>
<td>Student reading or teacher explanation to access concepts and terms that will be useful in interpreting evidence and explaining the phenomenon. Small group discussion to generate explanations, compare ideas and relate evidence to explanations. Individual writing, drawing and mapping to clarify ideas and explanations.</td>
</tr>
</tbody>
</table>
in terms of the evidence gathered. Compare explanations generated by different students/groups.

Formative assessment to provide feedback to teacher and students about development of investigation skills and conceptual understandings. Small group writing/design to generate a communication product (e.g. poster, oral report, formal written report or PowerPoint™ presentation, cartoon strip, drama presentation, letter) with attention to form of argumentation, genre form/function and audience, and with integration of different modes for representing science ideas and findings.

| Elaborate | Use and apply concepts and explanations in new contexts to test their general applicability. Reconstruct and extend explanations and understandings using and integrating different modes, such as written language, diagrammatic and graphic modes, and mathematics. Further investigations, exercises, problems or design tasks to provide an opportunity to apply, clarify, extend and consolidate new conceptual understandings and skills. 

Further reading, individual and group writing may be used to introduce additional concepts and clarify meanings through writing. A communication product may be produced to re-represent ideas using and integrating diverse representational modes and genres consolidating and extending science understandings and literacy practices. |

| Evaluate | Provide an opportunity for students to review and reflect on their own learning and new understandings and skills. Provide evidence for changes to students’ understandings, beliefs and skills. Discussion of open questions or writing and diagrammatic responses to open questions – may use same/similar questions to those used in Engage phase to generate additional evidence of the extent to which the learning outcomes have been achieved. Reflections on changes to explanations generated in Engage and Evaluation phases to help students be more metacognitively aware of their learning. |

2.4 Data loggers

Data loggers or data acquisition equipment are electronic instruments that can instantly detect, record and store real-world measurements of physical phenomena over a period of time. Equipped with the right type of transducer or sensor, data loggers can measure almost any kind of physical quantity (Aldis-Wilson, 2000). Carpenter (1997) describes many applications of data loggers including use in scientific research, industrial monitoring and control, and as a monitoring device in the food storage industry.

The school curriculum should reflect current use of technology and practice in the real world. The use of data loggers in the classroom is reflective of real world practice being used in scientific and industrial measurement and research. Microcomputer-based data loggers appropriate for educational use have been available for the Apple II
family of computers since the late 1970s. These were cumbersome, with slow processing speeds. System speed was increased in the late 1980s with data loggers becoming available for IBM and Macintosh computers (Sneider & Barber, 1990). These data loggers, however, were often bulky and awkward to use. In many cases computer programming skills were required to operate them. Portable data logging was also available via the use of graphics calculators, although these were limited in their computing power in the early 1990s (Taylor, 1995).

Today, data loggers provide a very effective way to achieve high frequency data sampling. Software turns the computer into a digital meter or chart recorder capable of collecting up to a million samples of data, with the ability to display data and graphs in real time or store it for viewing at a later date.

Sensors connected via an interface can be more reliable and accurate in collecting data than humans (Buecher, 2000; Kreuger & Rawls, 1998). Sensors currently found in schools include those to measure temperature, force, motion, light intensity, sound, pH and voltage. Some schools have invested in extra probes for measuring quantities such as dissolved oxygen content, conductivity and gas pressure (Reuter, 1999). The data logger can also incorporate video images collected from a video camera attached to a computer.

Some data loggers allow students to video record an experiment and collect data using the data logger for simultaneous play-back as a graph is drawn on the screen. This technology is not available to all schools and hence its application in the classroom is beyond the scope of this study.

2.5 Teaching and Learning with Data loggers

Despite the mounting evidence about the integration of computer technology becoming important to education, it appears that education systems still lag behind in technology utilisation (Pinnock, 2006). The potential benefits of using data loggers in the science curriculum have been described by numerous authors (Carpenter, 1997;
The benefits identified by the Curriculum Support Unit (1997) include:

- students can rapidly and accurately collect reproducible data;
- students are encouraged to investigate concepts without becoming lost in the methods used for collecting data;
- students are encouraged to modify experimental designs and rapidly validate the modifications;
- multiple readings can be taken rapidly, allowing students to record data normally out of the limits of traditional experimental equipment;
- multiple readings can be taken, allowing students to investigate processes that must be monitored for extended periods. These do not need to fit into the time constraints of the classroom; and
- students can be evaluated quickly on their ability to process data. (p.107).

Jonassen (1992) suggests that the use of technology can have the effect of either amplifying or augmenting cognition by carrying-out lower-order cognitive tasks, leaving the student free to carry-out more complex tasks. This idea is supported by Newton (2000) who suggests that computer-generated graphs of data provided by the data logger not only lessen the time that students are required to devote to the tedious activity of hand-drawing graphs, but also support a development of the higher order skills of data interpretation including the explanation of anomalous results.

A further benefit of using data loggers is that the data collected can be easily stored and processed, thus providing greater convenience for students. Experiments can be more easily monitored over extended periods without the need for students to be present. Since some conditions change gradually over long periods of time, a data logger can prove more efficient and feasible than manual spot checks (Aldis-Wilson, 2000). This can be convenient for investigating processes such as the change in temperature of a compost bin.

The accuracy of data collected also allows a greater variety of experiments and activities to be carried out. Many authors (Adams, 2000; Bridge, 1998; Brown, 2001; Brown, 2000; Buecher, 2000; Hozberg, 1988; Hunt & Dingley, 2002; Man, 2000; Pitt,
2000a; Pitt, 2000b; Reuter, ; Rogers, 1997; Russel, 1988; Venable, Batra & Hubsch, 2001; Willis, 1998) have demonstrated activities and experiments for use in secondary schools. These include the following investigations:

- accurate determination of the speed of sound;
- the effect of sweating as a cooling mechanism;
- measuring heart rate during exercise;
- determining the salinity of water samples;
- measurement of the contact time between a steel bar and a hammer hitting it;
- a comparison of the cooling of hot water compared to ambient room temperature;
- calculating the acceleration due to gravity;
- determining the concentration of an unknown solution;
- measurement of kinetic energy;
- determining the effect of putting a coat on a snowman;
- comparison of wavelength and frequency of guitar strings;
- measuring student reaction time;
- calculating time for a mousetrap to snap shut;
- analysing the way a ball bounces;
- demonstrating how the induced EMF depends on the rate of change of flux;
- studying the sound of a whistling kettle;
- measuring the rate of a chemical reaction; and
- comparing current and voltage in a circuit.

There is some discussion of data loggers in the professional and practitioner literature. For example, anecdotal evidence presented at a Quality Teaching conference on the implementation of data loggers in a NSW high school (McKay, 2004) indicated that science teachers at the school had identified the following outcomes of using data loggers:

- increase in student motivation;
- better understanding of graphs by Year 7 students;
- students in Year 9 were better able to understand the line of best fit;
- students in Year 10 had a better understanding of motion;
- the majority of teachers were happy to use data loggers;
• the use of the data loggers allowed more time to discuss concepts; and
• teachers were keen to extend their usage of data loggers and were looking for more alternatives activities.

The school was regarded as a showcase of using data loggers, had received considerable funding and had made the use of data loggers a high priority. However as with most of the literature available, it is based on anecdotal evidence or personal observations rather than on formal research to verify the claims presented.

There is also acknowledgement in the literature that in many cases the use of traditional measuring devices may be more appropriate in experiments that rely on initial and final values. For example using an alcohol thermometer to measure initial and final temperatures may be more efficient (Carpenter, 1997).

Research has been conducted to determine how laboratory activities can be enhanced by the use of data loggers (Adams, 2000; Bridge, 1998; Brown, 2001; Brown, 2000; Buecher, 2000; Hozberg, 1988; Hunt & Dingley, 2002; Man, 2000; Pitt, 2000; Pitt, 2000; Reuter, 1999; Rogers, 1997; Russel, 1988; Venable, Batra et al., 2001; Willis, 1998). Most of these have been short qualitative studies that focused primarily on one-off events. There is a scarcity of large-scale longitudinal studies being conducted. It is therefore difficult to ascertain whether the reported benefits of using data loggers in these situations is long-term or a result of the novelty effect. Furthermore, the use of data loggers discussed is often superficial. For example the advantage of speed of data collection or graphing is mentioned but no evidence is presented to support the claim that data logger use increases student learning or understanding.

Despite the number of research reports available that purport to the advantages of using ICT in teaching to stimulate student engagement, Hennessey and colleagues (Hennessy, Ruthven & Brindley, 2005) suggest that relatively few teachers are integrating ICT into their teaching in a way that engages pupils and enriches learning or stimulates higher-level thinking. Although teachers report to have changed their teaching practice, they are often simply using the technology to continue to do what they have always done (Newton, 2000).
The majority of literature reviewed associated a positive effect on the learning environment with the use of data loggers (Carey, 2000; Casazza, 1998; Hayes, Lingard & Mills, 2000; Mee, 2002; Newton, 1998; Rogers, 1997; Rogers & Wild, 1996; Russel, Lucas & McRobbie, 1999). However, there is conflicting evidence as to the effects that the use of data loggers in the classroom may have on student understanding. For example, in a preliminary study conducted in Hong Kong, Ng and Yeung (2000) found that the data logging in the classroom revolved around low level skills, such as data recording and graph plotting, rather than higher cognitive skills such as setting and testing hypotheses and problem solving.

The use of data loggers to undertake graphing has been the focus of some debate. The ability to draw, analyse, and interpret graphs is crucial to the study of science (Adie, 1998; Friedler & McFarlane, 1997) and in the NSW physics HSC syllabus (NSW Board of Studies, 2002) is a component of the key competency ‘using mathematical ideas and techniques’. Ferry and colleagues (Ferry, Hedberg & Harper, 1999) argue that learning to use and interpret graphs are important skills that scientists have to master due to the central role that graphs play in the practice and communication of science. Data logging software can display graphs in real time and can benefit students who are visual learners.

By way of contrast, Friedler and McFarlane (1997) found evidence that the use of data loggers in the classroom resulted in a positive impact on the manual graphing skills for 14-year-olds. Their finding is supported by Mee (2002), who reported on the use of data logging in Leaving Certificate physics in Ireland. Mee noted that the ability of data loggers to give the student immediate feedback by displaying graphs in real time stimulated students to provide explanations, make predictions and spontaneously make links to previously-acquired knowledge.

Rogers (1995) and later Rodrigues et al (2001) contend that the use of the data logger software renders the manual skills involved in collecting, tabulating and plotting data redundant and that the traditional emphasis on manual skills impedes the interpretation and understanding of graphs. Use of data loggers, they claim, allows students to be
freed from the need to record data item by item and the drudgery of graph production, to enabling them to devote more time to making careful observations of the phenomena in the experiment. Rogers (1995) also argues that in using data logging software, there is a great potential to shift the emphasis on student activity away from the gathering of data towards its interpretation. He describes several levels of sophistication in the process of interpreting graphs:

- viewing graphs qualitatively;
- reading values;
- describing variables;
- relating variables;
- making predictions; and
- transforming descriptions into mathematical form (p 32).

It is further argued that the use of ICT such as data loggers enhances student learning as it removes distractions (Rodrigues, Pearce et al., 2001). Rodrigues and colleagues (2001) also contend that using data loggers instead of ticker tape timers in motion experiments could shift student focus from the manipulation of strips of paper to the implications of graphical data that appear on the screen.

Some authors, such as Beare and Hewitson (1996), recommend the use of Microsoft Excel™ to analyse data collected by students, however data analysis software bundled with data loggers allows students to complete higher order analyses of graphs such as curve-fitting including straight line, parabolic, exponential, inverse and inverse square relationships without the need to redraw the graph.

The use of data loggers to record and analyse data means that more time is available for a constructivist approach to leaning. There is also a reduction of time required in the analysis of data as it can be analysed graphically in real time. Thus further reduces the time normally used in lower order tasks such as drawing graphs (Newton, 1997; Rogers, 1997). The additional time can be used to support constructivist approaches as described by Ash and Buchanan (1998) and Jonassen (1998) which requires more time for discussion and reflection at the group and class level, but it is claimed that student understanding is enhanced.
2.6 Student motivation and engagement

If the use of data loggers increases student motivation and improves students’ perceptions of the relevance of science to their lives then the use of data loggers is warranted. Numerous authors have reported an increase in student motivation when students were able to use data loggers (Atar, 2002; Barton, 1993; Grant, 1999; Jarvela, 2003; Man, 2000; Price, 2001; Rogers & Portsmore, 2001). Kreuger and Rawls (1998) reported that using data loggers in classrooms for low socio-economic status, low-achieving, and learning-disabled students resulted in students learning significantly faster, enjoying classes more, and showing a more positive attitude towards the use of technology. Man (2000) suggests that the use of data loggers assists teachers to engage students in student-centred problem-based learning involving hands-on scientific investigations with the use of information technology.

Nadelson (1995) described an example of how students’ motivation was increased with the use of thermocouples connected to a computer-interface to conduct temperature related experiments, such as determining the effect of different waxes and candle composition on the flame of a candle. Nadelson reported that the use of the data logging technology provided students with immediate feedback and the possibility of creating new opportunities for experiments.

Rodrigues and colleagues (2001) reported on the success that first year physics students achieved when they were involved with analysis or real-life motion activities using data loggers. The graphs collected were displayed in real time and students could see graphs showing different quantities simultaneously. The ability to control an object and see its motion appear on the screen was reported by students as assisting in their understanding of graphs.

As technology has advanced so has the portability of data loggers. Data loggers can now be used outside the traditional science laboratory. Data can be analysed easily using either a graphics calculator or laptop computer without the need to return to a classroom. There are numerous examples (Gipps, 2001; Jimoyiannis & Komis, 2001; Pitt, 2000; Russel, 1988) of outside or ‘real’ experiences that have been documented such as analysing the acceleration of a car, the acceleration of an elevator, the motion
of a bicycle and the temperature of its brake pads. In addition, attempts have even been made on a larger scale to use data loggers successfully to analyse the movement of amusement park rides (O'Keefe, 2005).

In a review of the effects of context-based and science-technology-society (STS) approaches to teaching science on high school students, researchers reported that there was good evidence to support the claim that context-based approaches motivate students in their science lessons (Bennett, Campbell, Hogarth & Lubben, 2007). This was found to foster more positive attitudes to science, though there was insufficient evidence to indicate that these approaches enhanced student understanding.

Case studies presented by Sheffield, Hackling and Goodrum (2005) revealed that students were able to greatly influence or support their teachers’ attempts to change teaching practices. They note one case in which the class had placed pressure on a teacher not to change her teaching practice to that of being more context-based because they were threatened by the shift from learning by memorisation to learning for understanding. This situation may indicate that the students’ perceived idea of success in learning is measured by performance in external tests. These students are driven to achieve good test results by remembering facts rather than going through the process of science experimentation, and hence do not want to waste time finding out their own answers.

The vast majority of research on data loggers appears positive, however Atar (2002) suggests that the research does not provide compelling evidence that the use of data logger technology necessarily improves student learning outcomes. Atar further suggests that although there are many studies conducted in educational settings, very few have directly investigated data logger usage in science laboratories from the students’ perspective.

McRobbie and Thomas (1998) reported on a study examining the implementation of data loggers in a senior chemistry class. The study focussed only on one teacher and eight of her students, however the results indicated that the promise of using data logging technology to enhance students’ understanding was not fulfilled. McRobbie
reported that in this case the teaching was “primarily didactic, based on objectivist semantics, and focused on the transmission of knowledge rather than on providing a learning environment in which students socially constructed meaning.” (p. 5). This resulted in students being almost exclusively concerned with and focused on following a recipe for practical activities as directed by the teacher and obtaining data. This demonstrates how crucial the teacher’s beliefs and training are in relation to successfully implementing new technology.

2.7 Barriers touptaking technology

It has been suggested that teachers model their teaching on the way that they were taught (Cuban, Kirkpatrick & Peck, 2001). This system of beliefs leads to teachers holding on tightly to educational practices that are difficult to change (Lao, 2000). Both Lao and Cuban suggest that teacher education needs to integrate the use of technology so that teachers experience alternative teaching strategies as part of their own learning.

It is not surprising that the attitudes of teachers and school leaders greatly influence the use of technology within a school (Pelgrum, 1993). Baylor and Donn (2002) further elaborate that in addition, planning, curriculum alignment, professional development, and teacher openness to change as well as teacher non-school computer use, all play a great part in the implementation of technology into the classroom. Newton (2000) reports that despite the identified potential benefits of computer approaches to practical work, data logging has not won the widespread professional support of teachers in the UK. He describes many reasons for this lack of implementation, including problems of provision and access to resources and training, as well as the obstacles of increased risk-taking required to solve technical problems in the classroom.

Hennessy and co-authors (Hennessy, Ruthven et al., 2005) report that the reluctance of teachers to abandon their existing pedagogy has resulted in more of an obstacle to teacher development in classroom use of ICT than limited resources.
2.7.1 Inservice training

Supovitz and Turner (2000) argue that the recently-published ASTA National Professional Standards for highly accomplished teachers of science recognises that the use of technology has many applications in science teaching and that it can both extend and enhance the learning experience for students. Furthermore, highly accomplished teachers of science can use scientific enquiry to allow students to develop competencies in the use of technology in authentic contexts, putting students in control of the technological tools wherever possible. However, the current way that science is taught in schools is predominantly teacher and subject-centred. Tytler (2007) describes the teaching of science as having an emphasis on conceptual knowledge, compartmentalised into distinct disciplinary strands.

Perhaps the greatest barrier to the uptake of technology in science education is not the cost of equipment but rather the experience, confidence and time allocated to inservice training of teachers. Friedler and McFarlane (1997) recognised that despite the technology available to schools any investment will not be fully effective if it is not supported by appropriate staff development.

Watters and Diezmann (2004) report that curriculum innovations historically have failed to influence teaching and learning practices due to the scarce opportunities that teachers have to learn new content and improve their practice. This has been further reported in an Australian study of 122 science teachers by Sheffield, Hackling and Goodrum (2005). Their study highlighted the complexity of changing teachers’ classroom practice. However, if the professional development is accomplished successfully then it can lead to a reduction in stress, improve low morale, and have a substantial impact on improving the quality of teaching and learning (Hewson, Kahle, Scantlebury & Davies, 2001).

Inservice training in the use of data loggers has been available, though limited in its accessibility. Training offered has normally been limited to single after-school activities, or performed as a one-off demonstration by the company supplying data loggers to the school. When teachers do get the chance to practise with the technology they are focused on manipulating the software and hardware. Little time is devoted to
the changing of classroom methodology or getting participants to analyse their current teaching methods.

In a survey (Silburn, 2002) on the implementation of data loggers into the science curriculum the author found that a significant proportion of teachers claimed that they did not use data loggers in the classroom due to inexperience, lack of confidence in the technology, and the limited amount of time available for training.

Some schools have devoted professional learning funds to training teaching and support staff in the use of data loggers. In some cases this has included the compilation of a teacher and student laboratory manual (Marrickville High School Science Faculty, 2004). Unfortunately, variation in the types of data loggers in use across schools has meant that very few of these manuals have been able to be used at other schools.

Data logging has been an elective component of the *Technology in Learning and Teaching* (TILT) science course since 1999 (Training and Development Unit, 2000). The need for teachers to be further trained in the use of data loggers was recognized and a specific course, *TILTplus Science-Data Logging* (Training and Development Unit, 2003) was developed in 2002. The course was offered in Semester 1, 2003, however due to the cessation of Australian Government funding for the *Quality Teaching Program* (AGQTP) this was the only time it was offered.

2.7.2 Preservice training

“Nothing matters more to the quality of education in our schools than the knowledge, skill and commitment of teachers.” (Australian Science Teachers Association, 2002)

Teachers can make a positive difference in the classroom through the infusion of technology. However, Pinnock (2006) argues that if proper training and modelling are not completed effectively in teacher training institutions then it is unlikely that teachers will implement technology in their classrooms.
It would seem to be a reasonable expectation that science teachers who had recently completed their training would be able to demonstrate a greater understanding of the use of technology than their predecessors. In a discussion conducted by the researcher with science teachers in their first year of teaching it appears that preservice training in the use of data loggers is very limited (South West Sydney, Beginning Science Teachers’ Inservice, Casula High School, March 2004). Further, there was no mention amongst the group of time being allocated to the discussion of educational issues related to the use of data loggers in the classroom to facilitate higher order learning.

In the published *Standards for the Education of Teachers of Science* (Spector, 2003) the National Science Teachers Association recognises that classification of science teachers to the level of professional competency should be able to demonstrate the ability to identify information technologies as fundamental to teaching, learning and the practice of science, and furthermore engage students both in the use of technologies and the understanding of their use in science (Spector, 2003). The need to give preservice teachers hands-on experience with computers and technology, including data loggers, in professional environments that support a variety of teaching methods is identified by numerous authors (Harry & Carbone, 2002; Lao, 2000; Whetstone & Carr-Chellman, 2001).

As with all technology and innovations generally, there would be an expected time delay in the implementation of new ideas into teacher training (Molebash & Milman, 2000). As teachers struggle to use the new technology, so do the people responsible for the preservice training of teachers, many of whom have not had experience in the use of data loggers in the classroom themselves.

2.7.3 Practical issues in implementation

In response to the implementation of the new HSC curriculum all secondary public schools in NSW received a one-off $4,000 grant to assist with the purchase of equipment and resources required to meet syllabus outcomes mandating the use of data loggers. Many schools used the money to purchase data logging equipment, however as this equipment was new to schools there was no history or evidence as to what constituted a good investment. There were varying degrees of support from
manufacturers, both in personnel training and in the provision of manuals and suggested activities. Many of these activities fitted into the domain of physics. This, combined with the complexity of the equipment, “sent the message that you had to be some kind of electronics and software ‘whiz kid’ to be involved in the data logging” (Barton, 1993) (p.75)

The fact that the use of data loggers only appears in the senior syllabuses has meant that their use has been mainly restricted to senior classes. In a previous study the researcher found that only 17 percent of schools used data loggers in their junior classes (Silburn, 2002). Furthermore, because of the limited number of data loggers available and the high replacement costs, teachers were reluctant to use data loggers with junior classes.

As the technology has further developed so too has data acquisition technology. Although data loggers are a relatively new device, the increase in demand for them has seen a decrease in their cost (Sane, 1998). Cheaper versions designed for the school market have evolved (Hecht, 1997), with some schools opting to use data loggers in conjunction with personal digital assistants (PDAs).

However, advances in technology have also created problems. Many of the original data loggers purchased connected to computers via the serial port. Schools have reported difficulty in connecting these data loggers with recently-purchased computers in which the serial port has been replaced with a USB port. There are also reports of software incompatibility when updating to a new operating system.

There is further concern that schools will not have sufficient equipment to use with junior classes if the use of data loggers becomes a mandatory experience in earlier grades, as proposed in the NSW Draft Amended Science Syllabus 7-10 (NSW Board of Studies, 2002) dated October 2002. McKay (2004) argued that despite an emphasis on using data loggers with classes it was still difficult to incorporate them due to difficulties with using the technology. These difficulties included:

- lack of computer access in science labs to transfer data and for visual activities;
- problems in transferring data from laptops to the school network;
• complexity of instruction sheets for students;
• concerns by teachers as to what happens if something goes wrong;
• the time for training; and
• limited availability and expense of various sensors.

Whilst the use of centralised computer rooms may solve problems for most subject areas, the presence of water, let alone acids, and the need to have students moving around the room in science activities, means that data logging is generally an activity that is usually not welcome in computer rooms (Tebbutt, 1999).

Pinnock (2006) claims that although economics may be a deterrent to the successful integration of technology in the classroom, the common thread that runs across these barriers is the lack of professional development, training, and positive attitudes. This is an important reminder of the difficulties that can still persist even when the practicalities of technology implementation are resolved.

2.8 Summary and relevance of literature to this study

This review has considered literature dealing with the implementation of data loggers in secondary science classes in three broad areas: the current issues in science teaching, the proposed and demonstrated advantages of using data loggers, and the barriers that have restricted their implementation.

The literature surveyed in the opening section relating to the current issues in science teaching clearly shows a decline both nationally and internationally in the number of students selecting science subjects in the senior years of high school since the 1970s. The flow-on effect has reduced the number of students selecting science at university level. It has been suggested that current practices in science education may be leaving students poorly educated about science and with a negative attitude towards science as a study option and eventual career.

Laboratory work is seen as an integral part of most science courses and offers an environment different in many ways from the ‘traditional’ classroom setting. Many
syllabuses stress the importance of science investigations and inquiry-based teaching strategies based on a constructivist learning theory, however it is suggested that although this may be a preferred option, many teachers rely heavily on ‘chalk-and-talk’ or textbook-oriented methods.

Advances in computer technology and a reduction in costs has allowed greater use of data loggers as an educational tool. Although available to schools since the late 1970s, the recent forms of data loggers are faster and easier to use, providing an effective way to achieve high frequency data sampling. Sensors connected to the data logger or computer via an interface can be more reliable and accurate in collecting data than humans and convenient either for very short periods of time or for extended periods of data collection.

The ability to draw, analyse, and interpret graphs is crucial to the study of science. Another benefit of the data logger is that the data collected can be easily stored and processed. Data can be presented instantaneously in a visual form, such as graphs or tables, thus encouraging visual pattern recognition skills and enabling students to become more adept at interpreting graphs.

Much of the literature highlighted the positive effect of data loggers on student motivation and engagement. Many authors suggested that the use of data loggers assists teachers to engage students in student-centred inquiry learning involving hands-on scientific investigations with the use of relevant and up-to-date technology.

The use of data loggers has been mandated in various senior science syllabuses and an initial grant of $4000 was allocated to all NSW government secondary schools to provide the equipment. Inservice training, although limited, was made available to schools, however the many different types of data loggers available, combined with the difficulty of some data loggers to use, made the training problematic.

Concern was raised by many teachers about the implementation of data loggers into the curriculum. Despite the noted advantages it appeared that most teachers had a negative view about using data loggers in the classroom. Barriers cited by teachers in
opposition to implementation were a lack of inservice and preservice training and the
cost and scarcity of equipment.

This chapter examined the research and conceptual literature providing a background
for the study and identified the gap in the literature and need for the current research.
The next chapter focuses on the research design and methodology used to develop
further understanding of how teachers use data loggers to support student learning in
secondary physics.
Chapter Three: Research methodology

3.1 Introduction
To address the research questions this study involved linked investigations that complemented each other. The specific data collection strategies chosen for each investigation were selected to be the most appropriate for the research question posed. Investigative strategies included questionnaires, individual interviews, group interviews, class observations, field notes and workshop responses. The use of multiple investigations allowed for the triangulation of results.

This chapter describes the methodology used in each of the seven investigations. Each investigation looks at the research problem from the view of different stakeholders and the results obtained are reported and discussed in chapters four to six. The study commences with the surveys and interviews of teachers, students and outside agencies and culminates in case studies incorporating the teacher, student and researcher views, classroom observations, interviews and field notes.

The purpose of this study is to investigate how teachers use data acquisition and analysis technology to support student learning in secondary school physics. The study will also identify the purposes of the different approaches taken by teachers. It will also develop descriptions of effective practice in the use of data loggers in secondary school physics teaching.

Research questions

1. What is the current impact of data loggers in secondary school physics classrooms?
2. What factors influence the ways teachers use data loggers with their classes?
3. What are the implications for integrating data loggers into the physics curriculum?
3.2 The Research approach

A mixed-method design, as described by Creswell (1994), of combining qualitative and quantitative approaches, was used to guide the design and implementation of the study. Many terms have been used for this type of design, including integrating, synthesis, multi-method and multi-methodology. This study uses the term ‘mixed methods’ as used in recent research texts (Creswell, 2003; Johnson & Christensen, 2004; Mertens, 2005; Tashakori & Teddlie, 2003).

The use of a mixed-methods approach to research has gained credence in the past decade with many articles, texts and chapters written about it. The application of combining qualitative and quantitative approaches in research has been acknowledged (Bazeley, 2003; Falconer & Mackay, 1999; Sydenstricker, 2004) as an effective way to increase the quality and validity of final results. In particular, its application in evaluating education programs and reforms has been acclaimed (Yamaguchi, Harmon, Darwin, Graczewski & Fleischman, 2005). A further proposed advantage is that a mixed method approach is likely to increase the credibility of findings and conclusions by the diverse groups that have a stake in an evaluation or investigation (Frechtling & Sharp, 1997). Caracelli and Greene (1997) advocate that using mixed methods provides richer data, and thus better answers for evaluators and program managers, than does any single framework alone. This is echoed by Johnson and Christensen (2004) who argue that the fundamental principle of mixed research is the benefit gained from collecting and analysing multiple sets of data using different research methods in such a way that the resulting mixture or combination has complementary strengths and non-overlapping weaknesses.

The term ‘mixed methods’ is most commonly applied to research involving a combination of quantitative and qualitative approaches to data gathering and/or analysis within a single project. Creswell (2003) advances three models of combined designs. One version is the two-phased design approach in which the researcher conducts separate qualitative and quantitative phases of the study. Another adopts a dominant-less dominant design, in which the researcher presents the study within a single dominant paradigm with a small component drawn from the alternative paradigm. Although these two models incorporate a combination of methodologies,
Creswell labels the third combined design as *mixed-methodology*. The *mixed-methodology* design combines aspects of the qualitative and quantitative paradigms at all or many of the methodological steps in the research design.

Creswell (1994) and Johnson and Christensen (2004) identify five broad advantages or purposes for combining methods in a single study: (1) triangulation, (2) complementarity, (3) development, (4) initiation and (5) expansion based on the work of Greene, Caracelli and Graham (1989). The conceptual framework is shown in Table 3.1.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triangulation</td>
<td>Seeks convergence, corroboration, correspondence of results from different methods.</td>
</tr>
<tr>
<td>Complementarity</td>
<td>Seeks elaboration, enhancement, illustration, clarification of the results from one method with the results from the other method.</td>
</tr>
<tr>
<td>Development</td>
<td>Seeks to use the results from one method to help develop or inform the other method, where development is broadly construed to include sampling and implementation, as well as measurement decisions.</td>
</tr>
<tr>
<td>Initiation</td>
<td>Seeks the discovery of paradox and contradiction, new perspectives of frameworks, the recasting of questions or results from one method with questions or results from the other method.</td>
</tr>
<tr>
<td>Expansion</td>
<td>Seeks to extend the breadth and range of inquiry by using different methods for different components.</td>
</tr>
</tbody>
</table>

The rationale for the use of a mixed methods design in this research was to use the results of the quantitative method to drive and inform the design of the qualitative investigation (developmental). It was intended that the qualitative data could then be used to validate the quantitative findings and produce a more comprehensive answer to the research problem (triangulation). Furthermore, the broad picture generated by the collection of quantitative data was followed up with in-depth investigations using qualitative methods (expansion).

### 3.3 The Design of this Study

Table 3.2 displays the sequence and timeline of the various components of the study. It details the subjects, purpose of the study, and the strategies used.
<table>
<thead>
<tr>
<th>Study</th>
<th>Time line</th>
<th>Subject</th>
<th>Purpose</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nov 2001</td>
<td>Teachers marking HSC and School Certificate</td>
<td>Pilot study To investigate a need for the study and to identify trends and possible research questions for later data collection.</td>
<td>Questionnaires</td>
</tr>
<tr>
<td>2</td>
<td>Nov 2001</td>
<td>Researcher’s own classes</td>
<td>Pilot study To investigate a need for the study and to identify trends and possible research questions for later data collection.</td>
<td>Questionnaires</td>
</tr>
<tr>
<td>3</td>
<td>July 2002</td>
<td>Year 12 students</td>
<td>Pilot study To investigate a need for the study and to identify trends and possible research questions for later data collection.</td>
<td>Questionnaires</td>
</tr>
<tr>
<td>4</td>
<td>Nov 2002</td>
<td>Teachers marking HSC and School Certificate</td>
<td>To investigate the general trend by teachers in the use and implementation of data loggers</td>
<td>Questionnaires</td>
</tr>
<tr>
<td>5</td>
<td>Jun 2003</td>
<td>TILT data logger facilitators</td>
<td>To investigate the general trend by teachers in the use and implementation of data loggers</td>
<td>Questionnaires</td>
</tr>
<tr>
<td>6</td>
<td>Jul 2003</td>
<td>Year 12 students</td>
<td>To investigate general trends identified by students in the use and implementation of data loggers</td>
<td>Questionnaires</td>
</tr>
<tr>
<td>7</td>
<td>Oct 2003</td>
<td>NSW DET science curriculum consultants</td>
<td>To investigate general trends identified by curriculum consultants in the use and implementation of data loggers</td>
<td>Workshop participant notes</td>
</tr>
<tr>
<td>8</td>
<td>Oct 2003– Feb 2004</td>
<td>Teachers</td>
<td>To identify specific data in relation to strategies used by teachers to implement data loggers into the classroom.</td>
<td>Interviews</td>
</tr>
<tr>
<td>9</td>
<td>Oct–Dec 2003</td>
<td>Students</td>
<td>To identify specific data in relation to strategies used by teachers to implement data loggers in the classroom from the view of students.</td>
<td>Focus group interviews</td>
</tr>
<tr>
<td>10</td>
<td>Oct–Dec 2003</td>
<td>Classroom observations</td>
<td>To identify specific data in relation to strategies used by teachers to implement use of data loggers in the classroom from the view of students.</td>
<td>Classroom observation and field notes</td>
</tr>
<tr>
<td>11</td>
<td>Oct–Dec 2003</td>
<td>Students</td>
<td>To identify specific data in relation to strategies used by teachers to implement use of data loggers in the classroom from the view of students.</td>
<td>Questionnaires</td>
</tr>
<tr>
<td>12</td>
<td>Nov 2003</td>
<td>Teachers marking HSC and School Certificate</td>
<td>To investigate the general trends in teacher use and implementation of data loggers.</td>
<td>Questionnaire</td>
</tr>
<tr>
<td>13</td>
<td>Nov 2003</td>
<td>Teachers from science faculties within the district</td>
<td>To investigate the general trends in teacher use and implementation of data loggers.</td>
<td>Questionnaire</td>
</tr>
<tr>
<td>14</td>
<td>Dec 2003</td>
<td>Company representatives</td>
<td>To investigate the general trends in teacher use and implementation of data loggers.</td>
<td>Interview</td>
</tr>
<tr>
<td>15</td>
<td>Jul 2004</td>
<td>Year 12 students</td>
<td>To investigate general trends identified by students in the use and implementation of data loggers.</td>
<td>Questionnaires</td>
</tr>
</tbody>
</table>
A schematic representation of the major sections of the study is shown in Figure 3.1 commencing from the initial findings of the pilot study and culminating in in-depth case studies.

3.4 Pilot study – data collection and results

A pilot study was conducted to trial the data collection methods. The pilot study commenced with a survey of the perceptions that students in the researcher’s Year 11 and Year 12 physics classes (23 students) had about the use of data loggers and how their teacher used data loggers. It was further developed to include 195 Year 12 students participating in a HSC Study Day at the University of Western Sydney as well as 133 science teachers marking the 2001 NSW School Certificate and NSW Higher School Certificate examinations.

This initial study focused primarily on the initial integration of the use of data loggers in the curriculum and identified that data loggers often were not used in science classrooms.
3.4.1 First student questionnaire

The initial one page student questionnaire focused on the researcher’s class and comprised six questions. These questions focused on students’ use of data loggers, their comparison between the use of data loggers and conventional science equipment, and the way in which their teacher (the researcher) conducted lessons using the new technology. The questionnaire is reproduced in Appendix 1.

The first student pilot questionnaire was administered to the researcher’s Year 11 and Year 12 physics classes as both classes had been introduced to data loggers at the same time. The results identified differences in the way the teacher and students interacted when using the data logger.

The Year 12 class, having already completed the Preliminary HSC course, had learnt how to identify trends in graphs and were confident with definitions such as velocity and acceleration. In most of the experiments, the teacher (researcher) was using the data logger and computer analysis to reinforce concepts that had already been taught. Because of their small size (only six students) the practical classes were informal and there were numerous times that the experiment being conducted would be modified to investigate another idea or ‘what if’ scenario that presented itself during the lesson. The Year 12 class often held animated discussions about the data collected because they wanted to test their explanations of what happened. As the Year 12 students were at the end of their course they could also explain what was happening in reference to other experiments.

The Year 11 class had not at this stage become familiar with interpreting graphs, hence a significant amount of teacher time was involved in explaining concepts and skills related to the topic and explaining how to use the technology. The size of the class (17 students) also meant there was less opportunity for ‘hands on’ use of the data loggers.

3.4.2 Second student questionnaire

These questions were duplicated in the second pilot questionnaire given to Year 12 students attending a HSC Science Study Day. Eight additional questions were added to the questionnaire. This was done to obtain further data about the students including
gender, amount of data logger usage, practical work completed and student learning, as well as teacher and student attitudes to data loggers.

The survey items and an explanation of the structure are provided in Appendices 3 and 4.

The questionnaire was administered to 195 year 12 science students attending a HSC Science Study Day. At this stage they had completed the preliminary component of their HSC course and approximately 80 percent of the HSC course.

3.4.3 Teacher pilot questionnaire

The purpose of the pilot teacher survey was to investigate teachers’ responses to, perceptions of, and ideas about the use of data loggers in science classrooms. Questions also addressed the issue of teacher confidence, the type of data logger used, and the effectiveness of professional development.

Questionnaires were distributed to science HSC and School Certificate marking centres during November 2001. This group consisted of teachers from a cross section of Government, Catholic and Independent schools. Because markers are selected from experienced teachers, this group did not include teachers in their first five years of teaching.

The survey items and an explanation of the structure are provided in Appendix 5.

Of the 133 teachers who responded to the questionnaire only 44 (approximately one third) self-reported that they used data loggers. However, 78 recorded positive comments on the use of data loggers.

3.4.4 Findings from the pilot study applied to the main study

There were many outcomes from the pilot study that informed the development of the main study. The key results from the pilot study were:
• data loggers, although mandatory, were not significantly being used by teachers;
• many teachers were not comfortable with or confident in the use of data loggers;
• many teachers had not undergone any substantial training in the use of data loggers;
• there was a range of data loggers in use in schools;
• often the data loggers were difficult to connect to the computers used in schools;
• when used in the classroom the data loggers were used in a variety of different ways;
• many teachers could see the benefit of using data loggers; and
• students identified a high level of satisfaction when using data loggers over conventional equipment.

3.5 Main Study – Data collection and analysis procedures

The study was initially designed to incorporate the researcher’s own school and nine other schools in the Campbelltown and Liverpool school districts of NSW. The total available schools was 27, however not all schools were in a position to participate for a variety of reasons including curriculum issues, and in some cases, the realisation that they had not used data loggers and would therefore be of limited use to the study. Due to the shortage of teachers available to participate, this sample was broadened to include NSW DET teachers who self-reported using data loggers proficiently in the classroom. Teachers were identified by the researcher, local science teachers association, head teacher science network or school principals. In total, 22 teachers from sixteen schools were interviewed. Figure 3.2 shows the participants and the data collection techniques used in the study.
3.5.1 Teacher surveys

The purpose of the teacher survey was to investigate teachers’ responses to, perceptions of and ideas about the use of data loggers in science classrooms. Questions also addressed the issues of teacher confidence, the type of data logger used and the effectiveness of professional development. The aim of the questionnaire remained the same as the pilot study, however the questions were rearranged to allow a more logical sequence for respondents. Some questions were reworded to achieve greater clarity.

The questionnaire was reviewed at a Head Teacher Science Network (Silburn, 2003) meeting, and resulted in changes to the questionnaire to increase the ease of answering questions, such as the inclusion of tick boxes and in identifying brands of data loggers currently used by science teachers. The questionnaire is reproduced in Appendix 8.

3.5.1.1 Participants

Three distinct teacher sample groups were recognised.

Group 1: Science teachers marking external exams for the NSW Board of Studies. This group consisted of 151 teachers (88 in 2002, and 63 in 2003) from a cross section of Government, Catholic and Independent schools. Because markers are selected from experienced teachers, this group did not include teachers in their first five years of teaching.

Group 2: TILT (Technology in Learning and Teaching) science data logging facilitators. This group consisted of DET teachers who were identified as being proficient in the use of data loggers in the classroom by their district science consultants. These teachers underwent four days of extra training in the use of data loggers.
loggers and in techniques to train other teachers in the use of data loggers. Thirty teachers participated in the training, from whom 27 responses were received.

**Group 3:** Faculty responses. This group consisted of teachers whose schools were identified. Questionnaires were circulated to twenty faculties through the head teacher. Four faculties from the Liverpool and Campbelltown districts responded. The researcher was advised by potential respondents to expect a poor response rate as several science faculties were under review at the time. The responses collected, however, allowed the researcher to have a better view of data logger use specifically for each faculty. This resulted in the researcher being able to prepare for in-depth interviews, allowed a comparison of teacher perception across the faculties involved and also verified claims made by teachers during the interviews. These questionnaires were analysed as part of the case studies and added to the researcher’s big picture. Completed questionnaires were entered into an Excel™ Spread sheet and a Filemaker Pro™ database for analysis.

### 3.5.1.2 Procedures

The design of the questionnaire was revisited after reviewing responses to the initial pilot study. The two-page questionnaire was modified from a questionnaire used in the two years prior to the study to which 133 science teachers had responded. This allowed some overlap of the questions and some comparison of base data collected. Modifications to the questionnaire were made in consultation with the researcher’s academic supervisors and the Liverpool and Campbelltown District Head Teacher Science Network in August 2003 (Silburn, 2003).

Every effort was made to ensure that the questionnaire was not only effective in drawing in relevant information, but also extreme care was taken to ensure that it did not cast a negative shadow over the profession of science teaching. (Many science teachers were concerned about another questionnaire that had been circulating at the time of this survey that included content that was seen as denigrating the professionalism of science teachers).
Questionnaires were distributed to HSC and School Certificate marking centres during November 2002 and 2003. Base data was also obtained from a similar questionnaire distributed in 2001. The items, format and details of the questionnaire are elaborated in Appendix 7. The analysis and discussion of the findings of the teacher’s view is reported in Chapter Four.

3.5.1.3 Data analysis
Completed questionnaires were initially entered into an Excel™ spread sheet and then into a purposely-designed Filemaker Pro™ database for analysis. Excel™ was initially chosen for data storage due to its flexibility, simple structure and ability to perform some initial screening and exploration of the data (Wyseure, 2003). The program was also readily available at the DET district office which assisted in data entry. Emphasis was made to ensure that the data entry phase was simple so as to increase the reliability of the data that was entered (University of Reading Statistical Services Centre, 2001). Drop-down lists were used to eliminate mistakes and discrepancies in data handling. Each questionnaire was given a unique serial number. All data entered was checked with original sources to ensure the validity of data.

Data was imported into a specifically-designed Filemaker Pro™ database. The database was designed with a view of providing two basic operations. The first of these relates to the process of data retrieval and sorting. Although Excel™ duplicated these same basic operations, the use of the database allowed the individual questions to appear with each response. The second was to classify and analyse survey responses. After reading all responses, a classification scheme was developed. This classification scheme was then used to categorise responses.

3.5.2 Teacher interviews
The aim of the teacher interviews was to establish a greater understanding of how teachers were incorporating data loggers into their classrooms.

Originally it was anticipated that teachers would be selected after viewing the teacher questionnaires, however due to the requirement to guarantee anonymity this could not be followed-up. Instead, teachers were recruited for interviews based on referrals from
the local science teachers’ association, the head teacher science network, principals and personal knowledge of the researcher. Twenty-two teachers were selected and formed the basis for the main study. Selection criteria included having a high level of confidence in the use of data loggers, belief that they were exhibiting effective classroom practice, permission of their principal to participate, and the availability to meet with the researcher.

3.5.2.1 Participants

Interviews were conducted with 22 teachers. Gender composition included 17 male teachers and 5 female teachers. Table 3.2 shows that they represented a large variation in teaching experience, school population, and usage and implementation of data loggers in the classroom. Eight were head teachers of science faculties and one was a deputy principal. Seven of the teachers were in their first five years of teaching. One had recently completed a one-year retraining course to teach science having taught history and English for over ten years. One of the head teachers had just completed a retraining course to teach physics.

The participants represented 16 NSW public secondary schools. All of the schools were comprehensive co-educational schools with the exception of two of the schools, those being single-sex (one for boys and one for girls) and one catering for Years 7 to 10 students only.

Six of the teachers had completed four days of training to become TILT (Technology in Learning and Teaching) facilitators. Two of the teachers had implemented the use of data loggers in the junior curriculum through funding received from the Australian Government Quality Teaching Program.

All participants interviewed were volunteers. All had used a data logger in class with varied success.

Table 3.3 describes the experience and gender of teachers interviewed for the study. It also indicates which interviews were in pairs and which were individual.
Table 3.3: Teachers interviewed

<table>
<thead>
<tr>
<th>Subject</th>
<th>Gender</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>AndrewHT</td>
<td>Male</td>
<td>Head teacher Experience as a science consultant and co-author of a resource on computer technology in schools. AndrewHT was also a TILT facilitator for data logging.</td>
</tr>
<tr>
<td>BarryDP</td>
<td>Male</td>
<td>Deputy principal BarryDP is an experienced physics teacher. Previous to the school he was a science head teacher at a technology high school.</td>
</tr>
<tr>
<td>CharlieHT</td>
<td>Male</td>
<td>Head teacher Heavily involved in professional development of other science teachers. He also occupies an executive position on the regional science teachers’ association.</td>
</tr>
<tr>
<td>DavidHT</td>
<td>Male</td>
<td>Head teacher Had just completed a retraining course to teach physics.</td>
</tr>
<tr>
<td>Edward</td>
<td>Male</td>
<td>Experienced science teacher Trained as a TILT Facilitator for data logging.</td>
</tr>
<tr>
<td>Frederick</td>
<td>Male</td>
<td>Head teacher Trained as a TILT Facilitator for data logging.</td>
</tr>
<tr>
<td>Geraldine</td>
<td>Female</td>
<td>Science teacher in her early years of teaching Trained as a TILT Facilitator for data logging.</td>
</tr>
<tr>
<td>Helen</td>
<td>Female</td>
<td>Science teacher in her early years of teaching Trained as a TILT Facilitator for data logging.</td>
</tr>
<tr>
<td>Ian</td>
<td>Male</td>
<td>Science teacher in his early years of teaching.</td>
</tr>
<tr>
<td>James and KarenHT</td>
<td>Male and Female</td>
<td>Experienced science teacher and head teacher Both participated in a project funded by the Quality Teacher Program (QTP) in science. Their school’s project was to incorporate data loggers into the school’s teaching program.</td>
</tr>
<tr>
<td>LiamHT and Mary</td>
<td>Male and Female</td>
<td>Experienced science teacher and head teacher Prior to employment as a secondary chemistry teacher had industry experience and had taught at TAFE.</td>
</tr>
<tr>
<td>Nick and Olivia</td>
<td>Male and Female</td>
<td>Both teachers were in their early years of teaching physics. Nick had just completed a one-year retraining course to teach science and physics. Prior to this course he had been a history teacher.</td>
</tr>
<tr>
<td>PeterHT and Quinton</td>
<td>Both Male</td>
<td>Experienced science teacher and head teacher School was in their fourth year of teaching the HSC course.</td>
</tr>
<tr>
<td>RobertHT and Sean</td>
<td>Both Male</td>
<td>Experienced science teacher and head teacher RobertHT had also completed the TILT science course. Sean was an experienced teacher and had taught the physics course once.</td>
</tr>
<tr>
<td>UlysiesHT and Ted</td>
<td>Both Male</td>
<td>Science teacher in early years of teaching and head teacher Ted, although in his early years of teaching, had completed training to be a TILT data logging facilitator.</td>
</tr>
<tr>
<td>Simon</td>
<td>Male</td>
<td>Experienced science teacher</td>
</tr>
</tbody>
</table>

For the purposes of this study, all of the participants have been assigned pseudonyms, with the exception of the students who are referred to as student 1, student 2 and so
forth. The postfix HT identifies teachers employed as Head Teachers; DP as Deputy Principal.

3.5.2.2 Procedure
The interview questions were formulated after reviewing trends in data collected from the previous stages of the study and hence closely mirroring the questions appearing in the questionnaire. Questions focused on individual teacher practice, asking for details about what they do in the class and why they do it. Interviews were tape recorded and transcribed for future analysis. The teacher interviews were analysed for themes and patterns, leading to the development of an observation protocol for classroom observations.

Teachers and principals were given the set of interview questions prior to the interview. This guided the interview process. Other questions of interest often arose from the participants’ responses and reflections, and from the interviewer’s knowledge of the participants and their schools. When needed, clarification or expansion of particular comments was elicited.

Four of the teacher interviews were analysed in combination with student interviews, classroom observations and field notes. These schools were selected on the basis of further availability of classes for observation, the availability of students for interview and the continued availability of the teacher. The four selected also represented a cross-section of teacher experience and school type. The triangulation of data allowed these teacher interviews to form part of four case studies that are elaborated in Chapter Six.

3.5.2.3 Data analysis
The interviews were audiotaped, and later transcribed in full. Transcripts of the interviews were made available to participants electronically by email as Microsoft Word documents for verification. NVivo™ was used to classify, sort and arrange textual information from interview and focus group transcripts. The format and details
of the interview questions are elaborated in Appendix 9. The analysis and discussion of the findings of the teacher interviews are reported in Chapter Five.

3.5.3 Student surveys
The purpose of the student survey was to investigate the frequency of use of data loggers as perceived by students, and student attitudes to their use in the science classroom. Questions also addressed whether students believed there was any difference in the way teachers conducted lessons when they used data loggers in the class. Information from the questionnaires was used to triangulate and verify teacher responses and classroom observations.

3.5.3.1 Participants
Student questionnaires were collected from two distinct groups.

Group 1: HSC study day students
Student questionnaires were distributed to students attending two HSC study days in July 2003 and 2004. Base data from a similar survey was also available from 2002. Student responses were entered into an Excel™ Spreadsheet for data analysis. Student questionnaires were used to analyse the students’ perspectives of the use of data loggers.

Group 2: Students of teachers interviewed
In some cases it was possible to survey a proportion of Year 11 students from classes that were taught by the teachers who participated in an interview. Student questionnaire results were used to verify the teacher’s self-report and to give the students’ perspectives on the use of data loggers. The results of the surveys for this group are discussed in Chapter Six in combination with other data in separate case studies.

3.5.3.2 Procedure
The pilot questionnaire used in the previous year was modified in consultation with the researcher’s academic supervisors from a questionnaire used in the year prior to the study to increase the clarity of questions. Questionnaires were distributed to students
participating in a HSC science study day for Year 12 students in July 2003 and July 2004. A total of 257 students responded to the survey - 116 in 2003 and 141 in 2004. The questionnaires were distributed towards the end of the HSC year, when most of the practical component of the courses would have been completed.

Students attending the study days were from public secondary schools. Included in this group were students from one selective high school and one semi-selective high school. These schools comprised the majority of the students attending the study day.

Where available, data from the initial student surveys of 2002 are included as base data. In some cases this information was not available as the questions posed in the 2003 and 2004 survey were modified so as to answer specific questions relating to this research.

The format and details of the questionnaire are elaborated as part of the analysis and discussion of findings from the student surveys in Chapter Five, Section One.

**3.5.3.3 Data analysis**

Completed questionnaires were entered into an Excel™ Spread sheet and a Filemaker Pro™ database for analysis. Statistics such as demographic information and analysis of questions that required yes/no responses were collated. Further analysis of extended response questions such as student attitude to using technology, preferences towards using data loggers or conventional equipment, changes to the way teachers teach or teachers learn were used to develop a coding system for the responses. Once constructed, the coding system was used to calculate statistics of student responses. This was especially useful when categorising attitudinal responses.

The use of both spreadsheet and database allowed each of the questions to be analysed for trends.

**3.5.4 Student Focus Groups**

The use of the focus group allowed the researcher to explore the themes and patterns that emerged from analysis of the teacher and student surveys, and to collect more
detail on answers to the survey responses. The focus group provided a less threatening environment for students and decreased the time involved in data collection, thus reducing the disruption to schools and complied with the NSW Department of Education requirements with regard to child protection issues arising from the recording and transcribing of focus group interviews.

The researcher obtained clearance from the NSW Department of Education for work with children. A copy of the focus group questions was given to the school prior to the interview (see Appendix 10). Interviews were carried out under supervision of an appropriate adult, in consultation with the principal.

3.5.4.1 Participants
Four classes were selected to refine the sample. Classes were selected to ensure that they represented a cross-section of the larger study and according to their availability. A student focus group, comprising a minimum of three students from each class, was interviewed.

3.5.4.2 Procedure
Interviews were tape-recorded and transcribed for future analysis. Unlike the teacher interviews, the interview transcripts were not sent to participants for verification due to the involvement of participants in formal examinations. This decision, although reducing the reliability of the results, was made so as not to interrupt further the students’ learning.

3.5.4.3 Data analysis
The focus group interviews were analysed for themes and patterns and informed the formulation of questions for the teacher interviews. The format and details of the focus group interviews are elaborated as part of the analysis and discussion of findings that form the basis of the four case studies that appear in Chapter Six.
3.5.5 Company representatives interviews
The purpose of the interviews was to investigate the broader issues relating to the implementation of data loggers in schools. Although these managers had a responsibility to promote their products, they were also at the forefront of training provided to teachers both at conferences and directly to schools.

3.5.5.1 Participants
Interviews were carried out with three educational managers representing the two companies that were leading suppliers of data loggers to schools.

3.5.5.2 Procedures
A set of proposed questions was given to the participants prior to the interview (see Appendix 11). This guided the interview process. Other questions of interest arose from the participants’ responses and reflections, and the interviewer’s knowledge of the data logger and training supplied by the company. When needed, clarification or expansion of particular comments was elicited.

3.5.5.3 Data analysis
The interviews were audio-taped, and later transcribed in full. Transcripts of the interviews were emailed to participants for verification. After verification, the interviews were analysed for themes and patterns using the qualitative package, NVivo™.

The format and details of the interview questions are elaborated in Chapter Four (Section 4.3). The analysis and discussion of the findings of the company representatives interviews are reported in Chapter Four.

3.5.6 Science curriculum consultants’ training workshop
The proceedings of a training workshop for 18 DET science curriculum consultants were analysed.
3.5.6.1 Participants
The NSW DET employed 20 curriculum consultants to assist schools in the implementation of the Stage 4-5 science syllabus. The consultancy lasted between 2001-2003. As part of their brief, consultants also assisted schools in the implementation of data loggers by facilitating school and district training.

All consultants had received some training in the use of data loggers, however many were not personally proficient or confident in their use of data loggers. As part of a training conference in October 2003 consultants participated in a workshop relating to data logger use in schools.

3.5.6.2 Procedure
Eighteen of the twenty district consultants participated in the workshop. Participants were randomly allocated into four groups. Each group was given a sheet of butcher’s paper that was divided in half by a line drawn down the page. The task was to list on one side of the paper the ideal situation of data loggers in schools and on the other side the real situation. Groups then reported back to the whole conference.

3.5.6.3 Data analysis
The posters created during the feedback session were collected and analysed. The analysis and discussion of the findings of the workshop are reported in Chapter Four (Section 3).

3.5.7 Classroom observations
Four lessons were observed to verify claims made by both teachers and students during the interviews. Furthermore these would reveal additional information and detail about the interactions that occurred in the classroom when the data loggers were being used.

3.5.7.1 Participants
Four classes were observed using data loggers. These were from schools that had been selected to continue in the study and represented a cross-section of the larger study and according to their availability. They ranged in size from four to ten students.
3.5.7.2 Procedures
An observation protocol (see Appendix 12) was developed from the analysis of data collected during the surveys and interviews. Analysis of the ‘teaching episodes’ (part of one or a series of lessons) also enabled the researcher to identify the similarities and differences among those teachers who exhibited effective practice in the use of data loggers.

This analysis allowed the researcher to identify and describe in detail the characteristics of effective practice in the use of data loggers in the science classroom.

3.5.7.3 Data analysis
The classroom observations were recorded by the researcher using a notebook and audiotape recording. The written notes formed a chronological record of the lesson. Notes focussed on teacher-student interaction, time on various tasks, data logger usage, and evidence of prior data logging usage. The analysis and discussion of the findings of the observations are incorporated into the case studies reported in Chapter Six.

3.5.8 Summary of data collection methods
Table 3.4 shows a summary of the data collection techniques used in the study.

Table 3-4: Data collection techniques used in the study

<table>
<thead>
<tr>
<th>Method</th>
<th>Quantity</th>
<th>Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher survey</td>
<td>172 teachers</td>
<td>See attached</td>
</tr>
<tr>
<td>TILT trainers survey</td>
<td>27</td>
<td>See attached</td>
</tr>
<tr>
<td>Industry representatives</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>interviewed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student survey</td>
<td>257 students</td>
<td>See attached</td>
</tr>
<tr>
<td>Student focus group semi-</td>
<td>27 students</td>
<td></td>
</tr>
<tr>
<td>structured interview</td>
<td>(5 groups)</td>
<td></td>
</tr>
<tr>
<td>Teacher interview</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Classroom observations</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

3.6 Ethics approval
Prior to the commencement of data collection a human research ethics application was submitted for review to the University of Wollongong’s Human Research Ethics
Committee. The application was granted (approval number HE03/090). (see Appendix 15)

The application undertook that:

- the participants be fully informed of the study.
- an information sheet be provided for future reference (see Appendices 16, 18, 20, 22 and 23);
- participation would be voluntary;
- participants were free to leave the study at any time, and be told that should they withdraw, data collected from them would not be used in the study.
  Participants were also assured that withdrawal would not affect their standing with the researcher or the school.
- information would remain confidential;
- participants were advised that their identities would be protected by the researcher and that pseudonyms would be used in any publications arising from the study;
- consent would be obtained in writing; and
- participants were asked to complete and return a copy of the consent form (see Appendices 17, 19 and 21).

An application to conduct research was also submitted to the NSW Department of Education (see Appendix 13). Approval was granted (SERAP Number 02.230) (see Appendix 14) on the condition that:

- school principals had the right to withdraw the school from the study at any time. The approval of the principal for the specific method of gathering information for the school also had to be sought.
- the privacy of the school and the students was to be protected.
- the participation of teachers and students had to be voluntary and be at the school’s convenience.
- any proposal to publish the outcomes of the study should be discussed with the DET Research Approval Officer before publication proceeded.

Information sheets and consent forms appear as separate appendices:

Information sheet (student) Appendix 20
3.7 Summary

This study adopted a mixed method design combining qualitative and quantitative approaches including a combination of survey, interviews and case study research methods. Data were collected over a three-year period from teachers, students and industry representatives in the data logging field.

For the main study, 199 science teachers (including 27 TILT facilitators) and 257 students were surveyed. In addition to the surveys 22 teachers, 27 students and 3 industry representatives were interviewed either singularly or as focus groups. Four lessons were observed. Data collected were analysed for emerging trends using Excel™ spreadsheets, FileMaker™ databases and NVivo™ qualitative analysis software. The mixed-mode methodology allowed for verification and triangulation throughout the study to increase the reliability of the researcher’s interpretation of the results.
Chapter Four: The big picture: results and discussion

In this chapter the data collected from the first stage of the research is presented and analysed. Section 4.1 reports on the data from the teacher surveys. This is followed by the results of surveys of experts in the field of data logging, presented in Section 4.2, and then results from outside agencies including the results of a workshop with science curriculum consultants (4.3) and interviews with company representatives (4.4).

This chapter gives a general picture of teachers’ attitudes to, beliefs about and practices in the use of data loggers in the classroom and sets the scene for the more detailed view described in Chapter 5.

4.1 Teacher Surveys

Table 4.1 shows the sample size and dates for data collected, including the initial data, from 2001.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>133 *</td>
</tr>
<tr>
<td>2002</td>
<td>88</td>
</tr>
<tr>
<td>2003</td>
<td>63</td>
</tr>
</tbody>
</table>

* Researcher had access to science teachers marking both HSC and School Certificate this year

4.1.1 Results

The teacher questionnaire

The questionnaire is reproduced as Appendix 8.

In some cases the respondents used capital letters or underlining to emphasis a point. These methods of emphasis have been duplicated in their quotes.
4.1.1.1 Questions relating to data logger use

The purpose of Question 1.1 was to identify the type of data loggers in use. This information although not part of the original questions of study was collected to identify if there was any relationship between the type of data logger used and teacher success in using data loggers in the classroom.

Table 4.2 displays the frequencies of types of data loggers used by respondents to the survey.

Table 4-2 : Analysis of data from Question 1.1

<table>
<thead>
<tr>
<th>Brand</th>
<th>Description</th>
<th>Number of respondents (n=63)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fourier . MultiLog</td>
<td>Hand-held and computer based</td>
<td>5</td>
</tr>
<tr>
<td>Pasco</td>
<td>Computer based</td>
<td>2</td>
</tr>
<tr>
<td>Vernier LabPro</td>
<td>Computer based</td>
<td>Nil</td>
</tr>
<tr>
<td>Texas Instruments</td>
<td>Hand-held graphical calculator</td>
<td>20</td>
</tr>
<tr>
<td>Data Harvest</td>
<td>Hand-held and computer based</td>
<td>29</td>
</tr>
<tr>
<td>Nil specified</td>
<td></td>
<td>7</td>
</tr>
</tbody>
</table>

The two data loggers that featured the most in schools were the lower priced data loggers, Data Harvest and Texas Instruments. Collectively they accounted for 87 percent of the market share amongst the respondents.

Question 1.2 asked teachers to report on the number of teachers in their faculty that were proficient in using data loggers and the number of teachers employed in the faculty. This question was designed to find the number of teachers at each respondent’s school who were proficient in using data loggers, and the overall proficiency of teachers in using data loggers for the total of respondents’ schools. The totals expressed as percentages are displayed in table 4-3.

Some respondents did not respond to question 1.2 in writing that they were uncertain about the term “proficient”. However the teachers who did respond to this question reported that 64 percent of the teachers at their schools in 2003 were regarded by them
as proficient in using data loggers. It can be seen that there was almost a twofold increase in the proportion of ‘proficient teachers’ from the previous year.

Table 4-3: Analysis of data from Question 1.2

<table>
<thead>
<tr>
<th>Year</th>
<th>% Proficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>31</td>
</tr>
<tr>
<td>2003</td>
<td>64</td>
</tr>
</tbody>
</table>

Question 1.3 asked teachers to report on the number of teachers within their faculty who were using data loggers.

Table 4-4: Analysis of data from Question 1.3

<table>
<thead>
<tr>
<th>Year</th>
<th>% Using</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>35</td>
</tr>
<tr>
<td>2003</td>
<td>75</td>
</tr>
</tbody>
</table>

In 2003, 75 percent of teachers were reported by respondents as using data loggers in their classrooms. This indicates that approximately 11 percent of teachers use data loggers in the classroom despite being considered by their colleagues as not proficient is their use.

Question 1.4 asked teachers to indicate which educational year groups they used data loggers with.

Table 4.5 summarises the data from Question 1.4 showing the frequency of use of data loggers in schools as compared to the year or class group for the 2003 data.
This question was designed to determine the use of data loggers across the science curriculum. Forty percent of the responses to this question indicated that data loggers were solely used in the senior school (Years 11 and 12 only). Some reasons for this could be:

- teachers lacking confidence to use data loggers with junior classes;
- teachers not wanting to use data loggers with larger classes in junior years;
- teachers not trusting junior students to take care of the expensive equipment;
- too much competition to use the data loggers, hence junior classes are restricted in their use (i.e. senior classes given preference);
- the use of data loggers is only mandatory in Stage 6 syllabuses.

Table 4.6 shows the percentage of schools that only used data loggers for senior classes in 2001, 2002 and 2003.

<table>
<thead>
<tr>
<th>Year</th>
<th>Percentage Use of data loggers in only senior years (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>59</td>
</tr>
<tr>
<td>2002</td>
<td>46</td>
</tr>
<tr>
<td>2003</td>
<td>40</td>
</tr>
</tbody>
</table>
This data shows that the percentage of schools using data loggers only in the senior school (Years 11-12) was decreasing. This may indicate that teachers had become more familiar with incorporating the technology into the junior classes after being required to use them in the senior subject areas.

Question 2.1 is similar to questions 1.2 and 1.3, however it relates specifically to the respondent’s own use of data loggers rather than their perceptions of use in their school. Table 4.7 shows the data collected from Question 2.1, showing the percentage of teachers who felt confident in using data loggers. Of the 61 teachers that responded to this question 56 (92 percent) responded as knowing how to use a data logger, but only 47 percent felt confident in using them.

Table 4-7: Summary of data for Question 2.1 (n= 61)

<table>
<thead>
<tr>
<th>Question</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Do you know how to use a data logger?</td>
<td>56</td>
<td>5</td>
</tr>
<tr>
<td>Are you a confident user?</td>
<td>27</td>
<td>31</td>
</tr>
</tbody>
</table>

Table 4.8 summarises the data collected for Question 2.1 compared to previous years.

Table 4-8: Confidence in using data loggers compared to previous years

<table>
<thead>
<tr>
<th>Percentage of respondents confident in using data loggers in the classroom</th>
<th>2001 (n=133)</th>
<th>2002 (n= 88)</th>
<th>2003 (n=63)</th>
</tr>
</thead>
<tbody>
<tr>
<td>28 %</td>
<td>40 %</td>
<td>47 %</td>
<td></td>
</tr>
</tbody>
</table>

In 2003, 47 percent of teachers reported that they were confident in using data loggers. When compared with the baseline data from 2001 and 2002, this indicates that the confidence of teachers in the use of data loggers increased over the three-year period of the survey.
Question 2.2 asked teachers what inservice training they had participated in regarding data loggers. Of the 62 respondents for this question, 8 (13 percent) indicated that they had received no training in the use of data loggers. A further four respondents (6 percent) indicated that they had received less than one hour of training. The majority of the respondents (80 percent) identified participating in training of two or more hours.

A variety of training sources were identified, including:

- the science teachers’ professional associations NSW Science Teachers Association (STANSW), Metropolitan South West Science Teachers Association (LAZSTA);
- sales representatives;
- TILT Plus Science (Technology in Learning and Teaching) - an Australian Government initiative for training teachers in using technology;
- In-school training either by a colleague or in a faculty development day.

It is not surprising that teachers who had either no training or limited training (1 hour or less) recounted negative attitudes in their responses to the questions in the survey, for example:

*At this stage I still check them out before class. None has been available so far. I have read the instructions and saw several demonstrated at STAWS (Science Teachers Association of Western Sydney) meeting, but the sales people were not proficient and could not make several brands work (We were suitably impressed.) (#24);*

*Just brief inservice from my HT [Head teacher]. I feel that before using it in the classroom I have to get it out and remind myself and practice. (#16).*

Other comments included:

*Very little and I would like MUCH MORE. Using the equipment. When un-proficient is terribly time consuming which leads to unwillingness to do so and so on downwards! (#3);*

*The physics teacher showed me (us) how to use it on a SDD [School Development Day] (need retraining each time you get it out) #23.*
Question 2.3a asked teachers to report on whether they used data loggers in the classroom.

Table 4.9 shows the data collected from Question 2.3a, showing the percentage of teachers using data loggers in the classroom.

Table 4-9: Summary of data for question 2.3 (n=63) (2003)

<table>
<thead>
<tr>
<th>Question</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Do you use data loggers in the classroom?</td>
<td>52</td>
<td>10</td>
</tr>
</tbody>
</table>

One of the respondents, who was not using data loggers in the classroom, reported that this was because the school had not purchased any. A majority (84 percent) of respondents in 2003 reported that they used data loggers in the classroom, however only 47 percent said they were confident (See question 2.1). This indicates that many teachers used data loggers in the classroom despite not being confident in their use.

Table 4.10 shows a comparison of the data collected for Question 2.3a compared to previous years.

Table 4-10: Comparison to previous years

<table>
<thead>
<tr>
<th>Percentage of respondents using data loggers in the classroom</th>
<th>2001 (n=133)</th>
<th>2002 (n=88)</th>
<th>2003 (n=63)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>43</td>
<td>63</td>
<td>84</td>
</tr>
</tbody>
</table>

The results show a steady increase in the data logger usage over the three-year period. The remainder of the survey was completed only by teachers who were using data
loggers in the classroom. The open nature of these questions allowed for more in-depth responses.

The first open-ended question (2.3b) asked teachers to describe how they used data loggers in the classroom. Responses were coded as high, medium, and low level users. Table 4.11 shows the rubric used to distinguish the level of data logger usage in analysing the responses.

**Table 4-11: Rubric for determining the level of use of data loggers**

<table>
<thead>
<tr>
<th>Level</th>
<th>Typical response</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>More than one sensor used and/or specified analysis of data in their response</td>
</tr>
<tr>
<td>Medium</td>
<td>Two or more experiments, but without detailed analysis using the functions of the data logger software</td>
</tr>
<tr>
<td>Low</td>
<td>Use of the data logger to record only simple measurements such as temperature</td>
</tr>
</tbody>
</table>
Table 4.12 shows a selection of responses to Question 2.3b demonstrating high, medium, and low level use of data loggers.

**Table 4-12: Selected responses to question 2.3a (2003)**

<table>
<thead>
<tr>
<th>Level of use of data logger</th>
<th>Typical response</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Temperature monitoring</td>
</tr>
<tr>
<td></td>
<td>Position analysis, pH, dissolved oxygen, light.</td>
</tr>
<tr>
<td></td>
<td>Temperature in greenhouse models, endothermic and exothermic reactions, change in temp when heating water. Heart rate before and after exercise. temp, pH probes in senior chem pracs. pH of substances in household and skin for senior science, water testing pH.</td>
</tr>
<tr>
<td></td>
<td>Measure temp change and pH, generate graphs on screen.</td>
</tr>
<tr>
<td></td>
<td>Primarily for recording temperature, pH meter has been tried, but is difficult to calibrate - used pH paper instead. Heart rate monitor and light gates are used to familiarise the kids with equipment.</td>
</tr>
<tr>
<td>Medium</td>
<td>Motion studies / temp of heating water / only because we have to.</td>
</tr>
<tr>
<td></td>
<td>To look at salinity and pH for marine studies.</td>
</tr>
<tr>
<td></td>
<td>Temperature v time – once.</td>
</tr>
<tr>
<td></td>
<td>To measure temperature changes in experiments (also to measure pH if the probe is working).</td>
</tr>
<tr>
<td>Low</td>
<td>As a replacement for other meters / thermometers.</td>
</tr>
<tr>
<td></td>
<td>Once per year - because the syllabus says you need to use them.</td>
</tr>
<tr>
<td></td>
<td>Basic function temp etc.</td>
</tr>
<tr>
<td></td>
<td>Have only used the temperature probe so far.</td>
</tr>
</tbody>
</table>
Table 4.13 shows the variation in level of use of data loggers by teachers.

<table>
<thead>
<tr>
<th>Percentage use of data loggers in the classroom (n=63)</th>
<th>High Level</th>
<th>Medium Level</th>
<th>Low Level</th>
<th>Not used</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>48</td>
<td>25</td>
<td>11</td>
<td>16</td>
</tr>
</tbody>
</table>

Although 84 percent of respondents in the 2003 survey indicated using data loggers in the classroom, the depth and frequency of use varied considerably. The majority of teachers who used data loggers, used them for high-level tasks such as open-ended investigations (including predict, observe, explain tasks). Only a small percentage of the teachers who employed data loggers used them for low-level tasks where the data logger was used only to record simple data such as temperature.

On reading the surveys it appeared that there may be a relationship between the teacher confidence level and the level of complexity of data logger usage, however this is beyond the scope of this report. There also appeared to be a relationship between the type of data logger being used. Specifically, teachers using graphic calculator type data loggers tended to not undertake high-level tasks.

### 4.1.1.2 Questions relating to teacher and student use

Question 2.4 asked teachers to comment on how the use of data loggers had changed the way they taught.

The responses to this question are summarised in table 4.14. This open-ended question was coded as to whether the use of data loggers had resulted in a perceived change of teaching (this included changes in the amount of time preparing for lessons, the interest level of classes, and the interpretation and collection of data).
Table 4-14  Summary of data collected for question 2.4

<table>
<thead>
<tr>
<th>Perceived change in the way teachers teach due to data loggers. (n = 52)</th>
<th>Changed</th>
<th>No change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>48 %</td>
<td>52 %</td>
</tr>
</tbody>
</table>

Of the 25 teachers who responded that the use of data loggers had resulted in a change in the way they teach, eleven (11) responded that their teaching had changed in a positive way, nine that it had changed in a negative way. Five of the teachers expressed both positive and negative responses.

Typical positive responses were:

*It has made it easier to show the pH profile curves and easier to assess its usefulness when indicators are used simultaneously;*

*Science is taught in a more sophisticated manner relevant to real life;*

*They have been useful in developing the skills of observation, hypothesising and inferring in students. The data logger provides data that can be used to generate a scientific approach to analysis. Sometimes, for example unanticipated trends or results are obtained. This is useful for analysing;*

*Made a number of tedious experiments much more efficient;*

*More interesting.*

Many of the teachers who responded in a negative manner to this question suggested that the use of data loggers had changed their teaching in a negative way due to the extra work and/or extra time required in class instruction time and preparation time:

*Work: added an extra layer of work. As the set-up time is long / availability of laptop /PC difficult they are a pain to use (note: no inservice training);*

*Work: Made it more complicated and time consuming (Note: Calculator model);*
Work: It has increased the preparation time, there is always a lot of prechecks on the data loggers to see if they are working (batteries charged, computer available, meters calibrated etc).

Teacher confidence was again mentioned as a significant influence:

Confidence: I have only used loggers in a limited way. I found them unreliable and cumbersome. More effort and time was spent in learning to operate them than on the point of the lesson. (Note: Calculator model);

Confidence: I am not confident in their use: I do not always fully understand the data that is provided by the logger. I am reluctant to use but we try when there is a reference to data logger in the 3rd column dot points.

Teachers were also asked whether they thought their students were proficient in using data loggers (Question 3.1). Table 4.15 displays the data collected for Question 3.1.

Table 4-15: Summary of data for Question 3.1

<table>
<thead>
<tr>
<th>N=51</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Question</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In general, are your students proficient in using data loggers?</td>
<td>10</td>
<td>41</td>
</tr>
</tbody>
</table>

This indicates that teachers generally did not believe that their students were proficient in the use of data loggers. This result would be expected in cases where data loggers were infrequently used or used by teachers who themselves were not proficient in their use.

Teachers were also asked how they thought the use of data loggers had affected the way students learn (Question 3.2). Only twenty-nine of the sixty-three respondents to the survey responded to this question giving a range of responses. The responses were analysed and classified into themes:
• data collection;
• motivation of students;
• increase in ICT skills;
• graphing skills and visualisation; and
• equipment concerns and student use.

These responses were further analysed as being either negative or positive response, however many of the responses included both positive and negative points.

All responses noting data collection were positive. Responses included positive comments such as the ability to collect data, the use of current technology, and students’ ability to interpret graphs.

Typical responses included:

- Allows them to record and observe things that they wouldn’t in the past;
- Several repeat experiments are easy - students concentrate more on the practical concepts rather than data collection;
- Data loggers in general only show students how to improve precision - sometimes the Authentic data has been generated. Students may be a bit more motivated to get involved with the experiment.

Most of the respondents depicted an increase in the motivation of students as a positive use of data loggers, for example:

- They are interested in the technology and tend to remember the data collected;
- They enjoy the use of DL. Lessons using technology are usually well received;
- Usually provide motivation and interest, context and technology sophistication.

Some teachers considered that although the data loggers did increase student motivation, there were negative aspects to their use. Negative responses included:

- Students find them confusing: too complicated;
- Although they love the gadgetry do not benefit;
- Not positively at all - they love all gadgetry but don’t really benefit from it in any tangible way.
Teachers identified that the use of data loggers resulted in an increase in ICT skills. Comments included:

*They do not rely solely on data logger technology, but rather use them to confirm their results or achieve more accurate results;*

*They come to expect that technology is used in practical experiences;*

*They are interested in the technology (some of them).*

Although it was noted that the use of data loggers increased students ICT skills there was concern that students did not understand how the data loggers worked. Some teachers referred to this as “blackbox” technology:

*Not that much - just another “black Box”;*

*Students are interested in the electronics but I do not feel they all have an understanding of the reasons for their use;*

*Quick collection and recording of results - instant graphing a bit too much “black box technology”.*

Some data loggers are able to easily allow students to draw graphs in real time. Only one respondent specified graphing as a positive outcome of using data loggers. Many teachers were concerned over students losing the skills to accurately draw and interpret graphs:

*Kids are keen to use them, but digital display and computer graphing can mean kids lose skills at reading analogue displays and graphing manually;*

*When on graphing functioning can see change occurring, but only suitable with small groups, has helped in understanding of concepts;*

*Their accuracy has removed the necessity to seriously consider errors from students immediate concerns. Since students no longer record individual data points they seem to lose the concept of the graphs as a group of data items.*
Teachers identified a reluctance to trust students to use the equipment due to the cost and risk of breakage. The small number of data loggers available for use in the school was also a limitation to their wider usage. Responses included:

We have money only to buy 1 logger. We are reluctant to let it out of our sight due to its cost;
The other has been borrowed from regional office;

Our only data logger can only be touched by senior students under close supervision.

4.1.1.3 Questions relating to student learning
Question 3.3 asked teachers whether they thought that the use of data loggers had increased student understanding.

Table 4.16 summarises the data from Question 3.3 showing the frequency of respondents’ perceptions of the effect of data logger use on increasing student understanding.

Table 4-16: Summary of data for Question 3.3 (N= 47)

<table>
<thead>
<tr>
<th>Question</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Has the use of data loggers increased student understanding?</td>
<td>Yes 17</td>
<td>No 30</td>
</tr>
</tbody>
</table>

Of the 47 teachers who responded to this question 36 percent claimed that the use of data loggers had resulted in increased student understanding. This included recognition that data loggers were able to record data previously unobtainable and enabled students to see trends more easily.

Typical responses were:

eg intensity proportional to distance squared can be seen quickly and graphed - data can be manipulated
eg - measurement of ambient light - leading to better understanding;

More accurate measure of data (usually) enabling results which confirm theories;
Maybe. If they enjoy they will remember. However, sometimes they need to focus on how and what the data collected means;

See very clear trends;

In reality I don’t think they help very much. The exception to this is the study of trends in science. The ability to take many samples over a given time (long or short) enable us to produce excellent graphs showing the trends that occur.

Some teachers were very critical of the DET in introducing data loggers and wrote copious amounts in their reply to the question, especially outlining the disapproval of the compulsory nature of their introduction. Others claimed that they were only using data loggers because of the syllabus. Typical responses included:

It has added to their burden of knowledge in an already overloaded syllabus;

It has increased understanding of data loggers, but a popular educational fantasy suggests that if a concept is difficult to understand it will be better understood by putting one or two extra steps into the process, thus giving the process to be learned more parts and making it more complex. Unless students are already familiar with data loggers as with rulers and pencils, we have them learning data loggers instead of science;

Only if the principles being taught are covered “long hand” first so that students know what the data they are collecting means. To then be able to collect and analyse real data trends is helpful.

4.1.1.4 Questions comparing data loggers to conventional practices

Questions 4.1 and 4.2 were combined for analysis. Question 4.1 asked teachers to report on how their use of data loggers differed from conventional methods. Question 4.2 asked teachers to report on the benefits of using data loggers in the classroom.

Although the intention was for the questions to be separate, many teachers answered Question 4.2 as in their response to Question 4.1 and either directed the researcher back to their response for question 4.1 or left the question blank.
Responses to these questions were coded thematically with reference to:

- the speed and accuracy of data collection;
- technology;
- graphing of data;
- student motivation;
- resource issues;
- “real” science;
- syllabus requirements; and
- student learning.

The responses were further coded as to positive or negative attitudes, and whether the respondent mentioned a future benefit of using data loggers.

**Speed and accuracy of data collection**

The ability to record accurate and high-speed data was seen as a major advantage for using data loggers and was mentioned by 21 of the respondents. Typical responses for these questions included:

*Student interest is enhanced. Repeat data enhances reliability. Quick timing provides “new” data unobtainable by other methods;*

*Direct measurements of situations which could only be recorded with poor accuracy are now available. Less maths is needed, therefore less maths is practiced.*

One respondent also highlighted the ability of data to be collected over an extended period of time.

*The REAL benefits would be in remote measurements, very slow changes which need recording over several days and quantities which change so fast or have such short durations as to be difficult to register. Software to print video frames from digital cameras would be of equal value and probably less cost.*

**Technology**
The increase in the use of technology was noted by 19 of the respondents. This included both positive and negative comments. Positive responses in general pointed towards an increase in effective use of technology by students. Some of these respondents also noted that the use of data loggers was “real” science and what students would use when they entered the workforce. Typical positive responses coded for technology included:

*If teacher is proficient then students are able to access a new, time saving technology;*

*Increase kids’ use of computers for more involved applications, other than word processing and internet;*

*As for 4.1 and takes science into technology era, introduces students to equipment available beyond most high school science.*

The use of technology caused frustration amongst some teachers, however of particular note was the limited number of data loggers available, the lack of computers available, and the frustration with trying to get the technology to work. Typical negative responses coded for technology included:

*At this stage very little - need to have access to cheap user friendly machines that become a tool and not the focus of the lesson;*

*I am dubious with their use with many classes due to the cost of the equipment and the relative ease with which students can destroy it;*

*They provide a change in using technology on the method of teaching. However they also produce high level of angst in lab assistants, teachers and students when things go wrong;*

*At the moment, very little - having only one computer in the lab, means you have to quickly download each groups results so they don’t really have a chance to manipulate the data themselves.*

**Graphing of data**
Whilst many of the respondents saw the ability to display data in a graphical form as being a positive use of data loggers, some respondents noted that this diminished the ability of students to draw and interpret graphs. Some claimed that the technology made students “lazy”. Typical responses included:

students use logger for results and graphs and decreases their own observations skills;

Not many! I still think they are the most expensive and complicated thermometers I have ever used;

Tends to make people lazy - they need fewer “skills” to read a digital thermometer than an analogue (conventional) thermometer;

Not at all. Merely makes data analysis a lot easier and possibly dumbs the process down for the students (ie the computer program now draws the graph).

**Syllabus**

The driving force behind the implementation of data loggers has been their inclusion in relevant science syllabuses. Some teachers noted the use of data loggers to fulfil syllabus requirements. Typical responses included:

Meet syllabus and therefore review requirements;

None at this stage. - just fulfilling the syllabus requirements - however I am hopeful of doing data analysis with some graphing results later.

### 4.1.2 Discussion

The teacher surveys indicated that although there had been an increase in the confidence levels and use of data loggers in the science classroom, there was still a significant number of teachers not confident in their use.

The lack of confidence may explain why teachers are either not using the data loggers or are restricting their use. Comments suggest that the use of data loggers often increased the personal stress felt by teachers.
Teachers using data loggers generally could see the benefits of their use, identifying the following:

- speed and accuracy of data collection;
- increased motivation of students;
- ability to visually obtain graphed results; and
- increase in ICT skills and use of modern technology.

Some teachers had expressed negative attitudes towards using data loggers. This included:

- Lack of teacher training;
- Decrease in the ability of students to draw graphs; and
- Equipment and classroom management issues.

These barriers to the uptake of data loggers are significant. The responses to the surveys showed that some teachers were not familiar with what a data logger could do. In some cases it was clear that they had only identified its use to record temperature. This was demonstrated by comments such as “I know they can be connected to a computer” or comparing the use of a data logger to a thermometer with no reference to using the data logger to analyse the data recorded.

Some teachers referred to the low numbers of data loggers available and the complexity of models available in their school as key issues.

The researcher attempted to determine the overall attitude of teachers to the use of data loggers. After reading all of the responses the comments were coded as being positive, negative, or indeterminate in their attitude towards the use of data loggers.

Table 4.17 summarises the attitudinal responses of teachers to the use of data loggers based on respondents’ overall responses to questions.
Table 4-17: Summary of teacher attitude to the use of data loggers (2003)

<table>
<thead>
<tr>
<th>Percentage of respondents displaying overall positive/negative/unsure attitude to the use of data loggers. N=63</th>
<th>Positive</th>
<th>Negative</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>38</td>
<td>25</td>
<td>37</td>
</tr>
</tbody>
</table>

Only 38 percent of teachers were judged as having a positive attitude towards the use of data loggers in the classroom. There are many possible reasons for this low response as mentioned previously, but the responses are an indication that many science teachers are not positive about the use of data loggers in their classes.

4.2: TILT Trainer Surveys

Teachers who were selected for training to become TILT (Technology in Teaching and Learning) trainers for the AGQTP (Australian Government Quality Teaching Program) data logging course were surveyed at the end of their course. All 27 teachers who attended the training completed the survey. These teachers were selected to attend the course after demonstrating that they used data loggers in the classroom and as a minimum requirement were able to operate a data logger to collect data using a temperature sensor. The questionnaire was distributed and collected on the last day of an intensive four-day course.

The intention of this survey was to find out more about teachers who were using data loggers successfully in the classroom. This survey was similar to the one given to teachers and analysed in Section 4.1. Questions in the survey relating to the type of data logger, inservice training and level of expertise of teachers within the faculty were not analysed as the researcher’s intention with this group was to be specific in regard to the teacher’s personal use.

4.2.1 Results

The TILT Trainer Questionnaire
4.2.1.1 Questions relating to data logger use

Question 2.1 asked trainers if they were personally confident in using data loggers. All 27 participants indicated that they were confident. Two further specified that this was limited to the brand of data logger that they had in their school.

This was expected, as each respondent had just completed four days of training. The minimum requirement to attend the training was that participants were to be able to connect their data logger to a computer and take temperature readings, although this selection criteria was not adhered to in all cases.

Question 2.3 asked the trainers to comment on whether they used data loggers in the classroom. Although participants were selected on their ability to use data loggers, some participants had little experience with them in the classroom, and had come to the course on the understanding that they were to receive further training. All of the respondents except one acknowledged using data loggers in the classroom. Five specified that this was “only occasionally” or “in a limited fashion”. This could be of concern as the respondents who had not used data loggers in the classroom were now to be in charge of training other teachers in the effective use of data loggers. This situation also demonstrates the limited support available to teachers in incorporating data loggers into the classroom.

Question 2.4 asked the trainers whether the use of data loggers had changed the way they taught. Eighteen of the respondents responded that the use of data loggers had changed the way that they teach. Typical responses were generally positive and included:

*It makes more convincing links with theory because the data more closely matches the theory;*

*A bit. Still do the same prac, but data acquisition easier - eg print graphs rather than take many measurements and plot. Quicker better results. More time in lesson for analysis and discussion;*

*It makes you think more seriously about classroom management, what prior knowledge is needed, and allowing peer tutoring.*
Six respondents indicated that the use did not affect their teaching. For example, one teacher stated that a data logger was just another piece of equipment that he used.

*It hasn’t really, it is just another tool / piece of equipment I use.*

**4.2.1.2 Questions relating to student learning**

The remainder of questions in the survey were in relation to the effect that data logger use had on student learning. Question 3.2 asked trainers to comment on how the use of data loggers has affected the way students learn? Comments were coded as having a positive effect, negative effect, or as no effect/ unable to discern. Table 4.18 summarises the data collected for Question 3.2

<table>
<thead>
<tr>
<th>How do you think the use of data loggers has affected the way students learn? N=27</th>
<th>Positive</th>
<th>Negative</th>
<th>No effect / unable to attain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>56 %</td>
<td>Nil</td>
<td>44 %</td>
</tr>
</tbody>
</table>

No negative responses were recorded for this question. These very positive comments were probably a result of the teachers’ personal confidence not only with the use of data loggers but also in an educational setting.

Responses included:

- *Some are catching the bug of data logging. Can be extremely efficient for producing very quick or long term experiments;*

- *It makes more convincing links with theory because the data more closely matches the theory;*

- *Easier to get good data - more time to analyse. Easier to see trends over time;*

- *It is inspirational. makes seniors feel experience is important. Allows longer term logging (made easy) for bio;*
Enables them to complete some more complex tasks. Increases accuracy of results;

They respect use of “new” technology. Develops interest, motivates - they are used to technology;

Made trends etc clearer, more independent learning;

Not really, its just allowed them to see science experiments moving into the 21st century.

Question 3.3 asked trainers to comment on the effect using data loggers had on increasing student understanding. Table 4.19 summarises the data collected for question 3.3

Table 4-19: Summary of data for question 3.3

<table>
<thead>
<tr>
<th>Do you think the use of data loggers has increased student understanding?</th>
<th>Yes</th>
<th>No</th>
<th>No effect / unable to attain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>58%</td>
<td>17%</td>
<td>25%</td>
</tr>
</tbody>
</table>

The response to this question was more positive in comparison to the teacher surveys analysed in Chapter Four, with 58 percent of TILT trainers reporting that data loggers had resulted in an increase in student understanding as compared to only 36 percent in the larger teacher survey.

Typical responses indicating that data loggers had increased student understanding were:

- Helps with visual learning and the application of theory in a practical sense;

- As a tool aids understanding, just as other tools do. Increased use may lead to greater understanding;

- Allows students to further investigations to chase up answers to problems as questions are posed;

- But it is in an indirect manner. “Direct” understanding does not happen, just by introducing data loggers. Data loggers, enrich and add to the central concept being studied.
Typical responses that indicated that data loggers had not increased student learning were:

No, changed some way of collecting. I’ll probably go back and use them more, until I have equipment failure!

But it has increased student participation and pride in better ownership;

There is still a need for simple, classical experiments that don’t have a “black box”;

Not yet. Under used.

Some responses indicated that they had no evidence of an increase in student learning due to the limited time they had used them in class.

Responses often indicated that they could not discern whether data loggers had as yet increased student learning, however could see the potential. For example:

It makes more convincing links with theory because the data more closely matches the theory;

Can’t answer. Not enough evidence;

No for skills. Yes for content. No for creative thinking.

Others stated they could now see the possibilities to increase student learning after completing the course. For example:

It will;

Lots of possibilities with thoughtful use.

Questions 4.1 and 4.2 were again combined for analysis. Question 4.1 asked trainers to report on how their use of data loggers differed from conventional methods. Question 4.2 asked trainers to report on the benefits of using data loggers in the classroom.

Responses were coded using the thematic coding system developed from the analysis of the teacher survey used in Section 4.1:

• the speed and accuracy of data collection;
• technology;
• graphing of data;
• student motivation;
• resource issues;
• “real” science;
• syllabus requirements; and
• student learning.

The speed and accuracy of data collection
Many trainers commented on the advantage of speed and accuracy of data collection when using data loggers compared to conventional methods of data collection. For example:

More accurate, precise measurement over time spans too small or too large to measure easily;

More flexible. Manipulation of data. Increased sensitivity. excellent in Bio;

Obtaining more useful data during experiments - allowing students to develop “what if”, could I do this;

Quicker, allows rapid repetition and selection of data sets instead of reliance on single data points.

The ability to collect data from phenomenon normally not measured by conventional methods (such as measuring light intensity, titrations, and colorimetry) was also highlighted. For example:

Easy and quickly manipulate data. Able to see phenomenon not visible other ways. eg lux of fluorescent light;

Enables possible sampling which cannot be done using traditional methods.

Technology
All responses relating to technology and ICT were positive. These included:

Linking technology to outcomes and skills;

Increase student confidence in use of technology;

Increases accuracy of measurement. Introduces ICT to students.
Graphing of data
The ability to display data in a graphical form in real time was seen as a positive attribute to using data loggers. For example:

*Real time results for graphs. Accuracy of results;*

*Link between shape of graphs and reality.*

One trainer commented that using conventional tickertape timers was of greater benefit than using the data loggers:

*However cutting ticker timer paper into strips etc can make the data more concrete.*

However, this comment was in relation to only using the data logger specifically for motion experiments.

Student motivation
All comments regarding the impact of data loggers on student motivation were positive. One trainer commented that s/he had not really used data loggers and that they were a gimmick. For example:

*Motivation. increased sensitivity, gives students more of an idea of real science;*

*Not really used, probably gimmick effect rather than anything else;*

*Increased student motivation.*

Resource issues
Many trainers mentioned that the lack of sufficient numbers of data loggers hampered their effective use. The lack of time to train teachers and students was also mentioned. Typical responses included:

*Need more DLs before effective;*

*Not a lot at moment due to lack of numbers of data loggers and time to train students;*

*Not a great amount, just a lot to organise and master (note no inservice training);*

*At moment conventional methods are used in preference.*
“Real” science
Responses identifying that the use of data loggers represented “real” science and were current methods of collecting data were positive. Responses included:

Data loggers are must for all science teachers to use - they are a key component in advances in food quality, horticulture etc;

Real world experience ie real world data acquisition. Sometimes better results than traditional methods;

Relevance to real life.

Syllabus requirements
No comments were recorded in relation to completing syllabus outcomes. It may be that the trainers considered the use of data loggers as a tool to use in the classroom. That is, it appeared that their use was not driven by mandatory syllabus requirements, but rather by pedagogy.

Student learning
All responses were positive about student learning. The ability to modify experiments quickly and to quickly record data was seen as a major advantage of using the data loggers over conventional equipment. Typical responses included:

Promotes flexible thinking, better experiment design, better methodology, ability to make modifications and see if they make a difference;

Allows students to further investigations to chase up answers to problems as questions are posed;

Concentrate on data and results / concepts rather than procedures to gather them.

4.2.2 Discussion
The results from the TILT trainers differed from those of the initial teachers surveyed. On the whole their responses were more positive, especially in relation to the advantages of using data loggers. As they were selected on the basis of their
proficiency it is not surprising that their responses demonstrated a greater understanding of the use of data loggers.

The trainers also appeared to have a greater understanding of how data loggers could be used in the classroom to increase higher order thinking skills among students. For example most of this group reported using the data loggers for more than temperature or motion analysis.

It appeared that the trainers were more motivated to use the data loggers in the classroom because they regarded this as good science and good teaching rather than only because of the syllabus requirements. Also they had better training and more access to the technology.

Informal discussions with the trainers indicated that these teachers were generally confident in using data loggers, generally very confident teachers and enjoyed what they were doing.

### 4.3: Consultants Workshop

**Introduction**

This section briefly outlines the views of 18 science curriculum consultants on the implementation and use of data loggers. As the district consultants were frequently in schools assisting teachers they were in a good position to observe the practice that was occurring with data loggers. All consultants had received training in the use of data loggers. Science curriculum consultants reported on the ideal and actual picture in relation to the use of data loggers in the classroom as part of a workshop facilitated by the researcher.

Participants were randomly allocated into four groups. Each group was given a sheet of butcher’s paper that was divided in half by a line drawn down the centre of the page. The task was to list on one half of the paper the ideal situation of using data loggers in schools and on the other half the actual situation. Groups then reported back to the whole workshop.
The technique of using “ideal vs actual picture” was similar to that used by the Department of Education, Training and Youth Affairs (Goodrum, Hackling et al., 2001) and familiar to the participants of the workshop.

4.3.1 Results

Table 4-20: Results of curriculum consultants workshop

<table>
<thead>
<tr>
<th>Group</th>
<th>Ideal Picture</th>
<th>Actual Situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>All students actively engaged&lt;br&gt;Teachers confident at basic level, including calibration&lt;br&gt;Data loggers as main means of gathering data in their own investigations&lt;br&gt;Data loggers adequate resources&lt;br&gt;Technical support&lt;br&gt;Teachers value them across the program&lt;br&gt;Teachers can draw on real examples&lt;br&gt;Data logger as tool for student-centred investigation</td>
<td>Little junior access due to limited numbers</td>
</tr>
<tr>
<td>Two</td>
<td>One per group and computer in the classroom&lt;br&gt;Computer in classroom&lt;br&gt;Internet to share info&lt;br&gt;Regular sustained use&lt;br&gt;Training&lt;br&gt;Data loggers used as a tool&lt;br&gt;Ideas on how to use&lt;br&gt;Match the syllabus&lt;br&gt;Open-ended research as opposed to “cook book”&lt;br&gt;Students want to use</td>
<td>Demonstration only&lt;br&gt;Lack of numbers&lt;br&gt;Safety of equipment&lt;br&gt;Most teachers not confident&lt;br&gt;Low priority&lt;br&gt;Poor computer access&lt;br&gt;Cost</td>
</tr>
<tr>
<td>Three</td>
<td>Teachers and students automatically reach for a data logger in order to measure physical phenomena&lt;br&gt;There is sufficient equipment to allow</td>
<td>Few teachers are confident in the use of data loggers&lt;br&gt;Insufficient data loggers available for students to use</td>
</tr>
</tbody>
</table>
students to work in small groups
Competence at interpreting logged data

| Four | Appropriate and frequent use
| All staff confident in data logging
| Explicit in programs and tracked/linked to skills
| Funds sufficient
| Ongoing and unlimited free support
| Open / investigation use – instead of “recipe”

| Practice is too infrequent |
| Not really being used. Only being pulled out of cupboard to do mandatory pracs – demos
| Teachers neither CONFIDENT or competent in use
| Rarely explicitly / systematically taught – tracked through program
| Rarely seen written into programs
| Support from tech / supplier limited
| Systems changing – software and hardware
| Possibly half teachers on faculty “their pet”
| Limited sharing of corporate knowledge.
| Take it with them
| Schools not happy with what they bought originally

### 4.3.2 Discussion

The consultants identified that in the ideal situation there would be sufficient data loggers and related technology available to schools, and that the level of professional development resulted in teachers being confident in their use of data loggers and relationship with the syllabus. Furthermore, students would be actively engaged in science and be able to use the data loggers for open-ended investigations.

In reality, however, there were insufficient resources in schools, and most teachers were not confident in the use of data loggers. The participants claimed that this was due to a lack of effective professional development. The consultants further claimed that in many schools the data loggers were only used by a few teachers. When these teachers left the school, so did the ‘corporate knowledge’ of how to use the data loggers. Furthermore, they felt that in many cases the use of data loggers was not integrated into teaching programs.
4.4: Company Representatives

This section reports on the interviews with three educational managers representing two companies that were leading suppliers of training and data loggers to schools. A set of proposed questions was forwarded to the representatives prior to the interview (see Appendix 11) and used as a guide during the interview process.

4.4.1 Benefits of using data loggers

As expected, both companies highlighted the effectiveness of using data loggers in the classroom to enhance student learning.

4.4.2 Implementation

One company was highly critical of the way that the data loggers were selected for schools. The company claimed that the Government (NSW Department of Education) had undergone a selection process to determine which brands of data loggers would be recommended for schools and in turn be supported by the DET in terms of professional development of teachers. However this advice was not followed by the Department’s major provider of stationery, business consumables and specialty products, which promoted purchasing from companies that it had already established contracts with for other services. As explained by one interviewee:

*The biggest problem I see. The overriding problem is that the fact that the government pulled out from being the advisor. Like a peak body to sieve through the wide line of products being poured into schools by opportunists… The teachers, most teachers, even the more capable are not able to decipher between [products] on the short time they have to understand what is the difference between this product and this product. They may go on price. … The government has to take this on because it is a lot of public money going into this area of equipment… The government has completely shied away from this area.*

Some of the brands of data loggers, although appearing to be a less expensive option, would only work with computers running the Windows 98 operating system. Hence schools using the current windows operating system supported by the DET, Windows XP, could not use their data loggers with newly-delivered computers. Also some data loggers would only connect to computers if they were fitted with a serial port and did
not make use of newer technology such as USB connections. One interviewee offered the following comment:

-One of the things with equipment and technology is running. As you know. In the case of software was running in 98 can't use 2000 etc. A company like **** for instance, they have as far as I know, not touched their product in terms of development since 95.

4.4.3 Teacher training
All company representatives identified teacher training as being of major importance in the implementation of data loggers, for example:

-Obviously there's a whole different grading of people with familiarity with computers and devices that can be connected to computers. But once people are introduced to them. Workshopped on them and they go ahead with confidence. We find that they are very much into using data loggers on a consistent basis. Which is very good.

The provision of teacher training in the use of data loggers was hampered by the many different models and computer software being used. One interviewee highlighted the benefit of promoting a limited number of brands of data logger in view of teacher training:

-It is common sense. That you expect. For such a large volume. If you want something to go into a school. You need to give training. But if you decide to give training, for all models and keep it all over the place. Then obviously, your stretched too far. And you won't be able to give the support.

-From my point of view, as a reseller, when you get the benefit of volumes. You can apply a lot more resources. But if you have sporadic sales of such as in Wollongong or Bathurst. If you have a large group it is much more economical to travel and to train. And part of your contract should be. If we buy from you in an organized manner, you need to commit yourself to training, need to commit yourself to software development.

One company representative highlighted his concern that in some cases the people who were responsible for making decisions about the implementation of data loggers into schools had limited knowledge and experience in using data loggers. One case
was highlighted in which two senior members of the DET had specified that data loggers should have the capacity to export data collected from the data logger into an Excel™ spreadsheet for analysis, whereas the data collection program that accompanied the data logger already contained a much more proficient data analysis software:

\[
\text{I remember our when that was first being discussed. That was saying that it was very important to teach teachers how to actually download the information into Excel. And even when we had that meeting here with *** and *** brought it up, that it was important to put the information into Excel. And I think, why would you bother, when the graphical analysis is so good. You can find the slope of a line. You can change the axis, no problems. Why would you put it into a accounting program.}
\]

### 4.4.4 Number of data loggers

Both companies agreed that the more data loggers in a school the higher the success rate of implementation. They argued that an increase in the number of data loggers would result in an increased availability of data loggers to teachers, and the commitment of large amounts of money towards their purchase would ensure that school leaders would be motivated to oversee the professional development of teachers, ensuring that the equipment was being properly used. One interviewee commented:

\[
\text{Well predominately. As those schools that have been able to put their own funding forward. And added it to the department's money. Because $4,000 doesn't go that far. And where they have been able to have enough or sufficient data loggers where they can use them practically in every classroom. Where they have six or seven workstations. They have up six or seven data loggers. So virtually the schools that have added numbers either gradually, or have got extra funding, quickly have bought a number of data loggers. The program is working effectively. Not so much in the ones that have only one or two.}
\]

The interviews with data logging company representatives indicated that there were variations in the level of implementation from school to school. Factors affecting the implementation included the number and type of data logger and the amount of professional development available for teachers.
The system approach to the implementation by the NSW Department of Education was criticised for not guiding schools in their purchase of data loggers. This had resulted in many schools purchasing data loggers that were cheap, but having limited company support, both in terms of teacher training and software/hardware development.

It was suggested that implementation would have been more effective if the Department had purchased one brand of data loggers for schools. This would have resulted in more cost-effective purchasing and better use of professional development.

4.5 Summary

The findings from this stage of the investigation provide the following insights into the use of data loggers in science classrooms.

Since the inclusion of data logger use in the NSW Science Syllabuses in 1999, science teachers have been faced with trying to include their use in the curriculum. Despite the mandatory requirement to use data loggers and the provision of funds to purchase data loggers, their use in the classroom has been limited.

The majority of teachers recognise the advantages of using data loggers, advantages such as the speed and accuracy of data collection and the ability to collect data previously unobtainable through conventional methods. Data logger use has the potential to increase the relevance of science to students through the use of up-to-date technology. This may also increase student motivation.

Despite the positives in favour of incorporating data loggers into the curriculum many teachers had not taken the step to use them. Most teachers currently in the teaching service were not originally trained in the use of data loggers. Teachers cite poor or insufficient professional development and the high cost and lack of equipment as major obstacles to their implementation.
Teachers identified by the Department to train as facilitators for the TILT training program experienced great success with the use of data loggers once they had become proficient in their use and were in most cases more positive about their use.

The multitude of data logger models available for schools has limited the amount of support available to schools. Many schools purchased data loggers that are too complex for teachers or students to use effectively.

The next chapter presents the results of the second stage of the study, which investigates the data collected from student surveys and teacher interviews.
Chapter 5: The Close-up picture. Results and Discussion

In this chapter the empirical data collected from the final stages of the research is presented and analysed. The first section (5.1) presents the data collected from student surveys, giving the student’s perspective on the use of data loggers. The second section (5.2) reports on the results collected from teacher interviews.

5.1 Student Surveys

This section presents data from the student surveys collected from Year 12 science students attending HSC study days in July 2003 and 2004 at the University of Western Sydney. Table 5.1 shows the sample size and dates for data collected, including base data from previous years.

Table 5.1: Student survey data

<table>
<thead>
<tr>
<th>Date</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 July 2002</td>
<td>192</td>
</tr>
<tr>
<td>23 July 2003</td>
<td>116</td>
</tr>
<tr>
<td>21 July 2004</td>
<td>141</td>
</tr>
</tbody>
</table>

5.1.1 Results

Questions 1 and 2 focused on demographic data such as gender and subjects studied. These questions were included for future reference so as to make the most of the survey opportunity. The data proved to be beyond the scope of this study and hence not reported.

Question 3 asked students whether their teacher had used a data logger with their class. If the answer was “yes”, students were further prompted to indicate how many times data loggers had been used.

Table 5.2 shows the analysis of Question 3 with the proportion of students who reported that their teacher had used data loggers with their class.
Table 5-2: Analysis of question 3

<table>
<thead>
<tr>
<th></th>
<th>2002 n= 192</th>
<th>2003 n= 116</th>
<th>2004 n= 141</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Has your teacher used a data logger with your class?</td>
<td>98 (51%)</td>
<td>94 (49%)</td>
<td>77 (66%)</td>
</tr>
</tbody>
</table>

These figures indicate that there was an increase in the proportion of teachers using data loggers among this sample. Despite the increase in the use of data loggers, these results do show that 30 percent of teachers were not following requirements mandated by the syllabus.

Table 5.3 shows the analysis of Question 3 showing the frequency of use of data loggers by teachers from the sample in 2003 and 2004.

Table 5-3: Analysis of data from question 3

<table>
<thead>
<tr>
<th></th>
<th>2003 n= 109</th>
<th>2004 n= 136</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question</td>
<td>Nil</td>
<td>Once</td>
</tr>
<tr>
<td>How many times has your teacher used a data logger with your class?</td>
<td>39 (36%)</td>
<td>14 (13%)</td>
</tr>
</tbody>
</table>

Question 4 asked students to indicate whether they had personally used a data logger in class, and if “yes”, to indicate the number of times this had occurred.
Table 5-4: Analysis of data from question 4

<table>
<thead>
<tr>
<th>Question</th>
<th>2002 n = 192</th>
<th>2003 n = 116</th>
<th>2004 n = 141</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you used a data logger in class?</td>
<td>Yes 67 (35%) No 124 (65%) No response 1 (1%)</td>
<td>Yes 57 (49%) No 59 (51%) No response 0</td>
<td>Yes 70 (50%) No 70 (50%) No response 1</td>
</tr>
</tbody>
</table>

The results indicate that there was no significant increase in student usage of data loggers over the two-year period, 2003-2004. This result of 50 percent suggests that some teachers were using the data loggers for demonstrations only, rather than allowing students to have hands-on experience. This may reflect a lack of equipment or lack of inservice training opportunities during this time.

Question 5 asked students whether they had used data loggers in junior school (Years 7-10). This question was designed to investigate the trend in data logger use as students progress from junior to senior classes. Note that the students were answering the question in relation to their time in junior school, at least two years prior to undertaking the survey.

Table 5.5 shows the analysis of Question 5, with the proportion of students who reported using a data logger in junior school.

Table 5-5: Analysis of data from question 5

<table>
<thead>
<tr>
<th>Question</th>
<th>2002 n=192</th>
<th>2003 n= 116</th>
<th>2004 n= 141</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you use data loggers in</td>
<td>Yes 10 (5%) No 176 (92%) No response 6 (3%)</td>
<td>Yes 12 (10%) No 98 (84%) No response 6 (5%)</td>
<td>Yes 17 (12%) No 83 (59%) No response 41 (29%)</td>
</tr>
</tbody>
</table>
It might have been expected that there would have been an increase in the use of data loggers in junior school as teachers became more familiar with the equipment. The results however indicate most students did not use data loggers until senior school. This may be due to teachers being wary of damaging expensive equipment, or that the use of data loggers was not mandated in the syllabus for juniors. Further, junior class sizes are usually larger than senior classes and hence would require more data loggers if the work was to be carried out by students rather than demonstrated by the teacher.

Question 6 asked students to indicate how many data loggers were available for their class. This question was included in the questionnaire to try to gauge whether there was any correlation between the number of data loggers used in the classroom and the success that students had with their use. However this was not analysed, as many students responded that they did not know this information.

Students who had not used data loggers did not need to continue with the survey.

Question 7 asked students to describe the experiments they had completed using data loggers. Students who had used data loggers could clearly remember the experiments performed. Many experiments demonstrated the use of data loggers in which the data collected could not have been collected using conventional science equipment.

Typical responses included:

- $CO_2$ prac, testing pH, measuring water temp;
- $CO_2$ in water. pH of chemical substances;
- Physics acceleration experiments. Bio $CO_2$ in water effect on pH;
- Light intensity over distance from light source;
- Titrations, fermentations, pH probes;
- pH water. soil. light intensity, soil temp;
- Gravity, acceleration projectile motion, intensity of light;
- Lots in projectile motion. frames of reference, anything with motion. calculate data.
In some cases students indicated that they had not used data loggers at school, but had used them on field trips. For example:

Mount Annan botanical gardens … light intensity, pH

Question 8 asked students to indicate which other measuring instruments they had used to record data. Most students identified a range of equipment, including:

- Tickertape timers;
- Rulers;
- Stop watches;
- Universal indicator;
- Litmus paper;
- Hand Refractometer;
- Barometers;
- Hydrometers;
- Electronic balance;
- Thermometers;
- PH probe;
- CRO;
- Beam balance.

Students were also asked to describe how the use of data loggers differed from other methods of collecting data (Question 9). Students noted many benefits of using data loggers, including:

- More accurate. Results are more specific. Easy to graph. Automatic. Electronic;
- Its more accurate. less human error;
- Allows continual reading over prolonged period;
- Its easier;
- Faster, more accurate, can record for ages. Instant;
- Rapid, accurate, automated graphing results can be recorded over a prolonged period;
- Its easier, makes a graph for you and more accurate eg stopwatch reaction time.

Responses to this question were coded as positive or negative in their attitude towards the use of data loggers (see Table 5-6).
Table 5-6: Analysis of data from question 9

<table>
<thead>
<tr>
<th>Question 9 Percentage of respondents’ attitudes to use of data loggers</th>
<th>2003 n=81</th>
<th>2004 n= 66</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>Negative</td>
<td>Unsure</td>
</tr>
<tr>
<td>58 (72%)</td>
<td>2 (2%)</td>
<td>4 (5%)</td>
</tr>
</tbody>
</table>

Almost all student responses were positive in relation to data logger use.

Question 10 asked students to indicate whether they thought there was any benefit of using data loggers over other laboratory equipment. Comments were coded as positive, negative or unsure in whether there was a benefit of using data loggers instead of conventional science equipment. The vast majority of responses to this question identified data loggers as being better than conventional equipment.

Table 5.7 summarises the data collected from Question 10 for the 2003-2004 sample.

Table 5-7: Analysis of data from question 10

<table>
<thead>
<tr>
<th>Question 10 Do you think there is any benefit of using data loggers over other laboratory equipment?</th>
<th>2003 n=81</th>
<th>2004 n= 66</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>Negative</td>
<td>Unsure</td>
</tr>
<tr>
<td>56 (69%)</td>
<td>1 (1%)</td>
<td>6 (7%)</td>
</tr>
</tbody>
</table>

Typical responses to this question included:

*Yes. They use the computer which is usually a reliable tool;*

*New technology so its cool;*

*Very accurate, beneficial for continuous results;*
More precise, reliable;
It is simple to use and more reliable. It can record different measurements simultaneously;
Can graph results immediately. Accurate.

Only one student (1 percent) from the 2003 sample and three students (6 percent) from the 2004 sample were coded as negative in their response. These students responded “no” or “nope”, but did not give reasons for their answer.

Question 11 asked students to indicate whether they thought their teacher used data loggers in the classroom differently to other laboratory equipment.

Table 5.8 summarises the data collected for Question 11.

**Table 5-8: Analysis of data from question 11**

<table>
<thead>
<tr>
<th>Question 11</th>
<th>2003 n=49</th>
<th>2004 n=46</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
<td>Unsure</td>
</tr>
<tr>
<td>Does your teacher use data loggers in the classroom differently than other laboratory methods?</td>
<td>16 (33%)</td>
<td>25 (51%)</td>
</tr>
</tbody>
</table>

Of the 46 students who responded to this question in 2004, 22 percent indicated that their teacher taught differently when they used data loggers. Some students indicated in their response that lessons were more enjoyable when using data loggers, and their teacher was confident in using data loggers. Other students noted that their teacher was not confident in using data loggers, that experiments took longer to set up, and that the use of data loggers was infrequent. Typical responses included:

*Data loggers allow recording of measurements to be simpler. Performing experiments using different methods if collecting data makes science experiments enjoyable;*

*Less familiar with data loggers so uses them rarely and often lets the class 'figure it out';*

*No. just adapts loggers to the prac;*
Sometimes although takes longer to set up;
Yes. They require more care when using handled. They need to be calibrated;
We barely ever use them.

Question 12 asked students to indicate whether they preferred to use data loggers rather than other laboratory equipment. Students were also asked to give a reason for their answer. Table 5.9 summarises the data collected for Question 12.

**Table 5-9: Analysis of data from question 12**

<table>
<thead>
<tr>
<th></th>
<th>2003</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=62</td>
<td>n=59</td>
</tr>
<tr>
<td>Question 12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If you had a choice</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>would you use data</td>
<td>33</td>
<td>15</td>
</tr>
<tr>
<td>loggers over other</td>
<td>(53%)</td>
<td>(24%)</td>
</tr>
<tr>
<td>laboratory equipment?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Most students indicated a preference for using data loggers. The results also indicated an increase in the proportion of students who preferred to use data loggers over the two-year period.

In giving their reasons, students demonstrated an in-depth knowledge of the use of data loggers and were able to justify their answers.

Students who preferred to use conventional equipment over data loggers generally referred to the problems they had with getting the data loggers to work. Typical responses indicating a choice for using conventional equipment included:

- No. like the original ways;
- No. they are complicated to use;
- No. they rarely work;
- No. too complex and difficult;
- No. too hi-tech, too many buttons, too easy to break.
Student success in using data loggers, however was evident in the positive responses.

Typical responses indicating a choice for using data loggers included:

- Yes data loggers. more accurate results are produced and abiotic factors can be compared;
- Yes, data loggers are easier to use, more accurate, and provide easy to read results;
- Yes, they are easier to use, less complicated and straight forward;
- Yes, its quicker, more accurate and increases the validity;
- Yes, data loggers. easier, makes a graph for you and more accurate;
- Yes. easy to use, simple to set up;
- Yes. fun to use, graph it done for you. Versatile.

Typical responses indicating no particular preference for using data loggers or conventional equipment included:

- Yes. They are a more accurate method to other equipment. No. Sometimes a variety of methods and equipment usage is good;
- Depends on experiment;
- Depends on experiment. yes , if unsuitable to log manually eg rocket prac. No, if cumbersome or not entirely necessary eg pendulum gravity prac;
- It depends. Although it is easier to record data. There is a long process of setting the data loggers up. Which can be frustrating;
- No. Whatever is appropriate.

These comments indicate that students generally preferred to use data loggers because of the effectiveness of collecting data. In some cases, students showed high levels of understanding in evaluating their choice of equipment, identifying that for some tasks conventional equipment might be more appropriate.

Question 13 asked students to indicate whether they enjoyed science experiments more when they used data loggers. Students were also asked to give a reason for their answer. Table 5.10 summarises the data collected for question 13.
Table 5-10: Analysis of data from question 13

<table>
<thead>
<tr>
<th>Question 13</th>
<th>2003</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Do you enjoy science experiments more when you have used data loggers?</td>
<td>30 (51%)</td>
<td>23 (40%)</td>
</tr>
</tbody>
</table>

Responses that identified science experiments as more enjoyable when using data loggers included:

Yes. Because its not theory and enables more independence from the teacher;
Yes. Because its easier and gives the satisfaction of having a more precise experiment;
Yes. As results can be immediately displayed;
Yes. Because it is fun;
Yes. I enjoy it a hell lot more, since I can finish earlier;
Yes. Its fun and you get to know how to use new technologies;
Yes. The results are more accurate and trends can more easily be seen on the graphs;
Yes. More technical than other science equipment to be used during experiments.

Responses that identified no greater enjoyment in science experiments when using data loggers included:

No difference. They are good to use for something different, however the structure of the lesson allows all different groups to utilise different equipment;
No. I enjoy using a variety of equipment when conducting science experiments.

Some students stated that the use of data loggers resulted in fewer hands-on activities:

No. less hands on, with indicators etc you see a change;
No. We have nothing to do. classical work is good;
No. When using data loggers there is less for the experimenter to do, although it is more efficient;
No. I prefer using the other equipment which requires me to manually observe and record the results of my experiment:

Responses that identified no preference in enjoyment in science experiments when using data loggers compared to conventional equipment included:
The same. I enjoyed all scientific techniques and measuring instruments;
The same. it all depends on how much time we’ve been given;
Depends. Its different to the norm. Quite easy to use when its set up , takes less time;
Don’t mind its just another method of measuring data;
Don’t care. all experiments are fun!!!.

5.1.2 Discussion
The student surveys suggest that there had been an increase in teacher use over the three-year period. However 30 percent of the students surveyed claimed that their teacher had not used a data logger with them. Student use appears to have remained the same, with approximately half of the students reporting that they had used a data logger in class.

The survey responses indicate that the use of data loggers appears to be more prominent in the senior years compared to junior classes, with less than 12 percent of respondents recalling having used data loggers in their junior school years. The reasons for this low proportion may be due to the difference in size of classes (junior school normally being classes of over 25), the small number of data loggers available for larger classes and the perceived problems associated with using the expensive equipment with younger students.

Students could clearly remember the experiments when they had used data loggers, verifying that their teachers had used data loggers. Many of the experiments demonstrated an appropriate use of the technology when conventional equipment would not have been successful. This included measurement of CO₂ concentration, pH, light intensity, and numerous motion studies.

Students could recall using other measuring devices, which indicates that their teachers were allowing them to participate in practical experiences using equipment other than data loggers, and were therefore in a position to answer questions relating to the use of data loggers in comparison to conventional equipment.
Almost all of the respondents to the survey who had used data loggers indicated that the data loggers were better for collecting data than conventional methods. Benefits identified included the increase in accuracy, reduction of human error, and the ability to instantly see relationships in graphical form. Students also indicated the advantage of data loggers for collecting data over very short or extended periods of time.

Approximately 30 percent of the students responded that their teacher “used data loggers in the classroom differently than other laboratory methods”. Differences included the need to calibrate the equipment, and the increase in care required with the equipment. Some students suggested that their teacher was not confident in the use of data loggers and hence rarely used them, whereas other students noted that their teacher simply modified the nature of the experiment.

The majority of students identified a preference for using data loggers over conventional equipment, especially in reference to the effectiveness of obtaining data. In explaining their preference for either data logger or conventional equipment, many students demonstrated a high level of understanding in their responses, articulating that the choice of which measuring device to use was dependant on the task at hand.

The majority of students indicated that they enjoyed science experiments more when they used data loggers. Reasons for this included that they obtained greater satisfaction through having a more precise and accurate experiment, and more immediate results, and that it enabled them to be more independent of the teacher. Some students did however raise the issue that by using the data loggers it meant that there was less hands-on activity.

5.2: Teacher perspective (interviews)
This section reports on interviews conducted with 22 science teachers describing their experiences in using data loggers. Pseudonyms are used to ensure the confidentiality of participants. The suffix HT identifies teachers who were employed as head teachers and DP as deputy principal.
5.2.1: Results
Five themes emerged from the interviews:

- Teacher confidence;
- Teacher professional development;
- Access to resources;
- Classroom management issues; and
- Reasons for use.

5.2.1.1 Teacher confidence
The large variation in confidence in using data loggers in class was apparent even though these teachers were predominantly using data loggers in the classroom. Some teachers seemed to easily understand the use of the new technology, while others struggled with its use.

There appeared to be no relationship between the teaching experience and the amount of confidence displayed by teachers. When asked how she became confident in using data loggers, one teacher in her early years of teaching commented:

Document: LiamHT/Mary (15/12/03)
Mary: I am wire phobic. And if I can use it [Multi log pro]. And I can use it really confidently, then anybody can. That's because, I mean, I don't do wires. I am not good with wires and connecting things up. And if I can get that thing running like I can now, and get it really happy, then it has to be easy. That's the barometer that I use. I say I am not electrically inclined.

Another teacher in her early years of teaching commented that it was the ability to take risks and not being upset over problems that arose explaining that:

Document: Geraldine (2/2/04)
Geraldine: I suppose technology wise, I am not very stressed about it. Although, I have a bit of a Physics phobia. To be honest. A Physics phobia. So if it's a Physics experiment, I would probably tend to freak out more than if it was a biology or chemistry one. That's just me. And that being the case, I am probably more likely to stuff that one up.

Interviewer: Geraldine. You're very comfortable in using data loggers. What have you done to get to that level of confidence in using them?
Geraldine: Well, the first thing I did was just pull them out of the package and just try to use them, but what worked really well, was it to just get the books and the information that you can sometimes download from the websites and basically following through the experiments. It helps you. It really tells you what to plug in where. What is the best way to do it. And then I tried taking it into the classroom after I was very confident and had a few more problems there. But in the last few years just practicing and doing it a few times helps. And now it's really quick for me to set up and I know which cables go where, and how to set it to work.

Some younger teachers, with limited teaching experience, had received some training in the use of data loggers as part of their pre-service education. One teacher explained that he had used data loggers for experiments whilst at university, however he was still not confident in using the data loggers and had found it difficult to obtain time to practise.

Document : Ted/UlysiesHT(1/12/03)

Ted: Yeah. I used it last year at Uni for a little bit. Just basic things like gravity calculations. Very simple type stuff, but to actually getting it, like I said. It's a combination of time. Like I am not totally confident with it. The time to get in and work at it and have it at a level where you use it effectively as well as everything else.

Of the teachers interviewed, the most at ease with using data loggers in the classroom were in fact the most experienced teachers. Both had been involved in data logging from an early stage.

Most of the teachers interviewed mentioned that their confidence improved with use, but there was a major commitment of time in getting to the stage of being comfortable with the data loggers in front of a class.

Document: Nick/Olivia (3/12/03)

Nick: There was a slight reluctance, I think, from some teachers, myself included. I thought this was going to be too complicated. But once you get into it and start using them, you have less problems. And I think most people are starting to become aware of them.

Document : DavidHT (19/12/03)

DavidHT : One of the disadvantages is getting adept at using it. It takes awhile and some staff are, you know, have to spend a good amount of time to get used to using them. So that's a disadvantage.

Document : Andrew (19/12/03)
Andrew: It takes time for teachers to get confident in their use. I think that's probably the biggest problem we have got. The confidence of teachers to be able to say, "I will take this, and plug this in, and it will work." And when it doesn't work, to very quickly track down the problem. And I guess some of the problems come from the scope of the systems we use now to measure a whole range of things. If it is not set up properly, that is initially a problem. Unless you can work out very quickly that I need to be measuring this. And change the software parameters very quickly. The probes themselves are not very much of a problem. You plug them in and turn it on.

Frederick: I don't think most people would be comfortable with data loggers at this stage. Those that have tried them would feel reasonably comfortable. It takes an investment in time for them. Where many of the teachers out there have not had the time to invest, and then see the applications. Once they do, they may see that it will make their teaching much more effective. And student learning more effective. It's a matter of being brave enough. Adventurous enough, to try it. And time is very precious for most teachers, but it's an investment that will really pay off for them.

Some of the teachers mentioned that the lack of confidence resulted in a more stressful time in the lesson. This meant that even if they had been trained in their use, the infrequent usage in the classroom meant that they soon lost the skill.

Ian: I have gone to inservices, and even the TILT Plus course this year. And still I don't feel that confident in using it. It's mainly the time and the difficulty in using them.

PeterHT: A disadvantage is that I am not very good at using it. Every time I have to remember from there the last time, a few months ago. Every time for me it is as if I am doing it the first time. So it is time consuming. I have to go back to the catalogue, just to read through. the last experiment in particular, using the pendulum.

Mary: It's like anything. If you show it to people and they don't use it for two months. They are not going to remember. And they are nervous about using it.

Further discussions with head teachers highlighted a reluctance in teachers to engage in the use of data loggers. The head teachers commented that some teachers would not
use data loggers unless they were forced to do so and this was done by ensuring that the data logging was written into faculty programs.

Document: LiamHT/Mary (15/12/03)
LiamHT: The biggest problem is just try to find time for people to use them and to get comfortable with using them. From my point of view, the easiest way to do that is to say, during this topic, you have to use it as a teaching strategy. And when they get to that stage, if they don’t know how to use it they have to ask or have to find out. It’s just a case of unless you force the issue, people will stay with the traditional methods.

In several cases it was indicated that the stress of incorporating the new technology was reduced when the faculty had worked as a team to assist each other in their use:

Document: James/KarenHT (24/11/03)
KarenHT: We have taken all the fear out of it. We have now got little booklets. There is a booklet that we have made up and it guides you through step by step. We have had the lab assistant use it. It has been tried and tested. Our kids use it.

Document: Helen (2/2/04)
Helen: And at other times we have just talked together. A teacher has said, this might be good as a data logging experiment. And we have just sat down and talked and gone through the steps, until they’re comfortable with using it.

One teacher identified a problem that the faculty had solved together:

Document: James/KarenHT (24/11/03)
KarenHT: The first group we said to upload your data, print a graph, and print a table. And stupid us, we saw all this paper that coming off the printer with no names on it. And it was hilarious because I had no idea of whose was whose, apart from the fact that some of the kids were standing there in line.

5.2.1.2 Teacher professional development

Responses to the question about the lack of professional development opportunities was identified as a major challenge. This was supported by the interview responses.

Many teachers expressed disappointment in the amount and quality of professional development available to gain familiarity with the technology, given the fact that syllabus documents mandated the use of data loggers:

Document: RobertHT/Sean (8/12/03)
Sean: And with very little training from the Department, I did find that it did require a substantial amount of your own time to get it working.

RobertHT: I think it is a huge resource issue and training issue. You can’t just suddenly throw a black box at someone and say this is fantastic, we want you to use it, and away you go… But unless you have really got some experience and the time to develop it, so [that] you are familiar with the gadgets and you’re not stuck looking around for cords. Does this connect to this. And this connect to this. Without reading a recipe out of a book. And you and not going to be able to benefit classes if you are only at that stage with it [data loggers].

RobertHT: Because the DET is not prepared to put money into training its teachers in a useful way, they expect us to do it in our own time. A couple of hours after school. Occasionally they have the hide to say we’re good for and trained to the minute. We are not. Most things that teachers are achieving through this system is through their own efforts with very little support from the Department.

Document : CharlieHT (27/11/03)
CharlieH: I know, it's the time that it takes to get au fait with it. Because when I got my new Vernier one, which I could put into the data projector, it took a lot of inservice time on my part to get up to speed to use it. Whereas, if I was to give it to my staff now, they would not use it. It needs time and effort to learn how to use it. Where do they find the time? So we had a big drawback. That it is new technology and people do need to be trained in how to work it.

The attitude of teachers to the use of data loggers was reflected in the amount and proficiency of their training. One teacher noted positive outcomes when his school had provided considerable time for him to train other staff in his faculty:

Document : Edward (2/2/04)
Edward: The support they have had up till now has been on two of the Staff Development days. We run a session on how to use them. We have got out of date now, but a manual of how to go, step by step through an experiment and there has been a couple of afternoons during our Faculty meeting time, where I have run an inservice with them. So they have all had at least three or four sessions of about two hours of instruction on how to use them.

Teachers identified that in most cases it was through their own perseverance that they were able to now use data loggers. Regardless of their initial computer literacy, a
substantial investment of personal time was required to obtain proficiency and confidence:

Document : LiamHT/Mary (15/12/03)
Mary: Even with me, if I haven't used it for a while, I have to remember to plug in the back. It's like computers when we first used them. If you in-service staff, but they don't get it to go and practice, you are just wasting your time. And it's the same with the data loggers.

Document : RobertHT/Sean (8/12/03),
Sean: Unless you are prepared to sit with it over the weekend or after school for hours, then you're not going to come out to the level of expertise that is needed. But not everybody has got a weekend to devote. So, I see teachers as seeing themselves not supported. A lot of teachers would be happy to give up weekends, or plenty of time after school, or take the toys home to play with them, if they were also getting some of that time funded by the department as well. You know, At least a 50/50 basis of it. That's what teachers are looking for.

Teachers identified five major sources of professional development:

- State (including funding sources from federal initiatives)
- District level
- Professional associations and networks
- School-based initiatives
- Company support.

**State initiatives**
The Department of Education and Training (DET) had for some time incorporated a curriculum directorate that included a science unit. This unit was successful in obtaining funds not only from the state government, but also from the federal government, to increase educational outcomes in the area of science and technology. The Science Curriculum Unit also coordinated the science curriculum consultants who worked with schools and at district level.

The DET was successful in obtaining funding through the Australian Government Quality Teacher Program (QTP). This program included the production of resources to assist teachers in programming, assessment and reporting. Funding was also made
available to schools and individual teachers to complete projects. The team of twenty curriculum consultants were trained to implement this program in schools. Also as part of the funding, the state government was able to train teachers in incorporating technology into the classroom through the Technology in Learning and Teaching Program (TILT). The TILT program developed from a generic professional development program into one catering for specific subjects. After the need was recognised, the TILT Plus Science course was further developed to become a course that concentrated on the use of data loggers, known as TILT Plus Data logging.

Of the 22 teachers interviewed, 6 had completed training to become facilitators for the TILT Plus Science Data logging course. During the interview process two facilitators (from the researcher’s districts) were asked questions directly related to the TILT program. One facilitator had not been able to conduct a course due to low enrolment. The other facilitator was able to commence two courses, each with an enrolment of five and six teachers respectively.

The facilitator’s comments regarding the TILT course were:

*Document: Andrew (19/12/03)*

Andrew: TILT science missed the point completely. TILT-Plus Science data logging totally missed the point. Teachers involved in the course, I had two groups, they did not come into it as people with sufficient expertise, expertise to get things to plug in and work. Most of the schools had hand held data loggers and in trying to complete the project work found it very difficult and frustrating. Because of the problems, they started being unreliable. One a group from xxxx (name suppressed), five teachers working together, they actually got some stuff that worked. One teacher dropped out, out of the five. That was the person that probably had the most enthusiasm initially. They were just so totally frustrated by their efforts in trying to get the hardware to do what they wanted it to do. They just gave up. The other group, not one single person in this second group finished. And people just looked and said there are other priorities in the school. This is just taking too long to master, or even too long to get familiar with.

The facilitator also elaborated that trying to complete the course was difficult when there were so many other things expected of teachers.

*Document: Andrew (19/12/03)*
Andrew: And they weren't willing to find time in the context of writing reports and other things they had to do to finish off their projects.

The Curriculum Unit also sponsored the production of a DVD designed to assist teachers in using data loggers. Each secondary school in NSW received a copy of the DVD, however at a cross-district head teacher meeting it was realised that over the two districts, no teacher had viewed the DVD.

**District initiatives**

At the time of the syllabus change to include the use of data loggers, the DET employed 20 curriculum consultants to facilitate the implementation of the new science syllabuses into Years 7–12. Each consultant was responsible for two districts.

The consultants were also responsible for implementing the QTP. Some consultants were able to use the QTP funds to assist in training teachers in how to use data loggers. However, most consultants were not proficient at using data loggers and had in most cases not used them in a classroom environment.

One teacher explained that her school had received funding from the district, however because the funding was limited, only a few of her staff could participate at one time:

*Document : James/KarenHT (24/11/03)*

KarenHT: We had a some time at district office, a small amount, funded by the District. A small amount of time funded by District. That was all. That was combined with our free periods. So, if I was free in the morning, I went along with whoever was working, they continued on and then I went back to class. I got bits of information that way.

Although the funding was limited, the workshops organised by district consultants were favourably viewed when they allowed teachers to be relieved of classes to go to another venue:

*Document : Helen (2/2/04)*

Helen: Last year we had a day when a group of us got to get together and we just went through some basic experiments such as measuring temperature and then we went through to set up for different times to make it [the data logger] to take a sample when you want it to, not just run it as a continuous experiment. And they basically had a complete day of sitting there, plugging it in, trying different sensors. Because different teachers were interested in different ones, depending upon
what classes they taught. That worked really well. And a lot of teachers after that were a lot less afraid in putting it together I think they thought they were going to break it and get into all sorts of trouble.

This was supported by other teachers:

Document : Frederick (2/2/04)
Fredrick: Obviously there's a whole different grading of people with familiarity with computers and devices that can be connected to computers. But once people are introduced to them, workshopped on them and they go ahead with confidence, we find that they are very much into using data loggers on a consistent basis, which is very good.

Another area of assistance was from workshops organised by local branches of the science teachers’ association:

Document : RobertHT/Sean (8/12/03)
RobertHT: I think it comes back to teachers not being trained, and teachers not having the time. And even, we're looking at what LAZSTA [Metropolitan South West Science Teachers Association] is doing, running workshops on some afternoons during the year. And that gives you a great snapshot and gives you a bit of a look at the potential for it. But, it doesn't give you that day or couple of days of regular workshops. That would help you to really sit down and come to grips it.

Company support

Initially the Science Curriculum Unit reviewed the various data loggers that were on the market. This was to identify the data loggers that it would train consultants to support, as well as to identify the data loggers that were reliable and had identified company support. This information was ignored by the major supplier of science equipment and with the multitude of companies competing for the new market many schools purchased data loggers from other vendors. With the multitude of data loggers available, so was the variation in support given by companies.

Teachers often had little, if any, support to troubleshoot problems with the equipment and software:

Document : James/KarenHT (24/11/03)
KarenHT: it was a huge a learning curve the first time we used it. And then we thought there has to be a way of doing all this. We then had to suss out how we were going to get to the printer to cope
with large numbers of sheets coming off, and how we were going to identify students’ work as it came off the printer. Particularly, when there were multiple sheets.

James: It took awhile to get into it. The manuals that came out were useless to us. We actually spent two days trying to work out how to use it. And we are still scratching the surface, finding out what we can do with it. So there is a long way to go. We had the problems with the bug in the system. I wasn't happy with the contact person, over the data. We rang a couple of times and tried to organise for the person to come out to give us a hand and see what we were doing. We had a cancelled appointment, and for various reasons it just became difficult. Especially when we had a deadline to complete the QTP Project.

BarryDP: I did not give up on the errors. And as I said, I have rang the company and rang the company and rang the company. So I came across a lot of errors. Predominantly, the main areas were, there are three types of the standard errors. Even though it is on, the battery supply is not putting out enough to cater for the sensor. And therefore it looks like it's on, but you have to refresh the batteries. The company did not know this. So that was trial and error… So you have to work with those limitations. And unfortunately, the suppliers don't know those limitations. And even if it were, it would not be a very good selling point.

5.2.1.3 Access to resources

The need for appropriate levels of access to resources was stated frequently by teachers. The initial cost of the equipment meant that many schools had only purchased one data logger and one set of probes. This resulted in teachers finding various ways to still use the data logger:

Mary: We are getting another one. I don't think one's enough. But I'll come back to that later on. You know, when you are doing, I don't know, measuring the temperature of solutions with a junior class, one data logger is not going to do it. So yes, you can show it to them, but they have to use the basic thermometer. Plus, the same with the pH meter. You have only the one and you can't expect 30 kids to file up one at a time to use it.

Sean: I think there is still quite a lot of uncertainty in teachers' minds and they are hesitant to use data loggers. They are not overly accessible. For example, in this faculty, we only have the one and the computer is downstairs. So for someone like me, upstairs, it's not really viable or practical. It's not very accessible to just get in there and use it. Plus teachers need to have confidence in
using it. And not until they are confident, they will be hesitant and stick to the older, but well tried methods.

Document: PeterHT/Quinton (16/12/03)
Quinton: I kept on chasing the laptop. We have a number of them. It just happens that it was booked and I had to wait, and wait. Eventually, I did not get the computer. So I just used the data logger to grab, to see what was happening. And when I use it, it is always a demonstration. There is not enough data loggers for the whole group.

Document: Geraldine (2/2/04)
Geraldine: Another disadvantage in our case is that we only have one logger. And I see that as a disadvantage in respect I think there should be two or three.

One head teacher remarked that the school had only one data logger, but this was not a problem because no one was using it anyway.

Document: Andrew (19/12/03)
Andrew: The limited number is a problem. We have one system. Basically one computer. We are working on that. It will be a problem. Not so much at the moment, because we are still working out how to use it.

The limited number of data loggers meant that many teachers would not use them with junior classes, and only used them for senior classes:

Document: James/KarenHT (24/11/03)
KarenHT: I don't see that as a problem in the seniors. In fact, in senior classes where the classes are smaller, it should be that much easier for you to have a handle on what is going on. It's doing this with a large number of kids, like 30 in the class, with data loggers.

When teachers were using the data loggers for larger classes they had to come up with solutions. This included having some of the students use the data logger while the remaining students were occupied with another task:

Document: Ian (16/12/03),
Ian: Because of the small number of probes we have, one group has to be using the data logger while the rest of the class to do something else. So it's more classroom management.
In one school the provision of computers meant that the science faculty did have their own mini computer room with four computers. This room had previously been used as a storeroom, and had been used as a place to store the computers. One teacher expressed her concern over having to leave some students unsupervised while she supervised the rest of the class using the data loggers.

Many teachers saw the use of data loggers as the domain of the physics teacher. This was reinforced by marketing strategies to sell data loggers bundled with sensors that were predominantly used in physics. Subsequently, most data loggers were purchased with sensors targeted for collecting data for physics experiments such as motion, light, sound and electricity:

\begin{itemize}
\item \textit{Document: Nick/Olivia (3/12/03)}
\item Olivia: I think one of the disadvantages is we have most of the sensors that are related to Physics. We don't have many related to biology or chemistry. I think as a whole science faculty, we should have more related to it each of the subjects. I think it we should use data loggers for all of the subjects in science, but we end up using only for Physics.
\end{itemize}

The limited availability of data loggers to classes meant that teachers needed to ensure that there was some other activity for the remainder of students to do. This included using the data logger as an activity within a series of activities that the class would rotate through. This involved extra work for the teacher, and was problematic in terms of having to use a computer lab and a science lab at the same time.

\begin{itemize}
\item \textit{Document : Edward (2/2/04)}
\item Edward: Most of the time, because of access, you have to make sure it's a station in a series of experiments. Although slightly we are getting the numbers to run it as a normal experiment like we would for any other, but we need to have access to computers. So we have the lab and a computer lab booked the same time.
\end{itemize}

In some cases teachers used only one data logger, but would use a data projector to share the information recorded with the class. Some teachers thought this would be a good solution to the limited availability of data loggers.

\begin{itemize}
\item \textit{Document : PeterHT/Quinton (16/12/03)}
\item PeterHT: One connected to a data projector would be ideal. That is the aim, but I cannot see that occurring for a while. We have the computer, but not the data projector where it can be used by everybody.
\end{itemize}
One teacher had even gone to the extent of providing his own equipment:

Document: Ted/UlysiesHT(1/12/03)

UlysiesHT: We have one [data logger] that attaches [to a computer], but again we have another problem. That is if you want to run it in the lab you have to have a laptop or computer. Now Ted has all his own gear. He has his own lab pro. He has his own laptop, his own data show. So basically he can run it independently without using faculty hardware. Whereas for the rest of us, we do not have a laptop that is dedicated. We have to borrow one from the library. You then have to fiddle to ensure it fits the lab pro properly. Then you have to run the software on the calculator if you are using that.

As the technology changes, so too do the specifications of the hardware required to run it. In one case the problem associated with running the data logger was trying to find a computer that had a fast enough processor to run the data collecting:

Document: James/KarenHT (24/11/03)

Karen: We had problems finding powerful enough PCs to run the program with serial ports for the towers.

To compound the problems in schools, many early-model data loggers used a serial port for connection to the computer. This technology has been superseded by USB connections:

Document: Ted/UlysiesHT(1/12/03)

UlysiesHT: We had a science consultant that had an inservice on using data loggers. People were told to turn up with your own laptop and your data logger, and then found that none of them all work. Because they had all the new laptops, super fast, but they don't have serial ports any more. And there were problems that some of the software would not run on Windows 2000.

Other teachers explained that the school had purchased data loggers early when they had recognised the need to invest in them. However, because of their early entry into the market, they did not have any information on which to make their decisions, and so purchased data loggers that appeared cheap, but were inappropriate for student use:

Document: Ian (16/12/03)
Ian: Like many other schools, we just rushed in and bought whatever was on the market, not realizing what was out there.

The initial cost of purchasing data loggers has also led to problems in their implementation. Some schools have been reluctant to invest in data loggers.

Document: RobertHT/Sean (8/12/03)

RobertHT: I have used the thermometer probe. Just as a way of getting measurements. And again, it's a lot of money spent just to go and take the temperature of a solution. I have used it for recording times of things cooling down. That was quite handy. But then again, is that of value to kids? When they can do it just as easily with my thermometer over a 20 minute period. So I haven't really seen a great deal of stuff that is value added, in the expense that you are tied to that one piece of equipment. And the equipment that I really can't let the students have too much access to. There is the potential for damage to some very expensive equipment.

Document: PeterHT/Quinton 16/12/03)

Quinton: Probably from where I see it is the prohibitive costs of some of the sensors. It is quite high. You could not have any more than one. In reality of the Geiger Muller tube at $700 per sensor.

However even in schools that have invested the money, teachers are hesitant in using them for fear of damaging the equipment.

Document: James/KarenHT (24/11/03)

KarenHT: So we have a tremendous amount of money invested in data loggers. $1700 worth of probes is only 10 probes. Pretty scary, isn't it.

Researcher: It is a lot of money?

KarenHT: When you are handing these out to the bottom Year eight class and you hope that everything is going to be all right.

The need for resources is not just in the technology, but also in the human resources. One school noted that in order to run the data logging equipment successfully with a junior (Year 8) class, they needed to ensure that they had help from other teachers within the faculty for supervision and troubleshooting. This also included assistance from the science laboratory assistant to prepare all of the equipment. They recalled the problems they had in setting the parameters for the data loggers to collect data and noted that they would not have been able to continue with the lesson if there was only one teacher on the class.
James: And the stress in that lesson was not with that the kids would vandalize it, or if the kids would be off task. But it was actually whether the equipment would be working.

KarenHT: And I did not realize this until we got out into the playground with the kids. Turned it all on, and "it's stopped running Miss, it's all over!" What. [laugh]. And I had XXXX and XXXX, both with periods off to assist me. He had gone up to the computer room [to wait for students]. We had worked out what had gone wrong. And I said. Take your equipment up to Mr. XXXX. And they did that. And we reprogrammed [the data loggers] very quickly. It takes a couple of minutes.

In some cases teachers had just given up trying because of the problems they faced in order to get the technology to work:

CharlieHT: They get an initial kick out of using it, but it also gets frustrating too. Because sometimes, especially the motion sensors don't work too well. And we get some funny readings with the motion sensor sometimes. I remembered we did one prac with bouncing or dropping a big ball for acceleration. A couple of times it worked and a couple of times it didn't. And the rolling of a ball down an inclined plane, we had problems with it too.

Andrew: With the CBL we had a major difficulties. We could not get it to work at all.

A head teacher was more blunt in showing his frustration:

UlysiesHT: The problem we have is that basically, at the moment, is getting the bloody thing to work properly. We have problems with the calculators, with the software, all sorts of problems. If we knew every time, that if you just turned it on, plugged in a sensor and run a program that it would work, we would have a much better chance of using it. We have a data shell which is great for doing that, but only one calculator that can run it, which is fine, but it is our biggest drawback, which is why I have seldom used it at all.

The chance that the technology will fail also means that teachers need to have a back-up plan just in case:

UlysiesHT:… There is a lot more tentativeness as in, as in, there is always more work. Because you have to have a backup.
The limited availability of data loggers in some schools caused problems when more than one teacher wanted to use them. This resulted in teachers having to find times when both the data loggers and the computer room were available. There was also mention of the time that was required in preparing the data loggers for classes. Teachers and lab assistants had to ensure that there was time available before the experiment to prepare the equipment. This included having to download software for different applications, the charging of batteries and the uploading of data collected by students.

*Document: James/KarenHT (24/11/03)*

KarenHT: The use of data loggers precludes another class’ use of the equipment. Until they have uploaded the data. There are clashes with other classes for the computer space. Clashes with other Science classes for the equipment all have to be addressed well before the activity. A lab assistant has to set up the RCX’s [data logger], and the teacher has to book the equipment and the computer room for an entire class to ensure success.

James: You really need to train your lab assistant to ensure that they can program the bricks [data loggers] because it takes about four to six minutes each. Five to six minutes to download the software… But every time you want to use it, you have to put your batteries in and upload the software. So, if you add in 10 bricks. You need one hour of your lab assistant’s time to do it.

One teacher, Olivia, voiced frustration in that she had been trained in one data logger and had changed schools. She was now faced with having not only a different brand of data logger, but also in a reduction in the variety of sensors she could use. She explained some of the difficulties created by staff transfers:

*Document: Nick/Olivia (3/12/03)*

Olivia: Yeah. But like a different data logger when you have many new teachers coming to a school that are not familiar with them. And then those staff that originally may have undergone an inservice at that time. How many staff do you have next year that were not here this year? That makes a lot of difference.

5.2.1.4 Classroom management issues
For some teachers the prospect of standing in front of 30 teenagers and trying to use new technology may seem daunting. It is expected that when students leave the classroom and move on that they have gained from the experience. All teachers interviewed indicated that they were keen for students to learn and obtain positive
outcomes as a result of their lessons. One stumbling block faced by teachers is the fear of “looking stupid” in front of a class.

Teachers were asked if there were any differences in the way they would run a lesson when using data loggers, as compared to a normal lesson. This raised a range of organisational issues, such as the problem working with large classes, limited availability of equipment, and the strategies needed for teaching different year groups.

Document: Ian (16/12/03),
Ian: Because of the small number of probes we have, one group has to be using the data logger while the rest of the class to do something else. So it's more classroom management.

Document: Edward (2/2/04)
Edward: We only have one set of equipment so there is a problem in having to demonstrate it and getting everyone through so that they can see the experiment.

Document: LiamHT/Mary (15/12/03)
LiamHT: With only the one data logger we don't have to worry about kids. And we use it with a laptop anyway... So the teacher is only supervising one thing, and that's good in terms of making sure all the equipment is looked after.

Document: CharlieHT (27/11/03)
CharlieHT: I have a small group of physics kids. Only eight kids. It's not a big problem. If I had a group of 16 or something it would change because we have only got, for example, two Motion sensors. No. Sorry. Three at this point.

Document: Geraldine (2/2/04)
Geraldine: You can teach them the traditional way of doing something and just draw a graph on a piece of paper. But with this particular class they also have the advantage of having the technology there as well. I haven’t used it with lower ability classes. With lower ability classes it was used as a demonstration rather than actual hands-on. We didn’t quite trust them enough to use it. … And for juniors, with larger class sizes, you have to think about larger groups. And you have to think whether the experiment will work with groups of that size. You have to rethink your strategy when you only have a limited resource.

One school identified that they had invested heavily in obtaining four data loggers and had converted a science storeroom into a technology area with computers and the data
loggers. Although this room seemed a good idea during its conception, they were now facing problems relating to the duty of care of students who were not being directly supervised by a teacher. The small size of the room resulted in the computers being placed very close to each other. This meant that only one person could sit in front of each computer, which in turn created problems with students getting in each other’s way when trying to complete experiments and the limited view of the computer screen by all members of the group.

Document: Nick/Olivia (3/12/03)

Olivia: We have a separate room. I take the senior classes to the technology room where we usually do it and then we have four students per data logger.

Nick: I found the same problem. But how do you do it with 30 students. And I have two classes this year with 30 in Year 7. We have 20 in physics. The senior classes here are very large and it is difficult to get them into that room. You can't allow them in there by themselves. So you have to be supervising them. So that is a problem.

The teacher, Nick, explained that he had to move computers out of the technology room in order for students to have more access:

Nick: The way I got over it was to take the students. Take the equipment out. Take one machine out and a data logger out. One computer on a trolley and I had it in the classroom. I also used the laptop at one stage. More than once. That solved [the problem] for some extent. Why do you have a technology room? If you can't take the students in there.

The increase in the noise level of the class and the problem of supervision was again mentioned:

Olivia: One more point in the technology room. You have to be very careful about the sensors and equipment. We don't want something to disappear. The first time I took my year 11 Physics, I had to leave half of the class in the quad [playground], and I had to take out students to explain, because I could not explain it in such a crowded room. I had to leave some of the students outside unsupervised. You can't leave them in the lab of course.

One head teacher commented that his staff were having problems trying to use the data loggers in the classroom due to classroom and equipment management issues. This included the extra time required by his staff to obtain and set up the equipment, the unreliability of the equipment, and the supervision of students not participating in the activity:

Document: Ted/UlysiesHT(1/12/03)
UlysiesHT: It's a management issue in the classroom. You do not have classes that you can simply give text book work whilst you set it up. Again, the time involved. The time involved in setting up a data projector and making sure you have a laptop, and again the physical connections in just setting it up cuts into time, and again the reliability of the software to actually run. That has basically been our biggest handicap. I don't know what the answer is… But it's just getting the whole thing to work. I just don't have the time to trouble shoot with it. XXXX certainly doesn't. XXXX just started teaching and he's just coping quite well and we don't have anybody else on staff to take it on. So we have got some of the gear. We know its potential.

Teachers identified that when they did use data loggers, they preferred to use them as a demonstration rather than allowing students to touch them. This reduced the stress placed on the teacher through having to worry about students breaking the equipment.

Ted: And you don't have to worry about this group of boys with a $500 piece of equipment, with water and a bunsen burner going on next to it. It just takes away some of that stress.

UlysiesHT: Because you don't have predictable students. No matter how much you trust them. Someone will try and experiment.

One head teacher explained how student behaviour and ability influences the use of data loggers, expressing the belief that successful student use of data loggers depended on the students being well behaved and motivated, such as in a selective high school. He remarked about a demonstration of using a data logger by a teacher from a selective high school, involving students using an accelerometer sensor and data logger to measure acceleration:

UlysiesHT: Things like that are beyond the realm of 90% of us. Whether we are close to a train line or not. But that is a fabulous application. But it's the difference in the amount of equipment you are working with and the clientele you're working with. You get those two things together. It's no wonder XXXX has so much success with it.

Another head teacher explained that even though the school had eight sets of data loggers for group work, they were still not being used. He was concerned over the possible theft of the equipment:
Another teacher expressed her concern about using the data loggers with junior classes because of the risk of the equipment being deliberately damaged.

Document: LiamHT/Mary (15/12/03)
Mary: The fact that we know, at times the younger kids would deliberately damage it, you know, and behaviour issues. What I do is I set up the experiment such that they are doing busy [work] … and I bring up to one group at the time to the front, and they bring up at their solutions and do the test, and write down the results. And I call up the next group and so. So it’s a bit more management required that I have to use.

One teacher remarked that she was initially concerned that the equipment would be vandalised however “there was no of vandalism of equipment. They took to it, ducks to water.” (KarenHT)

5.2.1.5 Reasons for use
Despite the problems faced by teachers in initially using the data loggers in class, many were able to give numerous reasons for the use of data loggers in the science lab.

It was clear that teachers were using data loggers because their use was mandated or suggested in the senior syllabus. This was probably one of the reasons for the infrequent use of data loggers in junior classes as they were ‘saving’ the equipment for senior classes.

Analysis of the data showed five reasons for using data loggers:

- syllabus outcomes;
- integration of technology;
- accuracy and reliability of data collection;
- student learning and engagement; and
- real science.

Syllabus outcomes
The Stage 6 syllabuses clearly mandate the use of data loggers, however the student and teacher surveys indicated that this was not “related” into practice. Teachers interviewed felt they had a responsibility to ensure that data loggers were used so that their students were not disadvantaged for their final exams.

*Document: Nick/Olivia (3/12/03)*

Nick: The data logger is suggested in the syllabus and it's also it in the textbooks. In Jacaranda Physics. I think it's necessary, just like computers. Technology. This aspect of technology is necessary to cover the syllabus.

Olivia: And not only that, last year's year 11 chemistry had one question on data loggers, and the students could not do it because the chemistry teacher had not used the data loggers. But fortunately, they had used them in physics… We all have to use technology. I think even if is in a minor way as a demonstration.

**Integration of technology**

One teacher expressed a concern that science teachers continually use old technology and do not keep up with the methods used by industry and scientists in the real world:

*Document: LiamHT/Mary (15/12/03)*

Mary: We are never at the forefront. And a data logger is something that they can do that is a bit more technological and the rest of our equipment.

This sentiment was echoed by another teacher.

*Document: PeterHT/Quinton (16/12/03)*

PeterHT: I think the kids enjoy using something different and it was more technologically. A step up in technology. As opposed to the old thermometer or Geiger Muller tube, or something that is quite old.

Some teachers reported that unlike their colleagues, students did not appear to have any problems with using the technology.

*Document: PeterHT/Quinton (16/12/03)*

PeterHT: I think the kids just take it in their stride. It's just another piece of technology used to help us do the job we have to do. Maybe they go wow! … They weren't scared to use it. They treat it as another type of thermometer. Let's go. They are open to new technology. A little bit more than you and I am.

Another teacher

*Document: CharlieHT (27/11/03)*
CharlieH: I think they see it as something new. I don't think they get au fait with the technology. When they jump in the first time we used it, they loved it. We probably spent more than four double periods using it. They jumped at the chance and wanted to work at it. If I had more sets of equipment every kid would have wanted one. They were playing in pairs, where one wanted to work with it and the other wanted to work with it too. I found it. They found it was new technology that was good to use.

Teachers warned however that it was a bad practice to use the data loggers just for the sake of using technology.

DavidHT: I don't think they [students] are getting caught up in the technology. I think that they are starting to realize. Maybe the first time they use the data loggers they thought it, but now, when they use data loggers they know it's an instrument to collect information for the actual experiment. It's the tool they use to get their results.

UlysiesHT: We have the complication of an example whereby you use the data logger just for using technology. We have the skill of using a triple beam balance or pan balance, verse using a small electronic balance. Now, sometimes we have to rationalize what skill do we want them [students] to use and what do we want them to learn. So data loggers could undermine some of those ideas. Perhaps the results could make more sense.

**Accuracy and reliability of data collection**

Teachers were almost universal in identifying the benefit of data loggers in providing fast, accurate and reliable data.

Mary: They [data loggers] are more accurate for one thing. You can, for example, when we were using them today for temperature, there is no error in reading this scale, it's already there. You have two decimal places, so when you are doing things like colourimetry … you can still get. You know. A much more accurate picture of what is going on. pH wise. The same. Whether I am doing pH with my Year 8 or 9, or 11s. When I am doing pH, I have everything out and then we try to evaluate. Particularly, with the Year nines, I try to discuss with them, which is the most accurate way of measuring. And still with the data loggers and they realize the limitations of the other methods they have used, such as indicators and pH paper and all that stuff. So I mean, that's the good thing about it. The accuracy really, and it's very easy to use too, once you have set it up.
Quinton: For me, it [the advantage of using a data logger] is that you can get an accurate reading of time. This is an advantage. A few weeks ago I set a practical exam for my Year 12 Physics, to determine the acceleration due to gravity using a pendulum… But later on, when I got the data logger with the light attachment where all these factors are reduced like friction it is really nice and smooth. And in the whole period every kid was able to take a reading and using the new technology they could see it was an advantage.

The speed of the data collection also allowed experiments to be modified, allowing for modifications to be quickly done to an experiment.

Document: Nick/Olivia (3/12/03)
Nick: If you're doing something like bouncing a ball, where you are drawing a graph. Which is a difficult concept to understand. You can do that with a data logger again. Within seconds. Now to do that by hand, by longhand, would take an awful amount of work.

Document : Andrew (19/12/03)
Andrew: The data logger gives you much quicker and reliable data, and allows you to control the variables with the data logger.

The speed of data collection means that more time can be devoted to theory and exploring other avenues of student interest.

Document : BarryDP (15/12/03)
BarryDP: I will do the ticker tape prac. It will take me a week. I would have lost half of the kids along the way. I will do the digital sensor analogy. We will have it done in a period, and point by point, we will see what goes on along the way.

Document : Andrew (19/12/03)
Andrew: With falling objects. We used a copper sheet to fall through a light beam. Plotting data. Getting one data set every 20 seconds. By the time they picked it up off the floor. Straighten it up, and dropped it back through again. That gave it the options of starting to look at options like adding parachutes. And other shapes and things… Were we to do it without data loggers. With stop watches, we would be doing it for months. That extension of very rapid data collection brings a new dimension for us of being creative.

Document : Edward (2/2/04)
Edward: With the seniors it [teaching] has changed because a lot of the pracs [practicals] that took along a time set up, are now taking less the time. So you can introduce theory around them rather
than having a full double lesson for practical. We are able to do theory during a prac which is more of a follow-up. Rather than just spending the whole double lesson setting up.

The speed of data acquisition also means that you can record information for phenomena that the human senses cannot detect.

Document: Nick/Olivia (3/12/03)

Nick: On the advantages. It [the data logger] will show you displays that are beyond your normal perceptions, which I found useful. You know, heat, motion or light or the experiment Ken [the researcher] showed me where you look at the refresh rate on a computer monitor, which you can’t see. You can’t look at that yourself. So this high-tech thing is brilliant for light, sound and motion. That is beyond the normal level of our sensors.

The data can also be collected over long periods of time, which are unobtainable to students, such as recording data at intervals of two hours over a 30-day period.

Document: PeterHT/Quinton (16/12/03)

PeterHT: We have done a few experiments, with different data loggers looking at temperature. I think we did one in the prep room that showed the variation in the storeroom.

Researcher: Over a day?

PeterHT: Over a month. We set it up over a couple of weeks of the holidays, and you could see the fluctuations. You know, morning and night. Morning and night. Depending upon where it was set up.

Another advantage identified by teachers was the reliability of data collected.

Document: Ted/UlysiesHT(1/12/03)

Ted: Also you can repeat the experiment more readily. Take my situation. You're trying to calculate gravity and you come out with 7.8, then all of a sudden you tell the guys its actually it's 9.8. They go well. Errh. But if you can manage to get it. Like we did with the gate that you just drop through [light gates] it comes to almost smack on. It also gives them a bit of a pickup, that we are not just doing theory.

**Student learning and engagement**

There were mixed opinions as to whether the use of data loggers had a positive influence on student learning. It was clear that the use of data loggers (when successfully used in the class) did increase student engagement, but this was not as clear for teacher responses concerning student learning.
Positive responses included:

Document : LiamHT/Mary (15/12/03)

Mary: Going back to the S curve thing. It's like, you can teach the theory of an S type pH titration. You can talk about the pH shooting up during neutralization, but, when they actually see. See, what we do is we run the burette without even measuring the volume, just so that they can see the pH start low and then shoot up. So they actually see an S curve. But other than that, yes, you can do it manually and plot it. Which there is not really much point in that. You can go and use computer simulations. They basically take it over. And it's one of those things, particularly with the seniors. You get pushed out of the learning experience, because they just want to take over and do it themselves. They are more than happy to take that on.

Other teachers claimed that the visualisation allowed students to relate the theory to the practical.

Document : CharlieHT (27/11/03)

CharlieH: For the year 11s, I think the big difference is that it is very instantaneous, whereas ticker timers or some of the kinds of photography you have to devote a lot more time and to it. Whereas with motion sensors it is very much instantaneous. In terms of the learning and in terms of the instantaneous results, it's much quicker, so it's much better that way.

The use of data loggers has in some cases changed the way teachers think about the course content and skills they are delivering.

Document : Frederick (2/2/04)

Frederick: … it has made me question students more about evaluating procedures of investigation. So in that fact, I suppose, I am concentrating on a different track rather than just let's get the data and analyse it. Let's look at how best to get the data and I think that's a good move.

Document : Geraldine (2/2/04)

Geraldine: It's changed the way I think about teaching. I mean you can't change the syllabus from what it is, but you can maybe introduce work that is slightly different and more relevant to them. Put the focus, back onto skills rather than theory… Getting them to think outside of the square. How is this better or worse than using a thermometer?

The benefit of having correct data has been noted as a great advantage to teaching concepts.

Document : Ted/UlysiesHT(1/12/03)
UlysiesHT: The kids at this instant have the ability to see what they are thinking if they try this. They can see it straight away. They don't have to do a big experiment and then draw a graph and extrapolate it. They can actually do an experiment on the spot, check it, check the slope. They can do it all instantaneously, virtually.

DavidHT: I think they are [learning more, using the data loggers]. I don't think they getting caught up in the technology. I think that they are starting to realize. Maybe the first time they use the data loggers they thought it. But now, when they use data loggers they know it's an instrument to collect information for the actual experiment.

Skills outcomes

A large proportion of the teachers surveyed identified that the use of data loggers made students “lazy” because they were not forced to manually plot graphs (see section 4.1.1). Furthermore it was claimed that the skills of constructing graphs was being lost because the students relied heavily on the computer to do the work for them. This negative aspect was mentioned by only one of the teachers interviewed:

Edward: In some ways it is making them lazy. They're becoming better at interpreting what a graph means. But not necessarily knowing how to draw a scale so it's going to be and linear scale and also having to sort out this scale before hand. All those processing skills, you have to start with. It's no use using a data logger … they just get lazy and don't bother picking up on things like that. But, by using them [data loggers]. They are starting to see trends better.

When asked if the computer-generated graphs made students lazy, one teacher argued that the skill of drawing a graph was different from that of interpreting graphs. She recounted a case of one Year 8 student who did not have the ability to draw a graph but who had been able clearly to demonstrate a high level of understanding of what the graph represented.

KarenHT: This kid could not draw a graph if he tried. [pointing to a student's science report] But it has not affected his understanding of a graph. What about that for a statement. He understands what the graph is, and there was a lot of information missing from this stuff. If you look at the graphs we have got, they are not identified as probe one and probe two. But he did. This experiment on an insulating material [again pointing out the report]. And he has already made the
assumption that the top line is the one that was the insulated can, and the one that cooled down fastest was the un-insulated can, and [he] has then gone on to say something else.

James: I mean, you teach the skills of drawing graphs, tabulating and all that anyway. At so many stages a long seven to ten. Well, for one lesson we take out that part of the skills, and the kids can actually produce actual computer generated reports. That actually look at the data and you can draw a conclusion. For this class it is quite good.

Many teachers identified the ability to see the graph being drawn in real time as being a major benefit for students.

Document : Edward (2/2/04)
Edward: One of the biggest things is that the seeing a visual thing on the screen when it's occurring. So for Newton's third law, when they are doing the experiment, they can see the results straight away.

Document : PeterHT/Quinton (16/12/03)
PeterHT: The other advantage, I thought was also the data manipulation. To produce a graph in real-time, and kids to see changes to your experiment, and then those changes in real-time showing on the graph.

Document : Nick/Olivia (3/12/03)
Nick: There are literally thousands of things you can do. The sky's the limit really. You get instant results. You can see it on the computer screen what is happening within seconds. I found basically the graphing part, the best thing to do. If I was doing temperature or motion or voltage, whatever or light, to have it graphed in front of students and then to have a hard copy printed out. I found that quite good.
And also for the seniors, for their practical experiment book.

Olivia: I agree. Seeing the results in a graph, or even a table, even as a meter. When you show the temperature as a gauge it looks very nice. The manipulation of the data and the print forms. I found it very convenient. Usually they use the graph and the table and that's what they are used to doing. Analysis of the graph or in table form, but the things we could do without working very hard on the mathematical part of it. And many of the students in Year 11 Physics are doing four unit mathematics. They are really good at mathematics. But since it is so easy for them to just do it by clicking. And they are very good at computers also. In some cases they are more better than doing that, than me, in interpreting the data because they are so used to it. More than me.
Olivia: and visualization of numerical data is always much better. So it is better to visualize it in the form of a graph. They remember it… It's like seeing the graph go up or down. You don't have to tell them to look at the figure. It's like asking them which way it will go. And then to visualize it on the screen. And I think boys are much more adapted to anything that they can see it in the form of a computer. You know, because they used to working with it. Visualization actually helps them a lot to develop.

In most cases teachers identified that the use of the new technology had also meant an increase in student engagement.

Document : Geraldine (2/2/04)
Researcher: Has it had a positive outcome for students?
Geraldine: Well, in the classes I have used it. It has. It has been a motivational tool for some.
They really want to get their hands on it. But, the fact that it can display data, and then display data that you can manipulate. Particularly for the top classes. In particular the gifted class. They really want to do that sort of thing. They like getting their heads around the meaty bits.

Document : Ian (16/12/03),
Researcher: Do you find that kids enjoy using it?
Ian: Yes. I think they do. Particularly if they've been using them in Year 10. I haven't been using them younger. With Year ten, they were very enthusiastic using new equipment. They were used to using computers, not with the data logger, but with putting the information in and to draw a graph.

Document : Edward (2/2/04)
Researcher: With students. Do you think it makes any difference in their perceptions of Science by using data loggers?
Edward: It definitely makes a difference. Up till now, we always had comments science was becoming irrelevant because the equipment is old. Now we are getting new stuff they are starting to say. “Well OK, this isn't just something we're talking about, it is something they are starting see”.

Document : LiamHT/Mary (15/12/03)
Mary: Well I think kids at keeping up with using more technology. There is a lot of things we talk about in high school. A lot of things they don't actually see.
LiamHT: And that the kids definitely like using it.

LiamHT: Well there is. If they tend to get a bit captivated by the use of the technology, then at least they are interested. You have more of a chance of getting your message across that way. I have had a lot of success using it.
Mary: well for seniors… They just push you out the way and just run with it. Which is good. It makes it more student centred. Once you have showed them the operation they are into it.

CharlieH: I would probably say the same point again. I found my middle stream in Year eight loved it. And I had it out on the desk for a week and a half, with a data projector. So, out of the storeroom for a week and half showing them things. So they found it quite stimulating. So I think it’s not a replacement for traditional methods. But its certainly in especially the junior years a way of enhancing the learning environment. And in terms of the physics stuff, you can get rid of some of the old equipment like photography and linear air tracks, and use the data loggers.

Document : Helen (2/2/04)
Interviewer: And how have you found the students reactions to using data loggers in the classroom?
Helen: They [students] find it[data logging] really exciting. They take it a little bit for granted. Because they haven't seen me putting in all the effort into getting them to work. They just see them working brilliantly on the day for them. They like the fact that you can see what is happening straight away. It's not like you are taking a reading and then it you know, getting a table, and going away and drawing a graph, and you have kind of forgot what is happening. You are looking at what is happening as you are doing it. So it makes it a lot clearer to the kids. What the experiments about and what science is about the experiments.

Real science
A trend appeared in many of the interviews was that the use of new technology was needed in the science class. Many teachers commented that the conventional equipment they were using was obsolete and turning students away from science.

Document : Andrew (19/12/03)  
Researcher: The advantages of data loggers over conventional measuring devices. What advantages are there?
Andrew: the biggest one has to be it takes science out of the 21st century. If it students go on to do any further science it is going to be based on data logging equipment. All automatic equipment rather than thermometers and tape measures. While those things a useful to introduce concepts. You get past that with the initial introduction of concepts. You probably find that in year eight. I think once teachers start to think more critically about experiment and design of experiments.
Document : Edward (2/2/04)
Researcher: With students. Do you think it makes any difference in their perceptions of Science by using data loggers?

Edward: It definitely makes a difference. Up till now, we always had comments science was becoming irrelevant because the equipment is old. Now we are getting new stuff. They are starting to say. Well OK, this isn't just something we're talking about. It is something they are starting see.

Document : Helen (2/2/04)
Interviewer: Looking at the bigger picture now. What do you see is the place for data loggers in science teaching?

Helen: I think it it makes it a lot more immediate for kids. I like to use it mostly for that reason. In that it really makes the science really clear to them straight away. I think it's important for them to have to use logical thinking skills in using those sorts of equipment. I guess they will come up against that sort of equipment when they leave school. So that's important as well. And also, I did a lot of experiments that you could not do in a normal way, you know, the temperature probe. Sometimes you could use a thermometer. But it can take readings over night, and to do is going to stand there on a cold winter's night taking temperature readings over 24 hours. Not me. For example, the heart rate monitor. You can get a heart rate monitor that just straps on to person. Get them jumping up and down. You can see on the screen straight away how their heart rate is changing, or until it comes back to resting. And you can't do that with other Science equipment in the lab normally.

One teacher commented that it was necessary to be careful that students did not see data loggers as just another science toy.

Document : Geraldine (2/2/04)
Researcher: Yes. Do they? Do they see it as being more relevant now that you are using the technology?

Geraldine: It's hard to answer. Some kids will love science no matter what you do. No one has come up to me and said" use I really love science now" I think they can really see the relevance of science now. But then again, when you introduce the logger for the first time it is probably an idea to explain what a logger is, and that you probably come across it, and to explain that you do come across it in your life. Because. Otherwise they just see it as another science toy. And they will still put it in that science category. In that science basket. Not as something that we will use outside of science. Not something we would use in the real world. So that's why I say in my particular instance. I honestly don't know if it has changed their perspective of science. They just see it as another piece of science equipment. Just put it in that basket.
5.2.1.6 Does the type of data logger make a difference?

There are currently several different brands and types of data loggers available on the educational market. These data loggers vary greatly in their specifications, features and support. Despite the many differences, there are basically two ways in which a data logger collects and displays data. One is the type of data logger that connects directly to a computer and is controlled via an on-screen menu. Some of these are equipped with automatic configuration and preloaded experiments.

Comments made by teachers referring to the computer-based data logger included:

*Document : Nick/Olivia (3/12/03)*

Nick: to use it in a basic way is pretty easy. The Pasco is very easy to set up. Once it's there, it's there. It's so intuitive. To go beyond that and do more complicated work takes some research, but just to measure the temperature of two beakers of water for instance. Graph it out, get your results. You can do it in less than a minute and you get the instant results that you don't get through a normal procedure.

*Document : PeterHT/Quinton (16/12/03)*

PeterHT: But I think the ease at which they can be used. The ones we have are basically, you turn it on, plug it in and go, and you have readings being pumped out, provided you have it set correctly… Whereas the ones that we have, we plug in, turn on, plug in the sensor, it detects it, bang, you're away.

The other type of data logger is the hand-held graphics calculator model. These data loggers are cheaper and do not require a computer to show data. However teachers reported that this type of data logger was difficult to use because of the way that it handled data and the difficulty in modifying the program that it used to collect data.

*Document : Ian (16/12/03),

Ian: Like many other schools, we just rushed in and bought what ever was on the market, not realizing what was out there. I have gone to inservices, and even the TILT-plus course this year, and still I don't feel that confident in using it. It's mainly the time and the difficulty in using them.

*Document : Ted/UlysiesHT(1/12/03)*

UlysiesHT: The problem we have is that basically, at the moment, is getting the bloody thing to work properly. We have problems with the calculators, with the software, all sorts of problems. If we knew every time, that if you just turned it on, plugged in a sensor and run a program that it...
would work, we would have a much better chance of using it. We have a data shell which is great for doing that, but only one calculator that can run it, which is fine, but it is our biggest drawback, which is why I have seldom used it at all.

Document : BarryDP (15/12/03)

BarryDP: Again the problem there is the number of systems that we have. Certainly, the CBL system that was in the school previously. I would hate to bring into a class, they are so difficult, so unreliable, that we would just be causing a problem.

5.2.2 Discussion
Overall the responses to using data loggers were much more positive in the interviews than those collected during the teacher surveys. This was due in part to the fact that all teachers interviewed had used data loggers with some of their classes whereas those surveyed were representative of the general population of science teachers and hence included teachers that had not used data loggers.

The teacher interviews indicated issues relating to the implementation and use of data loggers and identified the benefits of using them. Teachers interviewed claimed that many of their colleagues found the prospect of implementing the use of data loggers in their teaching to be too difficult for various reasons and hence gave up.

Many teachers identified that a significant challenge to their use of data loggers was the low level of teacher confidence in using them in the classroom with students. Most teachers had not been trained in their use. Often the equipment would fail and they would not be able to rectify the problem. Teachers also claimed that there was insufficient time for them to set-up the equipment.

The low level of teacher confidence was compounded by what was reported as insufficient professional development. Many teachers expressed disappointment at the quantity and quality of professional development, claiming that they had learnt how to use the data loggers primarily through their own perseverance.
Where professional development training was available it was often with a different type of data logger to the one at the teacher’s school. As there was little use of the data logger back at school, any skills picked up were soon forgotten, resulting in teachers having to re-learn how to set-up and use the data loggers each time they were used.

Attempts were made at various levels to increase the skills of teachers, however this was problematic, given the amount of variation in data loggers. One attempt was made at state level to develop a DVD that provided examples of various data loggers and data logging experiments. Every DET school was sent a copy of the DVD, however it appears that the DVD has received little, if any, viewing.

The purchase of data loggers is costly in terms of faculty budgets. This resulted in teachers being hesitant to use them in case they were damaged. Often the data loggers were placed under special lock and key. This level of security made it difficult for some teachers to get access to the technology and added to the concern over damaging them.

Some schools purchased cheaper data loggers that were not recommended by the DET. The added complexity of these data loggers resulted in their infrequent use.

Teachers reported that the type of data loggers that were connected directly to computers were mostly easier to use than those that were operated through hand-held graphics calculators, especially if they were able also to print graphs.

A majority of teachers complained that they had limited access to technology including the data loggers. This included access to computers to which they could connect the data loggers.

Having only limited numbers of data loggers (sometimes only one per school) meant that teachers had to devise concurrent teaching methods that would allow some of the students to be on an alternative task while others were using the data logger.
One school implemented a science technology room that had computers set up to use the data loggers. Although this seemed to rectify the problem of lack of resources it meant that teachers were faced with a cramped working environment for their students and with a dilemma regarding how to supervise students who were using the room while other students were still in the initial classroom.

Many teachers were reluctant to use the data loggers with junior classes, citing the increased difficulties of classroom management and the fear of damaging the equipment.

The use of data loggers was mandated by the relevant syllabus. Despite the negativity surrounding the implementation of data loggers, most of the teachers recognised that the use of data loggers in the classroom was beneficial for students. Teachers identified that there were many benefits in using data loggers, including the speed of collecting data, the accuracy and reliability of the data collected and the integration with other ICT skills.

The use of the data logger to display graphs in real time was seen unanimously as a major benefit in increasing student learning of graphing skills. This was in contrast to the teacher survey in which some teachers were critical of using data loggers, claiming that they made students lazy in regard to drawing graphs.

All teachers claimed that students enjoyed using the data loggers and that this increased student engagement. This was validated by student survey responses. Teachers also claimed that the integration of data loggers ensured that students were using appropriate and real science equipment that mirrored the equipment used in modern science laboratories.

The next chapter presents the results of the third stage of the study, combining interviews and class observations to compile relevant case studies.
Chapter Six: Case studies

6.1 Introduction

In this chapter the data collected from selected classes is presented in the form of case studies. Each case study describes how data loggers were used on a school-by-school basis. Participating schools were invited to take part in the case study investigations by allowing the researcher to interview year eleven physics students and, where possible, to observe classes using data loggers. This information was combined with teacher interviews and surveys that related to each individual school.

The schools selected demonstrated a variety of conditions in teacher experience, data logger type and class size, as illustrated in Table 6.1.

Table 6.1: Characteristics of participating schools

<table>
<thead>
<tr>
<th></th>
<th>AAA High</th>
<th>BBB High</th>
<th>CCC High</th>
<th>DDD High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher experience</td>
<td>Experienced head teacher</td>
<td>Newly appointed head teacher</td>
<td>Experienced deputy principal</td>
<td>Five years teaching experience</td>
</tr>
<tr>
<td>Teacher technology experience</td>
<td>TILT trainer</td>
<td>Recently-completed physics retraining course</td>
<td>No formal training but had used data loggers for several years</td>
<td>Completed TILT course</td>
</tr>
<tr>
<td>Teacher attitude to using data loggers</td>
<td>Positive</td>
<td>Positive</td>
<td>Positive</td>
<td>Negative</td>
</tr>
<tr>
<td>Computer access and availability with data logger</td>
<td>One computer in science lab</td>
<td>Computer in science staffroom</td>
<td>One computer in science lab</td>
<td>No computer with software loaded</td>
</tr>
<tr>
<td>Type of data logger</td>
<td>Computer-based</td>
<td>Graphics calculator type</td>
<td>Graphics calculator type</td>
<td>Graphics calculator type</td>
</tr>
<tr>
<td>Socio-economic factors and school environment</td>
<td>Comprehensive high school</td>
<td>Low socio-economic *</td>
<td>Comprehensive high school</td>
<td>Low socio-economic *</td>
</tr>
<tr>
<td>Class size</td>
<td>14</td>
<td>4</td>
<td>10</td>
<td>8</td>
</tr>
</tbody>
</table>
* As defined by DET Priority Action Schools Program

To protect the anonymity of participants the names of the schools and the interviewees have been changed. The case studies are each reported using themes similar to those that emerged from the previous research, organised under the following headings:

- Background;
- Experiments performed;
- Benefits of using data loggers;
- Benefits of using conventional equipment;
- Comparison of data logger and conventional equipment;
- Negatives;
- Student engagement;
- Student learning;
- Teacher approaches;
- Use of data loggers with junior school; and
- Summary.
6.2 AAA High School

6.2.1 Background
The researcher had close connections to AAA High School having previously taught in the school and acted as a trainer for the science faculty as part of the Australian Government Quality Teaching Program.

The physics students interviewed had completed Year 11 and remembered the researcher from his teaching days at the school as their Year 7 student advisor. This allowed the interview atmosphere to be more relaxed. Due to time constraints there was no opportunity to participate in observations of the class using data loggers.

The Head Teacher, Andrew, had been at the school for the past two years and was keen to be part of the project. Andrew was an experienced science head teacher with expertise as a science consultant and co-author of a resource on computer technology in schools. At the time of the study, Andrew was also a facilitator for the TILT-Plus Science Data Logging course.

Five years prior to the interviews, the previous head teacher had purchased a graphics calculator type data logging kit for use with the senior physics classes. This equipment included a training video and manual, however the kit had never been used with a class because it was too complicated. Andrew related the problems he had in his efforts to use the data logger with students:

… I tried to do stuff with linear air tracks. Not very successful. There was one time with hand held data loggers. But nothing seemed to run in class the way that it was suppose to… With the CBL [Computer Based Laboratory] we had major difficulties. We could not get it to work at all. With Year 11 Physics we did some work using the linear air track.

6.2.2 Experiments performed by the class
The situation changed with the purchase of a new data logging system. Andrew was successful with several experiments and demonstrations:
With Year 12 we have looked at astrophysics. The new data loggers had arrived in time. We looked at the effect of filters on light and measured the intensity of light through different coloured filters. That worked quite well… We just started the space topic this term. Acceleration due to gravity by falling objects, by objects down slopes, rotation sensor for pendulum, and we did the pendulum experiment traditionally with a stopwatch as well.

Students confirmed their teacher’s use of data loggers, recalling several data logging experiments that they had attempted over the previous year. All student interviews and questionnaire responses indicated that the teacher and students had used data loggers in class. When responding to the question asking students to indicate how many times they had used the data loggers, answers ranged between five and seven times.

Students indicated that there was one data logger available for their class to use. Experiments included projectile motion, calculating acceleration due to gravity, and using the light probe for astronomy experiments.

Andrew had emphasised practical work as important in teaching physics. As well as data loggers he said the following equipment had been used:

- voltimeters;
- ammeters;
- stopwatches;
- thermometers;
- rulers and protractors;
- tickertape timers;
- geiger counters; and
- cathode ray oscilloscope (CRO).

6.2.3 Benefits of using data loggers

Andrew outlined the benefits of using data loggers and recounted how a Year 10 student had been able to use the new data logger in his independent research project:

A student during a major project looked at the temperature of resistors. So he measured the current and voltage. He had a resistor made of wire and the temperature of the water. He was able to export it out as an Excel file to work on it.
When asked how the use of data loggers differed from those experiments using conventional equipment, students identified that the data loggers were easier to use, gave quicker results and were more accurate and convenient; for example:

…The data logger gives you much quicker and reliable data, and allows you to control the variables...

The students were also positive in their responses about the use of data loggers. One student stated:

*It's much more quicker. It allows you to do more, and allows you to get through the course without wasting time…*it allows you the flexibility to see what happens if you change this or that with your results…*We could modify the experiment to see what effect shape or things like parachutes would have on the motion.*

All student responses in the questionnaire were also positive to questions about how the use of data loggers differed from other methods. Typical responses included:

*Data loggers cancel out the need to perform manual calculations in order to find out the velocity, displacement, time, etc. The use of data loggers also required the participant to have some technical and computer skills in order to use the computer program to extract the information needed;*

*Quicker, more convenient, more accurate. Computerised-technology measures it rather than humans.*

When asked in the questionnaire what they liked about using data loggers, student responses identified the speed of collecting data, convenience, improved accuracy and reliability. One student responded:

*Data loggers are more accurate, convenient and faster in processing the data into information for the results of an experiment. Data loggers are reasonably easy to setup and take less time to pack up, thereby allowing more time to analyse the results.*

The questionnaire also asked students if they thought there was any benefit in using data loggers over conventional equipment. Again all responses were positive. One student suggested that using the data logger was increasing his computer skills:

*There are many benefits of using data loggers including the use of computer skills that could help the participant further his computer skills while carrying out an experiment.*
Andrew explained that the biggest advantage of using the data logger compared to conventional equipment was that automatic equipment better reflects the way science is done today, and that it allowed for greater experimentation:

...I think once teachers start to think more critically about the design of experiments, look at the variables and do some very creative work experiments. And then say, what happens if I do this? If it takes half a period to get two results with a stopwatch and it takes you 20 seconds to get a better set of results with the data logger, you have to go with the data logger and have the time to look at some other variables.

Andrew recounted an activity on describing the motion of falling objects, during which students were easily able to modify an experiment and collect results within a very short time:

We used a copper sheet to fall through a light gate, plotting data, getting one data set every 20 seconds. By the time [the students] picked it up off the floor, straightened it up, and dropped it back through again, that gave them options of starting to look at different scenarios such as adding parachutes... And some other types of forces involved instead of gravity as an extension. Were we to do it without data loggers, with stopwatches, we would be doing it for months.... That extension of very rapid data collection brings a new dimension for us of being creative.

6.2.4 Benefits of using conventional equipment

When asked about the benefits of using conventional equipment rather than data loggers, two students identified that sometimes there were problems associated with the data loggers when they did not work or when there were problems with the setting-up of the experiment.

Andrew explained the initial problems that he had in using the data loggers with the class, not just in getting the equipment to work, but also in allowing students to discuss and share their results:

...The hand-held screens. The software is very quaky and the screen itself is extremely limiting. And that's what I have found is the problem. That's really the problem. There's no opportunity for the kids to sit down and be collectively shown how things work. You are limited by the screen. So that shared learning that you try to start off never occurs.
During the student interviews students were asked to comment on the benefit of using conventional equipment rather than data loggers. Comments included:

- Student 1: You are controlling more of the experiment rather than the computer;
- Student 2: Sometimes the data logger did not work;
- Student 3: With the linear air track we had problems with the way it was set up.

Students also explained that when they did use conventional equipment they could work in small groups rather than as a larger group. They also pointed out that they only had two computers available to use during class time, unless they went to the computer room.

### 6.2.5 Comparison of data logger and conventional equipment

Students revealed that despite having to use the data logger as a class instead of working in smaller groups they much preferred to use data loggers rather than conventional equipment.

The questionnaire asked students if, given the choice, they would choose data loggers or conventional equipment. Responses included:

- Data loggers are much more convenient in that they take less time to do the experiment;

I would use data loggers because they save much needed class time that can be better spent analysing the results rather than going through the mundane tasks of processing the information.

Andrew was asked to comment on the success that students had with using data loggers.

The results we have been getting have been really good. And they [the students] can see that they are good reliable results, and that they are repeatable. And we have done it with some of the variations that we have been able to do… The kids have enjoyed it. It is a different way of doing stuff. It's a bit more high-tech, a bit more realistic.

Andrew went on to explain that the students were keen to use the data loggers and required minimal assistance once they learnt how to set up the equipment:

… So they look forward with excitement. The kids enjoy using the stuff. They enjoy taking different roles... And once they get started… And you see that you work through the first couple
with them. And then you just give guidance where it is needed. ... If they think that the results are going wrong they ask you.

As an experienced teacher Andrew recognised the need to ensure that students were taught the basics before moving on to more complex outcomes. So rather than just allowing the data loggers to complete all the calculations, Andrew ensured that students were able to do the calculations required and then have the computer verify their results:

We were actually just doing a calculation to find the acceleration due to gravity...
However, we were able to have the data logger do all the calculations for us. So we went through the stage of having two velocities combining to find the acceleration. [Students were then able to calculate the acceleration based on the change in velocities] Then looking at what was coming out. At that stage we were able to look at shapes of graphs...

Andrew still emphasised the importance of graphing as a skill required by students and used the data logger to show trends in data:

We still draw graphs…. I have been very careful, to challenge kids with some of the things we are doing. From a very traditional and stopwatch techniques. And just follow it up with a data logging method. I have also. So the kids are good at drawing graphs. They are use to slopes and lines of best fit and that stuff.

Andrew was asked to respond to a comment that the researcher had received from another teacher, that the use of data loggers made students lazy because they no longer had to draw graphs.

I don't think getting a result in 10 seconds that you could normally take half an hour to do is necessarily lazy. I think we need to realize that you have taken a result in 10 seconds. Now, what other results do you want to take to extend the scope of an experiment?

Andrew went on to explain that he was having success with students using one computer to collect the information and another computer to analyse the data:

So we're getting used to collecting and graphing at the same time. And looking at the data and saying, "I need another point at this size or that size". If the information looks a little odd we might have to go back and repeat that one or checking to see what's going on.
Andrew had used data loggers for several years and believed that the inclusion of data loggers in the syllabus was a positive step. He pointed out that students now saw that the experiments using data loggers were significant in their studies for the Higher School Certificate:

_The data logging question in the 2003 Physics was a bit of an eye opener. They could see that the stuff that we have been doing with data loggers has more relevance than just playing with stuff._

**6.2.6 Negatives**

Although most of the responses from Andrew were positive with respect to using data loggers, he also pointed out some of the negative aspects:

_It takes time for teachers to get confident in their use. I think that's probably the biggest problem we have got. The confidence of teachers to be able to say. "I will take this, and plug this in, and it will work." And when it doesn't work, to very quickly track down the problem._

Andrew went on to say that because he and the students were just starting to use the data logger that he was not concerned over having only one data logger. However, once the class was more confident then he would require more data loggers so that students could become more independent.

_The limited number [of data loggers] is a problem...We will eventually get it to having kids working at seven or eight systems in the room at once._

It was obvious that the kind of data logger, ease of use, and reliability of results was crucial to having success in the classroom. Andrew elaborated on his attempts to use hand-held graphics-calculator-type data loggers with the class;

_And we have had our failures. When we tried with the CBLs [graphics calculator type data loggers] they didn't work…But when we look at the numbers. What the hell is going on here. We never tracked down what the problem was. We agreed to not use that information because it was so unreliable._

Andrew noted the problems his staff had experienced in using the data loggers.

_Again it's a matter of getting the equipment in. Learning about how it all works… It's not until you plug it in and have problems that you really find out how it works. I guess it's like any computer
stuff. It's negative feedback you get all the time. And then again, some people don't like that environment or the uncertainty of if I plug this in will it work or not.

6.2.7 Teacher approaches

Students were asked whether their teacher did anything differently when he was using data loggers. Students in the interview replied that there was no difference, however some students’ responses to the questionnaire indicated that there were some variations:

Yes, there are differences… Differences include: the procedures in carrying out the information gathering, analysing, and processing. It is generally shorter in terms of the methods to complete the experiment using data loggers when the teacher uses it.

Because we have a limited amount of data loggers, we seem to work more together as a larger group than individually.

This was consistent with the response Andrew gave when asked if using data loggers had changed the way he taught:

The limited number of data loggers probably changes the way you teach. It's probably also part of the natural learning ideas. That we sit down with a probe and we talk to the problem and everybody learns including the teacher.

Andrew went on to explain how teachers needed to change the way they teach in order to effectively use the data loggers:

I think for some of them [teachers] it is probably a scary part where you can say that you go in and you are going to plug this stuff in and we will collect this data. And then we will discuss where we will go from there. Or if things don't work properly, if there is a problem, how are we going to fix the problem? Talk to the kids. Which is one of the things that I am happy to do. I have always done stuff with experiments. So for me it hasn't changed very much what I do. I think for other people that are very traditional… would have to change some of the ways they do things.

6.2.8 Use of data loggers with junior school

All responses from the questionnaire indicated that the students had not used data loggers when in junior school. During the teacher interview Andrew noted that none of his physics students had used data loggers until the purchase of a new data logger
that year. As a result he had also recently begun trying to incorporate data loggers into the junior curriculum.

Andrew was asked to comment on his use of the data logger with junior classes. He explained that he had not used the data loggers with the junior classes due to the complexity of the data loggers. He elaborated that Year 10 classes were going to be timetabled into a computer room so that they would have access to the new data logger:

Again the problem there is the number of systems that we have. Certainly, the CBL [Computer Based Laboratory] system that was in the school previously. I would hate to bring into a class. They are so difficult. So unreliable, that we would just be causing a problem… Not so happy to bring probes and interfaces in where there is more for kids to explore possibilities where things should go… Next year we have actually booked Year 10 computer time. Once a week. That's already on the timetable. So hopefully next year. We can record good data… Kids will be certainly doing more in Year 10.

When asked during the interview if they would have preferred to have used data loggers back in junior school the general feeling from most students was a preference to using them in senior school. One student suggested that Year 10 would be an appropriate time to start using data loggers:

Maybe in Year 10. But not earlier. We did a lot of hands on. Manipulation stuff. This will prepare us for university, where it's all data loggers.

During the interview students also indicated that they would use data loggers at university and in their future careers.

6.2.9 Summary
This teacher appeared to demonstrate effective use of data loggers. Factors that positively impacted on his ability to use data loggers included:

• the teacher had a high level of professional development and technical knowledge;
• the teacher was experienced and had no problems with classroom management;
• the data logger was easy to use;
• students were confident with traditional experiments and graphing;
• students were able to use the data logger and obtain results successfully;
• students had a positive attitude to using data loggers and believed there were benefits in their use, including the advantage of quickly capturing and displaying data from experiments; and
• the teacher was able to modify experiments quickly to answer ‘what ifs’ and this gave the students a sense of ownership of the results.
6.3 BBB High School

6.3.1 Background
David was a recently-appointed science head teacher and was in his first year of teaching senior physics, having just completed a one-year re-training course to teach physics. During the re-training course David had received one day of training in using data loggers.

BBB school was small (approximately 350 students), situated in the outer western suburbs of Sydney and is considered one of the more “difficult” schools to staff. Despite the school being small in size it was in a strong financial position compared with other schools in the area due to extra funding it had received from various programs designed to improve the educational outcomes of students, in socio-economically disadvantaged areas.

David, as the head teacher, was keen to be involved in this study. The principal was also very keen for the school to be involved in the project having previously been a science teacher himself.

The researcher was able to interview David after a classroom observation of a lesson using data loggers. Classroom observation and informal discussion with the class was used to validate David’s responses to the interview.

6.3.2 Lesson observation
The lesson observed was a Year 11 physics lesson. The class was small, consisting of only four students. The objective of the practical lesson was to use an accelerometer to distinguish between inertial and non-inertial frames of reference.

David had been delayed in getting to the class. The students were sitting on desks and had not yet unpacked ready for work. The students had been given the practical task during the previous lesson and were expected to have read the instructions found in their textbook. However, it appeared that this homework was not completed. Despite
the obvious lack of preparation the students did not read the instructions in the textbook during the lesson, but relied on David for instructions.

The activity required students to measure the acceleration of a dynamics trolley when connected to various masses via a pulley system. The activity was also to be done using a real car, however the lesson did not progress to this stage. One student started to set up the equipment and appeared to be confident in the setting up. This suggests that the student had used the equipment before.

Throughout the lesson the students appeared engaged in taking turns in letting go of the dynamics trolley and in starting the data logger. After several trials, which resulted in nonsensical data, David changed the settings display and time interval for recording on the graphics calculator. This resulted in the data being displayed on the calculator window in a graphical form.

David and the students had to leave the laboratory and go to the science staffroom to download and print the resulting graphs. A fellow teacher expressed his concerns to David over students having to enter the staffroom and use the computer that he was currently using. David explained that he had to use the computer because it was the only one that had the software application that he required. The teacher reluctantly gave up the computer, but was clearly not impressed by the interruption.

The class and David returned to the science laboratory with a view to discussing the resulting graphs. One student observed that the graphs were “getting better”, although there was no evidence to support the statement in scientific terms. David asked the students to describe the graphs. In describing the graphs the students used terms such as “it’s up and down” and “there is a bump here”. Again there was no reference to the variables being examined.

The failure of the graphs to give any real meaning to the experiment prompted David to adopt a more hands-on approach. He became part of the team completing the experiment, working with the students. David was involved in the data collection by coordinating the release of the cart and starting the data logger to collect the data.
Again the class returned to the staffroom to download and print off another set of graphs. The graphs were again not what was expected. Students were given a copy of the graphs (see figure 6.1) and because it was close to the end of the lesson, quickly given instructions to analyse them for homework.
David said he would discuss the results with them the following day. However, as the graphs were of different scales and sizes there was no way that the students would
have been able to come up with a coherent explanation. Further to this, the axes were not labelled and there was no indication of the scale of the results.

A copy of the graphs was shown to the District’s TILT (Technology in Teaching and Learning) facilitator for comment as to the validity and reliability of the data collected. He said:

*The graphs look rather meaningless. There is such a range of different… With some points it's going up and down a bit. Probably from friction of the wheels or whatever. Or friction from the pulley slowing things down. So there are a couple that are quite meaningful. But there is also a couple that look like random data…. That is not a good set of data for whatever reason.*

The TILT facilitator said he thought this was a good way of “turning kids off using technology”. He explained that a great advantage of using the data loggers was that if the experiment yields unexpected results there was time to repeat the experiment and see if the same results were replicated. He described one of his experiences:

*We did some data collection a while ago and it was turning out really badly… The results were going right off. So I said “let's go back and look at it”. And the kids worked out it was due to the fact that they had been tilting the air track. So they weren't measuring the car going through the light gates… once they tracked down and established the light gates in the right position we were getting consistent results again.*

### 6.3.3 Teacher interview

David was interviewed the day after the classroom observation.

### 6.3.4 Experiments performed

Students confirmed that they had previously used the data logger in lessons. David confirmed the class had used data loggers with a variety of sensors and was able to elaborate on their use:

*I have used the microphone, the range finder, the temperature probe, the light meter. That was used for the inverse square law. The range finder was used for the basic motion ones. The microphone was used as an oscilloscope.*

In the lesson observed, David used a hand-held calculator data logger in preference to having connected it to a computer.
6.3.5 Benefits of using data loggers

David identified advantages similar to those stated by teachers surveyed, such as the reduction of time required to collect data. Reference was made to the advantage of using data loggers over conventional equipment such as tickertape timers:

*I think it cuts down the time required to collect data, by allowing you to get a graph and a total very quickly. So it makes some of the experiments quicker… and the kids use the technology as well. They are more adept at using computers if you are using a computer based data logger*

The experiment observed by the researcher would have been far too difficult to attempt using conventional equipment, however in this case the data collected was not reliable.

David said he could see that students benefited from using the data loggers due to the incorporation of technology and the motivational benefit. There was no mention of using the data logger to its full potential, such as the ability of the computer to draw graphs in real time:

*The kids do get a lot out of them. They seem to enjoy using it, and normally, I would do something else with it, rather than just collect data. With the ticker tape timer, you can get data or you can use a range finder, or light gates to do the same thing. So they get a look at both technology, but they like it and they pick it up pretty quickly.*

6.3.6 Negatives

David identified the major difficulties associated with the use of data loggers as being the cost of the equipment and the time required to become proficient in using them. He also mentioned that despite having the data loggers, his staff were still reluctant to use them, even though their use was mandated in the science teaching programs:

*One of the disadvantages is at getting adept at using it. It takes awhile and some staff are, you know, have to spend a good amount of time to get used to using them. So that's a disadvantage.*

6.3.7 Student engagement

During the lesson observation all students appeared to be engaged in the lesson, although focusing on using the technology rather than in interpreting the results. It was pleasing to note that although the results were nonsensical, David reported that there had been a discussion of their validity and what results would have been anticipated, had the experiment been a success, during the following lesson. David
reported that he had practised using the data logger the previous day, but was still learning how to use it:

> I'm still learning. That was the first time I had used [the acceleration sensor]. I used it for half an hour the day before, but I was still picking up things with what the graph represented. Now I've got that so both of us learnt together.

### 6.3.8 Student learning

David believed that his students’ learning was enhanced as a result of using data loggers. He believed that the students were past the stage of using the data logger as a motivational tool, but rather as a tool for collecting data.

> When they use data loggers they know it's an instrument to collect information for the actual experiment… It's the tool they used to get their results.

However, in the lesson observed, the students might have left the lesson with the idea that the data logger was a piece of useless equipment as the results that they obtained did not reflect the results expected by reading the text book.

### 6.3.9 Use of data loggers with junior school

When asked about the use of data loggers in the junior school David indicated that the school had purchased data loggers for use specifically for junior classes and was going to include the use of data loggers as a part of the junior programs, however he was concerned over junior students breaking the equipment. There were adequate numbers of data loggers to allow junior classes to work in small groups, though other teachers had not used them with classes:

> We're going to write some of it into our programs… I have been concerned about some of my classes with data loggers before. But we have eight of the lego ones. So we have basically one [data logger] between three.

### 6.3.10 Summary

The lesson observation indicated that data loggers were being used in class, however in this case the data logger was ineffective in producing reliable results because of the incorrect settings used during the setting-up of the equipment. Students were engaged in using the data logger, however did not understand the variables that they were
measuring or the anticipated outcome of the experiment. Students could have been left with an impression that the data logger was ineffective.

Despite the teacher being experienced and having no problems with classroom management issues, the use of the data logger appeared to be not effective. Factors that hindered the effective use of the data logger included:

- The teacher had a low level of technical and specific subject knowledge;
- The teacher had little time to prepare and practise using the data logger;
- The data logger was difficult to use;
- The students were unable to use the data logger to obtain successful results;
- The students had little understanding of the variables that they were measuring and the purpose of the experiment; and
- The students and the teacher had to move to another location (the staffroom) to print results.

### 6.4 CCC High School

#### 6.4.1 Background

Barry was an experienced physics teacher and at the time of the data collection had been appointed to the school as deputy principal. Previously he had been a science head teacher at a technology high school. Barry had been using data loggers since 1990.

This school was able to participate in a teacher interview, classroom observation and student interviews.

#### 6.4.2 Lesson observation

The researcher observed one lesson in a Year 11 physics class, with 10 students (9 male, 1 female)

The lesson started with Barry writing three questions on the board for students to answer. These were to check that students had completed the necessary reading for the practical.
Barry reorganised the classroom seating so that all students could be close to the equipment and see the data logger. He then demonstrated the data logger and various sensors such as the smart pulley, picket fence, trolley and photo gate.

Throughout the demonstration Barry questioned his students to ensure that they were both paying attention and able to relate the experiment to previous class work.

One student demonstrated proficiency in using the equipment by being able to organise and set up the program on the graphics calculator. The student followed a correct procedure, though this did not initially work. The teacher then checked the connections and then talked the student through the set-up.

The data collected from the data logger was then transferred to the chalkboard so that all students could have access to the data. Analysis of the data consisted of sketching a graph of the data on the board and then manually calculating the gradient. The teacher ended the lesson with setting homework for students to complete exercises similar to those practised in class.

6.4.3 Experiments performed
Barry was experienced in using data loggers having used them with classes for several years:

*I've been using data loggers since 1990. I have used five different types of data loggers. It's only the last, the syllabus change, where I have used the one recommended by the board [Board of Studies] and the Department of Education.*

Barry listed a variety of data loggers and sensors that he had used in teaching physics:

*Photo gates, motion sensors. They are the two predominant sensors that I have used. The Texas Instrument’s data logger. In fact all of them have been for determining distance verse time, and velocity verse time, and acceleration verse time.*

The recent usage was confirmed by the student surveys and interviews.
6.4.4 Benefits of using data loggers

Barry identified that a major advantage of using the data logger was the speed at which data could be collected and the ability to instantly display trends in graphical data:

_The data logger has the advantage in that it allows you to have rapid answers to questions. It also gives you a visual graphics display straight away. So you can have an instantaneous answer straightaway and instantaneous results that you can refer to._

Data loggers were used in conjunction with other conventional equipment. Responses from student surveys in relation to how the use of data loggers differed from other methods for collecting data typically identified the perceived advantages of using data loggers. This included:

_It is more efficient and more accurate if you were to put a lot of data in it. It would calculate it straight away;_

_Less messy eg, Setup and pack up._

6.4.5 Comparison of data logger and conventional equipment

The system that was used by Barry incorporated a graphics calculator that was used to show the data collected. It did have the capacity to express the data in graphical form however this was not used in the experiment observed. Rather, the data were given to students and then graphed manually.

Students identified that sometimes the graph produced on the calculator was not as expected. This demonstrated that there was a high level of knowledge integration:

_Female student: They are very sensitive. Sometimes the graph is all over the place._

_Researcher: So you really need to know what to expect from the graph don't you?_  

_Female student: If you have a close-up of the graph. You can see every little detail. But you really don't need to use it._

Barry identified that it was important for students to know the basics before using the data loggers. This included not just the ability to draw the graphs, but also being able to interpret and describe features of the graph.
6.4.6 Negatives

Barry was asked if there were any negative consequences of using data loggers:

> On the downside the students are not doing the basic mathematics and investigative buildup that the computer does for you. What I normally do is one of both. I do the classical way, and then use the data logger.

Barry had used both conventional data collection devices such as ticker tape timers and stopwatches to collect data as well as using the data loggers for similar experiments. Having used both types of equipment, students were keen to use data loggers. The only negative issue that students identified was the time and difficulty of initially learning how to use the data logger:

> Male student: You just need to know how to use it. ...[muffled response]
> Researcher: So learning how to use it is a problem?
> Male student: Yep.

However similar problems can occur with conventional equipment, as one female student described the problems that they had encountered when trying to get results with conventional equipment:

> Inefficient. Like [the ticker tape timers] weren't very accurate. You had to do it over and over again.

6.4.7 Student learning

Barry outlined that he could see a major benefit of using data loggers on the way that students learn. He went on to recount the difference between the way he had used conventional equipment to carry out a similar data logging experiment:

> I will do the ticker tape prac. It will take me a week. I would have lost half of the kids along the way. I will do the digital sensor analogy. We will have it done in a period. And point by point we will see what goes on along the way.

He compared the two approaches:

> The downside is that the kids that are capable of doing the more rigorous build-up are not getting the advantage, but everybody can see it step by step.
> It's not the only disadvantage. There are others. If you are using a data logger, being an electrical piece of equipment, like a computer, if it goes down, it goes down.
6.4.8 Barriers to use

Of the nine science teaching staff at the school, six had returned completed surveys. Only one other teacher on the science faculty apart from Barry had stated in the questionnaire (question 2.2) that he/she knew how to use a data logger and was confident in using them. Teachers’ responses explaining why they did not use data loggers included that the data logger that they had was “user-unfriendly” and “too difficult to use”. Barry had used the data logger to record data and then transfer it to the computer, but had not used the computer to show instantaneous results.

Barry had used the data logger connected to a graphics calculator for the classroom observation. He was asked if he had used the data logger connected to the computer to analyse data:

We have done that [connected the data logger to a computer]. With the last experiment we did with calculating acceleration due to gravity, in the space topic. It's something I would recommend, but it's not something you could show somebody how to do it. They would have to have a certain proficiency and competence in using computers before I would even tackle it, because they would have no idea of how to set it up, yet alone how to extract the data.

Barry agreed that when faced with errors when using the equipment, many teachers would have given up, suggesting that it was only due to his experience that he was able to find a solution. Barry went on to described how he was frustrated with the errors that the data logger would signal and the lack of support that the data logging supplier had given:

So I had come across a lot of errors. There are three types of the standard errors. Even though it is on. The battery supply it is not putting out enough to cater for the sensor. And therefore it looks like it's on, but you have to refresh the batteries. The company did not know this. So that was trial and error.

Barry also noted the limitations of his school’s data logger in terms of memory and speed:

It cannot hold more than two programs. So it comes with Vernier data gate. So if you load photo gate on top of it, it cannot handle any thing else. So if you want to go on to loading the motion sensor software, it can't handle it. And even if you just have the motion sensor software… if you
spin a revolution on the intelligent pulley, it cannot handle too many readings because there is just too much data and it just hangs. So you have to work with those limitations.

6.4.9 Use of data loggers with junior school

Barry had successfully used data loggers with junior classes in his previous school, however due to the complexity of the data loggers he was currently using, he had not attempted to use the data loggers with junior classes in his new school. He recalled that when he had used the data loggers with junior classes in his previous school he had great success:

At junior level. It’s fascinating. The kids love them.

Barry was asked if he could see a use for the data loggers in junior school:

Yes. But not these [data loggers]. I have used four or five others that have been superior as a teaching tool… [At my previous school] we had a whole lot of cross curriculum sensors that were being used, but it was with other data loggers.

Barry explained that it was a great benefit to get results that were accurate and instant, however he noted the problems with the data loggers that he was currently using. He commented that when conducting acceleration due to gravity experiments with data loggers in the past he had no trouble getting good data. However he found his current data loggers to be inaccurate.

Acceleration due to gravity experiments. This particular data logger, I cannot get the value better than plus minus 5 percent, and quite often get an error greater than 10 percent, which is an incredibly poor accuracy for a data logger. But in the past, even if going back 10 years, I was getting 9.8 + - 1 percent.

Barry’s use of data loggers was not restricted to physics. He also specified a range of other applications for which he had used them:

We had done temperature experiments. Light experiments, measuring the light change in photosynthesis of plants, temperature of soil, humidity. We did rain collection by sensors using a device called the weather monitoring unit, wind speed, wind direction over time.

Barry said that he had few problems at his previous school with using data loggers with junior classes provided the analysis software was not overly complicated:

If the software is user friendly. Most of them are. Just plug in and operate. It's normally just the experiment that tends to be more complicated.
Although currently using the data loggers in senior school, students could not recall using data loggers in junior school. When asked if they would have preferred to use data loggers back in their junior years of high school the students explained that they would not have been useful in junior school. They cited the complexity of the data loggers, the complexity of the content that was being taught and the lower ability of junior students:

*Student 1: The thing is. For little kids. It's too sophisticated for them. And they would not get it through their heads. You know;*

*Student 2: As they did not really concentrate on science. In junior school;*

*Student 3: Just the results;*

*Student 1: But I think in junior school that they need something to do;*

*Student 2: And they would not understand acceleration due to gravity;*

*Student 3: Attention span too;*

*Student 2: … in junior school, it's probably better to use conventional type tools for measuring things. More hands on.*

**6.4.10 Student engagement**

During the lesson observation the researcher had observed that the students were engaged in the lesson.

Barry guided the lesson using appropriate questioning of students, relating the experiment to previous lessons and activities.

Barry also guided students in the use of the data logger and graphics calculator. At one stage the calculator was not working, however he was able to correct the problem and then the class returned to the experiment.

Survey responses also identified that the students enjoyed lessons in which they used the data loggers more than when using conventional equipment. Reasons included:
Because we get to use it and take turns at carrying out different jobs.

More class involvement

6.4.11 Teacher approaches
Student surveys indicated that students could not discern any difference in the way their teacher used data loggers as compared to other equipment when performing an experiment. Students were asked in the interview if they noticed if their teacher did anything differently when using data loggers compared to other lessons. Although indicating that Barry did not do anything differently, they did infer that Barry was very well prepared and always would be in at school early to make sure the equipment would work:

Student 2: Because he comes in early sometimes and gets it set up;
Student 3: He has to check it and get it set up and working type stuff.

Responses to the interview and the classroom observation demonstrated that the students appeared to have a high level of respect for Barry and the way he taught them.

6.4.12 Summary
The teacher had demonstrated effective use of the data logger as a teaching tool. He was aware of the shortcomings of the equipment that his school had purchased, but was able to make the most of the equipment that was available. Factors that positively promoted the use of data loggers included:

- the teacher had a high level of professional development and technical knowledge;
- the teacher was experienced and had no problems with classroom management;
- the teacher was keen to solve problems when encountering errors and not to give up; and
- the students were able to use the data logger to quickly and accurately collect data.

Barriers to the use of the data loggers included:

- the complexity of the model and type of data logger purchased;
• the lack of support from the supplying company to rectify faults or to answer questions.

6.5 DDD High School

6.5.1 Background
Ian was in his early years of teaching and this was his second year of teaching physics. Ian had not received any training in the use of data loggers in his preservice training. As well as physics he also had experience in teaching senior chemistry. As with other teacher participants, Ian volunteered to be interviewed and allowing students from his class to be interviewed. His principal was keen for Ian to participate in the research.

The school was classified by the NSWDET as a school that was “difficult to staff”, hence most of its teachers and executive were less experienced than teachers in most other schools.

The school had purchased a set of ten hand-held data loggers that attached to graphics calculators and one attachment for using an overhead projector to project the results onto a screen. Ian mentioned that he had problems with loading the software onto the data loggers. He noted that the equipment was almost in mint condition due to little usage, and that he was the only member of staff who had attempted to use it.

There were only eight students in the physics class. From the student interviews it was apparent that the students had limited success using the data loggers.

6.5.2 Experiments performed
Ian had used the data loggers for experiments with his physics class, but admitted to having limited success. He recounted that he had started using the ranging device for students to become familiar with distance-time graphs before moving onto other experiments:

The last couple of years I have also used it for chemistry titrations. Mainly for physics. The first activity I always do is matching up the graph for displacement versus time graph with the ranger. Also dropping the ball to find the acceleration due to gravity and also the last couple of years we have been able to use the sound probe to show sound waves with a tuning fork.
This was confirmed during the student interviews.

6.5.3 Benefits of using data loggers
Ian believed that he could see the benefits of using data loggers, but had not been able to have personal success in the classroom with them:

I could see the benefit, but I have been unable to achieve that benefit yet. But doing experiments, and having the information straight up on the board, being able to graph, having the information right up there. Being able to manipulate it. I think that would be a great benefit, but I have not been able to achieve it yet.

This had caused some frustration in that Ian had been to inservice training on using the data loggers and had seen other schools using them effectively. Ian commented that unfortunately he was not able to duplicate the experiences back at school due to the equipment being so complicated. Ian also commented that as a newly-appointed teacher he did not have enough time to practise using the data loggers.

Students had limited use and success in using data loggers. When asked about the advantages of using data loggers over conventional equipment, only one student identified that data loggers were more accurate. This was in contrast to students at other schools who had been interviewed or surveyed.

6.5.4 Benefits of using conventional equipment
Students’ views on the data loggers were very negative. The advantage to them of using conventional equipment was that they could get a measurement when using the conventional equipment, but not with using the data loggers.

6.5.5 Comparison of using data loggers and conventional equipment
Ian explained that he had success in using the computer to draw graphs for junior years using the computer spreadsheet program Excel™, but not with the data logging software:

They were used to using computers. Not with the data logger. But with putting the information in and to draw a graph.
When asked if the students understood the graphs that appeared on the data logger, it was apparent that apart from the one motion demonstration, Ian’s major use of the data logger was to record the data. He had not used the data loggers to show the collection of data and the drawing of the graph in real time. However, he had achieved this in a chemistry lesson:

> The two types of graphs that I have looked at they have. A couple of years ago, I did the titration graph and that was okay.

When students were asked if they found it better to use the data logger to draw graphs rather than by using conventional equipment it became apparent that they had had little experience with the graphing capabilities of the data logging software.

### 6.5.6 Negatives

Throughout the interview Ian expressed his personal disappointment at not being able to use the data loggers effectively. When asked specifically about the negative side of using the data loggers he pointed out the problems that he had had due to the complexity of the data loggers that the school had purchased and the ineffectiveness of the training that he had received:

> Well the downside. There are really two factors. One is the time factor, and the other is just this school. Like many other schools, we just rushed in and bought what ever was on the market, not realizing what was out there. I have gone to inservices, and even the TILT-plus course this year, and still I don't feel that confident in using it. It's mainly the time and the difficulty in using them.

Ian’s negative experiences with data loggers were echoed by his students. Students cited the difficulty setting-up the data logger and problems with using the analysis and recording software:

> Awkward to set up;
> Hard to use;
> Technical difficulties;
> When you were trying to use it. You would go into different menus.

Ian had already mentioned the complexity of the data logger as a major challenge to its use numerous times during the interview. When asked what he thought was the reason
that stopped other teachers from using the data loggers he commented on the lack of
time that teachers have to get themselves proficient in their use. He also cited the lack
of availability of different probes that could be used to extend the usage of the data
logger to other areas such as biology and chemistry, rather than the majority of probes
being specifically useful for physics experiments:

\[\text{Being able to know how to use it properly, and the number of probes that we have got. The other}
\text{teachers have used it for chemistry and biology, but just in smaller amounts.}\]

6.5.6 Teacher approaches

When asked if there was any difference in the way that the teacher would run the class
when using data loggers the teacher explained that because of the limited number of
data loggers and probes, that he would get one group at a time to use the data logger.
His time would also be taken up with the group using the data logger, rather than the
students being able to operate it by themselves:

\[\text{Because of the small number of probes we have, one group has to be using the data logger while}
\text{the rest of the class to do something else. So it's more classroom management… Because it's new}
\text{technology, it takes them awhile to get used to it.}\]

6.5.7 Use of data loggers with junior school

Despite being more familiar with the data loggers the teacher was reluctant to use them
with his junior classes. Ian was asked if he would use it more in the junior school
(Years 7-10) now that he was starting to understand how to use them:

\[\text{No. Unless we have more probes. No. Unless it's worthwhile. Unless I have one data logger per}
\text{group. I don't see it as being worthwhile.}\]

6.5.8 Student engagement

Ian explained that the use of data loggers increased student engagement.

\[\text{I think they do. Particularly if they've been using them in Year 10. I haven't been using them}
\text{younger. With Year 10, they were very enthusiastic using new equipment.}\]

Ian’s view on using data loggers was different from that of his students. It appeared
that the students were not enthusiastic about using the data loggers. When asked if the
data logger made the lesson more enjoyable the students had negative views of using
the technology. One student adopted a negative tone, replying:
Students were asked if they would prefer to use ticker tape timers or a data logger to complete motion experiments. Two students stated that they would prefer to use ticker tape timers for experiments rather than data loggers as the ticker tape timers meant more hands-on activity.

6.5.9 Relevance
Ian explained that although he could see the relevance of using data loggers, this was not so with his students.

…I can't say the kids have seen it as relevant. Maybe that will change when we can put it straight into the computer. I can see the relevance of it, but I don't think the kids can.

It appeared that he had used data loggers in the classroom because it “was in the syllabus”.

As anticipated by the teacher interview, the students did not see the relevance of the technology. Although some of the students had decided to pursue science-related careers, such as forensic science and working as an electrician, they did not expect to use data loggers again:

Researcher: [Question directed to student who nominated forensic science as a career choice]
Okay. For example, if you are measuring the temperature of a decomposing body. What would you prefer to use. A thermometer or data logger?
Student: Don't know.
Researcher: And as an electrician. [Question directed to student who nominated electrician as a career] What would you prefer to use. A voltmeter or plug into a data logger?
Student: voltmeter.

6.5.10 Summary
The teacher had been faced with many challenges to the use of data loggers, resulting in a negative attitude in his students to the use of the technology.

This case study is an example of ineffective use of data loggers. Factors that hampered the use of the data loggers included:
• the teacher was inexperienced and had received no training in using data loggers during preservice training;
• the teacher was in a school which had been difficult to staff because of problem students, and hence classroom management was a high priority;
• the data logger was difficult to use;
• the lack of success in using the data logger effectively meant that students did not see it as a worthwhile technology;
• the teacher, although participating in inservice training, could not translate the training into effective use;
• with the demands placed on teachers (and in this case an inexperienced teacher) there was little time available to practise using the equipment; and
• there was no-one on staff that could assist or mentor the teacher in using data loggers.

Post comment
Ian has transferred to another school. After borrowing data logger equipment from the researcher, the school has now purchased new and easier-to-use data logging equipment that can be connected to a computer.

6.6 Overall summary/comparison
This chapter has reported on the case studies of four schools that participated in the study. The schools varied according to:
• teacher classroom experience;
• teacher technology experience;
• teacher philosophy to using technology;
• technology access and availability;
• type of data logger;
• socio-economic factors and school environment; and
• student motivation and classroom dynamics.
6.6.1 Experiments performed by the class

Students participated in experimental work in all cases, however the depth of discussion and learning varied considerably. Both AAA High and CCC High students appeared to have a deeper understanding of experimental technique. Observations and discussion with students indicated that the lessons incorporating experiments were structured and had a purpose. Some teachers incorporated predict, observe, explain (POE) techniques in the experimental process. There was also an expectation that the results would be recorded and analysed.

In contrast, the experiments carried out by BBB High appeared to lack preparation by students. For example, in the case of the classroom observation, no student had read the required information from the text prior to the experiment. Although students participated in the experiment there did not seem to be any link or discussion with the content being taught. Further, there was no recording of the experiment results except for a selection of graphs that were collected, but which were impossible to compare in further analysis.

The teacher and students from DDD High indicated that little practical work with data loggers had been accomplished. Discussion with students from DDD High further indicated that they had little knowledge of the use of data loggers.

6.6.2 Benefits of using data loggers

All four teachers revealed that they had knowledge of the benefits of using data loggers in the classroom, as previously mentioned by teachers in this thesis (section 5.2.2). One teacher expressed that he was disappointed he could not get to use the data loggers effectively with his students. Another teacher pointed out that although he was using data loggers with his classes, his use was limited because of the problems he encountered while using them.

It appeared that teacher and student attitudes to using data loggers were closely linked to the success or otherwise that they had in using the data loggers. The school that had purchased data loggers that the teacher was able to master, and hence demonstrate effectively to students, drew the most positive comments regarding the use of data loggers (AAA High).
6.6.3 Benefits of using conventional equipment

Three benefits of using conventional equipment were discussed by teachers and students:

- cost;
- familiarity; and
- reliability.

There was no need to purchase additional equipment as most schools already owned the conventional equipment. The purchase price of the data loggers meant that most schools were limited in the number of data loggers that their faculty could afford to purchase. This meant that some schools decided to purchase cheaper data loggers so that they could purchase more of them. Schools that had purchased cheaper data loggers had found that although they could afford more data loggers, those purchased were difficult for the teachers and students to use.

Students were familiar with the conventional equipment having used it in their junior years of schooling. Teachers were also more familiar with conventional equipment as they had had experience in using the conventional equipment in their own schooling and teacher training. None of the teachers had received training during their initial teacher training on the use of data loggers. One teacher who had participated in the case study had recently undergone retraining to teach physics. This included one day of training on using data loggers, but the teacher was still not able to effectively use the data logger with his students. Another teacher had participated in the TILT Plus Science data logging course, but he was still not comfortable in using data loggers with his classes and did not attribute any increase in skills to attending the course.

The greatest negativity came from students whose teacher had limited success with using data loggers. If the data loggers did not work it was expected that students would not be interested in using them. Two of the teachers, who clearly demonstrated effective use of data loggers, were confident enough through their own experience to trouble-shoot problems. Their ability to do this meant that they could solve the
problems and get their data loggers to produce meaningful results. This in turn appeared to foster student confidence in data loggers as reliable collection instruments.

6.6.4 Comparison between data loggers and conventional equipment

In the schools that had experienced success with using data loggers it appeared that students preferred to use data loggers rather than conventional equipment. However it was clear from students that it was important that they use conventional equipment as it helped them to understand the basic concepts behind the experiments. This meant that they could interpret the graphs provided as part of the experiments using data loggers. The students also suggested that data loggers were more suited to senior classes, as the junior classes required more individual hands-on experiments.

Teachers interviewed expressed that it was still important for students to obtain the basic skills before moving on to using data loggers, not only because of the familiarisation with the conventional equipment, but also because the automation in using the data loggers meant that students did not have to carry out the mathematics and graphing required to manipulate data. One teacher mentioned that the reduced time required to carry out experiments was a major bonus, but this did mean that more capable students were not extended in their mathematical skills.

6.6.5 Negatives

There were many positive comments and attitudes expressed about the use of data loggers, but the negatives were clearly present. It appeared that the greatest negative was brought about by the fear of using new technology and how teachers would be perceived if they used it and it did not work. This fear of the data loggers not working was well founded. All four of the teachers who participated in the case study phase identified that either they or their fellow teachers did not use data loggers due to the frequency of the data loggers not working.

The issue of insufficient or ineffective teacher training was also highlighted. None of the teachers in the case study had undergone training in the use of data loggers as part of their initial teacher training. One teacher had undergone training with the DET but had not been able to translate this training into effective classroom practice. Another
teacher had undergone training as part of a physics re-training course. He also acknowledged that he was still learning as he went. The two teachers who were having success with data loggers identified that it was their experience working with new technology that allowed them to have the confidence to solve problems and to not be afraid that their students would think of them as poor teachers.

Three of the teachers identified that the small numbers of data loggers available was a negative brought about by the large initial cost. One teacher also explained that although his school did have enough data loggers that he was concerned about the possibility of them being broken or stolen.

6.6.6 Student engagement
All teachers participating in the case studies identified that the use of data loggers increased student engagement. This was attributed to the students being able to use up-to-date technology and to obtain real results. Students who had success with using the data loggers agreed with their teachers, however in one of the schools the students were negative towards the use of data loggers, indicating that data loggers did not necessarily increase student engagement.

6.6.7 Student learning
All teachers participating in the case studies stated that they could see that using data loggers could have a positive effect on student learning. However, one teacher felt that his proficiency in the use of data loggers did not allow students to get the full benefit of the technology. During one classroom observation it became obvious that although the students appeared to be actively participating in the collection of data, they did not possess the necessary background knowledge to allow them to interpret the results. The students who had obtained success in the use of data loggers were able to clearly demonstrate a greater level of science literacy in their discussion with the researcher.

6.6.8 Teacher approaches
The two teachers who had demonstrated effective use of the data loggers claimed that they did not do anything differently to the way they normally carried out their lessons. They were both able to give examples of times when they had tried to use data loggers
but had not succeeded. Despite the initial setbacks, they were able to overcome obstacles and have success. One of these teachers was able to achieve success after purchasing new data loggers, the other by continual practice and troubleshooting. Both teachers were experienced, very well organised, and highly respected by their students. Furthermore, both teachers had backgrounds in using new technology.

Both teachers who obtained success had also developed classroom practices that fostered practical work. This included ensuring that students had the necessary knowledge and skills required to analyse data collected, and to be willing to generate different avenues of enquiry with the equipment. This was evident in the way that they would modify their students practical experiences to maintain interest and to discuss with students what they had learned.

The opposite case was highlighted in one lesson observation during which the students had been given the task of reading the textbook prior to the experiment, but it appeared that no student had read the prescribed section. Furthermore, the students did not read the instructions during the practical, instead relying on their teacher for instructions and guidance.

These results support the argument that effective use of ICT in teaching and learning requires a willingness of teachers to significantly develop new forms of activity and pedagogy (Hennessy, Ruthven et al., 2005).

6.6.9 Use of data loggers with junior school
Although all teachers who participated in the case studies claimed to have used the data loggers with junior classes, it appeared that this was only in limited situations. Reasons given for this lack of use included the complexity of the technology and the limited number of data loggers available for use. Junior classes are typically larger in size than senior classes and hence require more data logger equipment to carry out experiments. Also there was a reluctance to have junior students using the expensive equipment in case they broke it.
The next chapter draws together the many themes that have emerged in this and previous chapters and discusses the outcomes of this study and the conclusions derived from these findings.
Chapter Seven: Discussion

7.1 Introduction
This chapter draws together the many themes that have emerged in previous chapters and discusses the outcomes of this study, firstly by presenting a summary of the findings in relation to the research questions. This is followed by conclusions derived from these findings and their implications for practice. The final section discusses potential directions for further research, and the chapter is concluded with a brief summary.

7.2 Summary of findings
This summary was guided by a focus on how teachers support students to make best use of data acquisition technology in secondary school physics.

Research questions
How do teachers use data acquisition and analysis technology to support student learning in secondary physics?

Three research sub-questions were developed:

1. What is the current impact of data loggers in secondary school physics classrooms?
2. What factors influence the ways teachers use data loggers with their classes?
3. What are the implications for integrating data loggers into the physics curriculum?

A mixed-method design combining qualitative and quantitative approaches was used to investigate the implementation and use of data loggers and related data acquisition technology in secondary school physics classes. Investigative strategies included questionnaires, individual interviews, group interviews, class observations, field notes and workshop responses. The use of multiple data collection methods allowed for the triangulation of results. Participants in the study included students, teachers,
curriculum consultants and industry representatives. The relevant phases of the investigation are summarised and the results are presented in detail in chapters four, five and six. The key findings are summarised and discussed in relation to each of the sub-questions as follows.

7.2.1 How do teachers currently use data loggers with their students in physics classrooms?

Current usage rates

The NSW Stage 6 science syllabuses clearly mandate the use of data loggers. Ideally every school should be effectively incorporating the use of data loggers into science classes, but despite teachers identifying the benefits of using data loggers in all parts of the study, the student and teacher surveys indicated that the use of data loggers was infrequent. Therefore many schools are not fulfilling syllabus requirements.

As revealed in Chapter Four there has been a steady increase in the number of teachers using data loggers in their teaching from 34 percent in 2001 to 84 percent in 2003. Despite this apparent increase, the results indicated that generally the use of data loggers was infrequent and limited, with only 48 percent of teachers using more than one sensor or using data analysis software. This trend is consistent with other reports (Tebbutt, 1999) citing little use of ICT in science, even in schools with substantial equipment available for ICT. An external survey carried out during an inservice course on technology in science (NSW Department of Education, 2007) recorded that 50 percent of schools did not use data loggers with their Stage 6 (Years 11 and 12) students.

The student surveys (Chapter Five) revealed that only 70 percent of the Year 12 students reported that their teachers had used data loggers with their class. Almost all of the students who had used data loggers were positive in their comments about them.

Predominantly the data loggers were only used in the senior years of high school. Sixty percent of teachers claimed to only use data loggers with Year 11 and Year 12 classes. Some reasons given for this included the reluctance of teachers to trust junior
classes with the expensive equipment, the low numbers of data loggers available, and the fact that their use was not mandated in the Years 7-10 science syllabus.

The students interviewed suggested that the reason their teachers had not used data loggers with them in their junior years was that there were few data loggers available. As a result, the amount of ‘hands-on’ work that students could participate in was limited as most of the data logging experiences were demonstrated by the teacher. The students also believed that the data loggers and concepts being taught were too complicated for junior students and that as they were seniors they now had the maturity and knowledge base that allowed them to use data loggers. It may be that these comments are a reflection of what their teachers have said to them about why they are now using data loggers.

Discussion with teachers indicated that in some cases the teachers used data loggers to enhance the higher order thinking skills of students, such as performing extra experiments or analysing trends in data made possible because of the ability of the data logger to be quickly modified by students to change the variables being recorded and to take continuous readings. In these cases it was clear that the teachers had achieved success in using the data loggers with students, but most of the data logger use by teachers appeared to address only lower order skills, such as using the data logger to collect single data readings.

The researcher had anticipated the possibility that effective data logger use was more likely to be demonstrated by teachers who had recently completed their teacher training, and hence were more familiar with technology, as compared to older teachers, but this was not the case. The most effective lessons observed were from experienced teachers who had a sound knowledge base of science and science teaching, demonstrated an inquiry model or student-centred approach to instruction and had a good rapport with their students. This supports findings of a study of effective ICT use in English schools, although pertaining to general ICT integration, which identified that most teachers used technology to do what they had always done and that effective teachers were those who already possessed an innovative pedagogic outlook (Hennessy, Ruthven et al., 2005).
Impact of types of data loggers
There are several brands of data logger available and used in schools, ranging significantly in price, functionality and ease of use. They range from data loggers that require a computer or a hand-held graphics calculator to display data, to data loggers that both display the data and have inbuilt analysis software. Most of the data loggers have the capacity to download data to a computer for better graphical display and analysis. There is also a range of data collection speeds, up to 50000 data sets per second. The variety of different data loggers used by schools in NSW resulted in a decrease in the effectiveness of staff training. For example, teachers reported that they would attend data logging training, often to find that the data logger used during training was different to the one at the teacher’s school. To further compound the problem, teachers might have access to teacher notes and student handouts on setting-up data logging experiments but the instructions would be written for a model or type of data logger different to the one they had at school.

Most data loggers include specific data analysis software that is generally easy to use when the data logger is connected to a computer to analyse and manipulate data. Hand-held data loggers that connect to graphics calculators are more difficult to use, being restricted in the control interface, the graphical display and the amount of memory available for the collection and storage of data. There was also a misconception amongst teachers that it was important for data loggers to be able to export data into Microsoft Excel™. This step adds complexity to the data manipulation, but was required to analyse data in the early days of data logging. The current software is more advanced and easier to use. The impact of this misconception meant that teachers were trying to follow complex instructions for the export, import, and analysis of data when a simple and straightforward method was available.

Rationale for using data loggers
Two extremes of approaches to the use of data loggers are one that treats the data logger as a novelty and the other that portrays it as just a requirement that has to be met to fulfil mandatory course requirements.
As the data logger is ‘new technology’ it runs the risk of being used as a novelty or gimmick rather than a piece of serious scientific equipment. This may have been the result of much of the professional development of teachers in the use of data loggers, as most professional development courses concentrated on demonstrations of using the data logger to collect data, rather than on discussion of how to incorporate it into the curriculum. Teachers who had learnt to use data loggers may have been keen to demonstrate their ‘advanced skills’ to their students rather than empowering students to use these devices. An example of a data logger being used as a novelty occurred in one school in this study, in which the head teacher explained that he had the data logger set up in his room for three weeks during which he used it with all of his classes. The use of the data logger did not fit in with the scope and sequence of the science curriculum offered at the school, but rather was a case of ‘let’s use a data logger’. This type of use of the data logger as being an extra, or ‘one off’ appeared to be common in many schools, and was not only a reflection on the poor use of data loggers, but more seriously on the inability of schools to adequately incorporate the use of new technology into the scope and sequence of the curriculum.

At the other extreme, teachers who used the data logger as a requirement explained that they had used the data loggers with senior classes because it was ‘in the syllabus’. This perfunctory use occurred in two of the case studies that reported on the negative attitudes of students to data logging. In these cases the attitudes of the students may be a reflection of the attitude of their teacher to the use of data loggers.

Both of these are approaches, although based on good intentions, are unsatisfactory in that neither focuses on teaching and learning or on the integration of new technology into the classroom. There is a danger that if either of these approaches is used the teacher is not focused on the curriculum and the teaching is not achieving the intended educational outcomes for the students. This is further compounded by many science teachers not having successful experiences in Science from a “technology-dominated” position (Fensham, 1988) but rather a science-determined position. The necessity to focus on pedagogy and student outcomes is supported by a recent Australian study on exceptional outcomes in science education which indicates that although some teaching practices may be used for engagement it is important for teaching tasks to be
linked into the content and requirements of the science syllabus (Panizzon, Barnes & Pegg, 2007).

**Perceived benefits of data loggers**

Teachers using data loggers generally appreciated the benefits of their use, identifying the following as key benefits:

- increased speed of data collection;
- improved accuracy and reliability of data collection;
- ability to visually obtain graphed results;
- improvements in students’ ICT skills;
- completion of mandatory syllabus outcomes;
- integration of technology into the classroom;
- increased student learning and engagement; and
- students given experience in real-life science (investigations involving tools that collect real data).

Almost all of the respondents to the student survey who had used data loggers indicated that the data loggers provided greater assistance in collecting data compared to conventional methods. The students claimed that the benefits included the increase in accuracy, reduction of human error, and the ability to instantly see relationships in graphical form. Students also indicated the advantage of data loggers for collecting data in very short or over extended periods of time. These positive comments suggest that teachers may have discussed the benefits of using data loggers during lessons, and may reflect the positive attitudes of those teachers to using data loggers.

**Impact on student learning**

Of teachers surveyed, only 36 percent claimed that the use of data loggers resulted in increased student understanding. This was reflective of the overall use of data loggers across NSW and included teachers who did not use data loggers.

Teachers participating in interviews were selected on the basis of having used data loggers with their students. Overall, their view was different from the general view of
teachers and they predominantly reported that the use of data loggers had a positive effect on student learning. From this information it appears that when teachers actually use data loggers they are more convinced of the educational benefits for their use. Reasons given for this included the recognition that the data loggers were able to record data previously unobtainable and that students could see trends more easily.

Many of the teachers in this study saw the ability to display data in a graphical form as being a positive use of data loggers, hence having a positive effect on student learning. However, some of the teachers surveyed believed that this diminished the ability of students to draw and interpret graphs, claiming the use of data loggers made students ‘lazy’ because they were not forced to manually plot graphs. This fear of students losing or not obtaining the skills of constructing graphs due to the reliance of computers to do the work for them was not evident in teachers interviewed, with only one teacher mentioning this concern. The remaining teachers interviewed saw the ability of the computer to draw real-time graphs as being beneficial to increasing student skills, although it was a common idea that students needed to be taught the basics of drawing graphs before using analysis software.

Teachers’ attitudes
Teachers’ attitudes to using data loggers were influenced by a variety of factors including confidence in using the data loggers, training, and unreliability of the equipment.

Many of the teachers in this study identified teacher confidence in using data loggers as the major issue affecting the implementation of data loggers effectively in the classroom. Most teachers had not been trained in their use during their preservice teacher training or since starting teaching. Many teachers model their teaching on what they perceived as effective teaching when they were students. They remember being shown how to use and operate conventional equipment, such as the bunsen burner, during their schooling, but have not had the same experience with data loggers. As a result they may lack models of effective teaching with data loggers to inform their own practice.
Teachers may also lack confidence because of the unpredictability of the equipment to work effectively. The teachers in this study claimed that the equipment would often fail, or that they would not have the skills to set-up the equipment correctly and would not be able to rectify problems they encountered. Teachers also claimed there was insufficient time to set up the equipment. This may be as a result of timetabling and classroom allocation in secondary schools where teachers may not be allocated a home laboratory in which they can leave equipment set up prior to class.

Practicalities also affected teachers’ attitudes. Necessary organisational issues enforced by the school, such as the booking of equipment and computers, can unintentionally restrict class activities and make the task of getting the data logger out and using it harder. For example, data logging equipment is usually stored in a secure location, such as a locked storeroom. Access to the storeroom is normally controlled by the head teacher and the laboratory assistant. Teachers may be reluctant to ask for the data logger, knowing that it is in pristine condition (having hardly been used) and not wishing to be the teacher that ‘messes things up’. Furthermore, the restriction of not being able to have the equipment set up continually in a laboratory means that teachers using the data logger are forced to assemble and pack it up each lesson.

After overcoming all the obstacles involved in arranging to use the data logger, teachers also have to face the problem of access to computers that have the relevant software loaded. In all of the schools visited during the study it was apparent that teachers had to physically move computers into the lab in order to use the data logger. In one school the apparent lack of computers available to the science faculty was made obvious by the teacher having to take his class to the staffroom in order to download data. At the time of writing this, some schools were in the process of putting single computers into science labs so that data loggers and appropriate technology could be more easily accessed by teachers and students. This is required in schools that have purchased the data logging equipment, but have not invested in the infrastructure required to effectively use the equipment.

Data loggers were seen by the participants in this study as predominantly tools for physics teachers to use. As a result many schools had limited the types of probes they
had purchased to those relevant to the physics curriculum. The physics teachers in this study were generally comfortable using the data logging technology, as many had studied computing and mathematics in their original science degrees, making them more familiar with advanced scientific equipment. This situation further promoted the idea that the data loggers were for physics use only. However it is equally valid to use data loggers in other branches of science, for example chemistry, biology and environmental science. The idea that data loggers were solely for the use of physics classes has been compounded by many distributors of data loggers selling the data logger as a kit with probes suited to teaching physics. Additional sensors such as CO₂, pH or humidity probes were often offered at an additional cost and hence not purchased. Professional development activities mirrored this perception by focusing predominantly on the use of data loggers in the physics domain.

It was anticipated by the researcher that older physics teachers might have encountered greater problems in using the data loggers as they did not have experience with recent technology in their teacher training. However, the teacher interviews and case studies indicated the opposite. It appeared that the teachers who exhibited best practice in using the data loggers had not undergone any formal training in using data loggers or computers in their preservice training, however they were very experienced teachers who had spent considerable time to ensure that they could use the technology. They were also confident enough in their teaching to ensure that if they did make a mistake with a class they would not feel uncomfortable with students.

Some teachers felt very strongly about the roles of the Board of Studies (BOS) and the Department of Education (DET) in mandating the use of data loggers. (Note although the DET was criticised, this shows teachers’ unfamiliarity with the ways that syllabuses are written and implemented. The DET does not control the syllabus and hence did not mandate the use of data loggers, however the DET is responsible for the implementation of the syllabus in government schools). They complained that both the DET and BOS had added to their work load but had provided limited support.
Some teachers revealed that they only used data loggers because it was mandated in the syllabus. Their use was limited to adhering to the ‘dot points’ and mandatory experiences so that they could ‘tick’ that they had completed that prescribed outcome.

**Students’ attitudes**

Some teachers considered that students were motivated to use the data loggers because they were a ‘gimmick’. However the majority of students identified a preference for using data loggers over conventional equipment because of the effectiveness of obtaining data. In explaining their preference for either data loggers or conventional equipment, many students said that in some cases the conventional measuring equipment was more appropriate depending upon the task. This may demonstrate that students understand the appropriate use of technology and scientific apparatus in measurement, in that they realise that data loggers have a particular place and purpose in collecting data.

The majority of students indicated that they enjoyed science experiments more when they used data loggers. Reasons for this include that they obtained greater satisfaction through having more precise and accurate measurements, and more immediate results and that data loggers enabled them to be more independent of the teacher. Comments from students included that the data loggers were easier to use, more accurate, provided easy-to-read results and were fun to use.

During the interviews it was apparent that in cases when the teacher was unable to effectively demonstrate the data loggers the students presented negative attitudes to the use of data loggers and did not perceive any benefits. Students in this situation indicated that the data loggers rarely worked or were too complicated to use.

The teacher’s attitude played a significant role in the students’ attitudes to using data loggers. It appeared that students had a positive attitude to the use of data loggers if their teacher did. Students said that they enjoyed doing experiments because the equipment was working and they were getting satisfaction from collecting ‘good’ results, whereas students had negative attitudes when a teacher was not confident in using data loggers or did not use data loggers.
Classroom management and the management of student conduct are skills that teachers acquire and perfect over time, and that require teachers to have an understanding of the psychological and developmental levels of their students. Teachers proficient in classroom management generally are able to maximise the amount of time spent on teaching and engaging students in learning activities rather than spending the time correcting student behaviour. It appeared that teachers who were moderately familiar with the equipment were just as successful in the use of data loggers as long as they were efficient in their classroom management. Visually this can be represented by figure 7.1.

![Figure 7.1: Visual representation of teacher data logging](image)

Figure 7.1 provides an approximate representation of the predictors for effective data logger use. It appears that teachers who have a functional familiarity with the equipment and have effective classroom management skills are more successful in using data loggers with classes than those who may have a high functional familiarity with the equipment, but lesser classroom management skills. It appears that the highest predictor for the effective teacher is one who first of all has good classroom management and has the ability to operate the equipment to a functional level. However, there are other components that are important and add to this competency that are discussed further in the following sections.
7.2.2 What factors influence teachers’ use of data loggers?

Some teachers expressed negative attitudes about the use of data loggers. Their points of view included comments about the lack of teacher training, a decrease in the ability of students to draw graphs, lack of equipment, and problems trying to get equipment to work. Comments were also made concerning the difficulty of using data loggers due to the changes that had to be made in classroom management and the extra time required to set-up the equipment. The nature of these influences are explored in greater depth in the following sections.

**New technology and complexity**

Responses to the survey indicated that some teachers were not familiar with what a data logger could do. In some cases it was clear that teachers had only used one to record temperature. This demonstrated a low level of knowledge about the scope available in using data loggers. The limited use of data loggers may reflect the time and effort required to use them with classes. The preparation time needed was seen as high and the educational benefits uncertain due to the type of equipment available. Teachers need to see a greater benefit to themselves and their students in using data loggers, rather than seeing it as just using new technology.

Another factor influencing teachers was the complexity of some of the brands of data loggers and the lack of support from curriculum consultants. The NSW Department of Education had assessed various brands of data loggers and had developed a list of data loggers that it suggested schools purchase. These data loggers would be supported with professional training to aid in the implementation into schools. However, this advice was ignored by the Department of Education’s main supply branch, resulting in many schools purchasing data loggers that were too difficult for school use or not supported by the science curriculum consultants. Concerns were raised by many teachers that they were experiencing difficulty in using the type or brand of data logger that their school had purchased.
Syllabus issues
The inclusion of the mandatory use of data loggers into the science syllabus was clearly the driving force behind its implementation. NSW government secondary schools were provided with a grant to purchase resources to assist with the implementation of the new syllabus. Most schools used the majority of these funds to purchase data loggers, however some schools also used the money to purchase textbooks.

Teacher confidence
The teacher surveys indicated that although there had been an increase in the proportion of teachers using data loggers there were still a significant number of teachers not confident in their use (see section 4.1). The lack of confidence had resulted in teachers either not using data loggers or infrequently using them.

One stumbling block faced by some teachers was the fear of ‘looking stupid’ in front of the class. All teachers interviewed recalled times when they had tried to use data loggers with students and the data logger had not worked. Those teachers that had success with using data loggers with students were able to relate their success to either changing the type of data logger that they used or to their tenacity to solve the problem.

The teachers’ fear of appearing ‘incompetent’ in front of classes was well founded. There was a large variation in confidence levels of teachers reported by students.

Professional development and teacher training
The low level of teacher confidence was compounded by what was reported by participants as insufficient professional development. Many teachers in this study expressed disappointment at the quantity and quality of professional development, claiming that they had learnt how to use the data loggers primarily through their own perseverance.

Some teachers recounted that although they had participated in ‘one off’ professional development activities they were not sufficiently confident in using the data loggers in
front of students because they had forgotten the skills in the interim, or had not had a chance to practice their use.

When professional development training was available it was often using a different brand or type of data logger than the one at the teacher’s school. Teachers would participate in training, but as the data loggers being demonstrated were different to the ones that they had at school, they could not transfer the training to their own situation. Furthermore, as there was little use of the data logger back at school, any skills developed during training sessions were soon forgotten. As a result teachers had to re-learn how to set up and use the data loggers.

Attempts were made at various levels to increase the skills of teachers, however this was problematic given the amount of variation in the types of data loggers available in schools. One attempt was made at state level by the NSW DET Curriculum Unit to develop a DVD that provided video demonstrations of various data loggers and data logging experiments. Every DET secondary school was provided with a copy of the DVD, however in discussions between the researcher and science head teachers over two districts it was apparent that no teacher had viewed the DVD. Three possible reasons for this situation were mentioned by teachers. Firstly, the DVD was not publicised, secondly, it was not made available to staff and thirdly, the staff did not see the relevance of viewing it in isolation.

Variable levels of support and training were provided by the companies supplying the data loggers. In some cases teachers reported that they had to make telephone calls to overseas destinations for solutions to problems of equipment failure. Some schools found that the software provided with the data logger would not run on new operating systems or that the data logger required a serial port connection that was not available on most new laptop computers.

Teachers identified that in most cases it was through their own perseverance that now they were able to use data loggers. Regardless of their initial computer literacy, a substantial investment of personal time was required to obtain proficiency and confidence. Some funding was made available at district level for schools to
participate in data logging training, but this funding was limited and resulted in the training of only a small number of teachers.

**TILT training**

The DET had provided training to teachers through the introduction of a specific TILT (Technology in Teaching and Learning) course for data logging. The TILT facilitators interviewed as part of this study noted, however, that teachers did not obtain the outcomes they had anticipated. One facilitator claimed that in one course no-one had successfully completed the course outcomes. The reason for the low success rate was attributed to the problems teachers had experienced in getting the data loggers to work, and the heavy workload at school because they were not provided with any relief from their normal teaching duties.

**DET Consultants**

At the start of this research study the DET employed 20 curriculum consultants to facilitate the implementation of the new science syllabuses into Years 7-12. Each consultant was responsible for two districts. Some consultants were able to assist with training in the use of data loggers, however most of the consultants were not proficient at using data loggers and had in most cases lacked experience in using them in the classroom. Some consultants had tried to facilitate networks of teachers using data loggers, even to the extent of having different networks for different brands of data loggers, however these appeared to be not well attended by teachers and eventually were disbanded when the consultancy period ended.

**Teacher experience (community of practice)**

Many of the teachers interviewed claimed that they were the only teacher at their school who was currently using the data loggers with their classes. This meant that they had few problems in booking the equipment for use. However, they were also seen as the ‘expert’ and hence were required to help other teachers with setting-up the equipment.

Hennessy and colleagues (Hennessy, Ruthven et al., 2005) refer to the requirement of a ‘community of practice’ or the establishment of a social framework within schools in
which the planning, support and evaluation of student learning takes place in order for changes to pedagogy to be effectively integrated. This was not evident among teachers who had undergone training in the use of data loggers. They reported that when they had a problem, they had no other teacher at their school with whom they could confer to get support, so they had to seek out colleagues from other schools or solve it themselves.

As the only teacher in the school proficient in using the data loggers, there were extra demands on their time to assist and train other teachers, without receiving any relief. So for teachers, perceived at the school level as ‘experts’ in using data loggers, it was often a burden to be better at using the equipment.

The isolation of being the only teacher in a school proficient in using the data loggers also meant that there was limited professional dialogue with other teachers about the data logger use. This meant that for these teachers there were few opportunities to advance their practice through contact with other skilled individuals, as no formal follow-up meetings occurred.

The limited number of teachers in schools proficient in using data loggers also meant that the use of data loggers did not appear in most faculty teaching programs for Years 7-10, and hence there was little requirement to use them.

**Workload and time**

Many teachers saw the time required to set-up and learn how to use the data loggers as an increase on their already-heavy workloads. Interviews with teachers (see Chapter Five) indicated that a substantial amount of time was required to ‘get up to speed’ with the use of the data loggers. Negative impacts on teacher approaches were also recorded in the area of teacher workload, with many teachers indicating that the extra work and time required to use the data loggers impacted on class instruction time and preparation time. This made these teachers reluctant to use data loggers frequently in class or even to use them at all.
**Equipment and classroom management issues**

The limited number of data loggers available for classroom use was repeatedly mentioned by teachers. Some teachers also claimed that due to the limited number of data loggers available to them (sometimes only one per school) they had to structure the class activity differently from normal practical lessons so that all students could rotate through the activity. This resulted in what would normally have been a short practical being extended to occupy multiple teaching lessons. Teachers explained that although students using the data loggers were engaged and benefiting from the task, the remainder of the class would be occupied by work that would need to be continued without direct teacher instruction, such as personal research or studying from a text book. This is supported by findings of a recent survey of science teachers in which 81 percent of recipients reported that between 10-15 data loggers were required in order to conduct successful lessons (NSW Department of Education, 2007).

Teachers also claimed that because of the problems they encountered trying to get the technology to work, they had to prepare additional lessons in case the data logger lesson could not be run. This added further to their workload.

Approximately 30 percent of the students responded that their teacher ‘used data loggers in the classroom differently than other methods’. Differences included the need to calibrate the equipment, the increase in care required with the equipment, and the time required to set-up.

However, nothing was mentioned about how the teacher taught and students of the teachers who claimed to be confident in using data loggers noted that there was little change to their teaching strategies in that the method was typically direct instruction and demonstration during which students were required to collect data and complete the practical.

Some students did raise the issue that the limited number of data loggers available was a problem, which meant that there was effectively less time for hands-on activity in practicals using data loggers.
A majority of teachers complained that they had limited access to new technology, including the data loggers. This included limited access to computers that they could connect the data loggers to. The change to classroom routine also resulted in teachers having to address issues arising from the reduced supervision of students brought about by having to change locations in order to use computers.

The initial high cost of the data loggers also resulted in many teachers being afraid that students would damage them, and they gave this as a reason they were particularly reluctant to use them with junior classes in which classroom management could be a significant challenge. The loss of this equipment would also create difficulties for senior classes who needed to use them for mandatory practical experiences.

As noted above, some schools had purchased cheaper data loggers not recommended by the DET. These data loggers were less intuitive to use, there were more steps involved (increasing the cognitive load on the user) and lacked company support. This added complexity included having to navigate through numerous menus, limited graphical interface and requiring the user to manually set up the settings for each sensor used. According to the participants in this study, the added complexity of their operation resulted in their infrequent use.

Some schools had implemented a science technology room equipped with computers that were permanently connected to data loggers. Although this seemed to rectify the problem of lack of resources, it created other problems. These technology rooms were frequently rooms previously used as storage rooms and seen as a good location because of their security. They were seen initially as a good strategy, incorporating rooms that were not being used for educational purposes, however due to their small size they could not fit an entire class of 30 students, or for that matter allow students to carry out experiments. Furthermore, funding was not available for outfitting the technology space so science staff were limited in the type and amount of furniture that was available.

In one case a teacher claimed that she could only fit half her class into the data logging lab (an old storage room) and that she would leave the remainder of the class
unsupervised in the playground so that she could supervise students using the data loggers. Students were not given an alternative task as she did not believe the students would complete it unless supervised.

The overall suggestion by teachers concerning data loggers is that teachers would be happy continuing to do what they are comfortable doing and have been doing for many years. The inclusion in the HSC science syllabuses has forced teachers into using data loggers, but their use has been limited. There are numerous examples of teachers who have achieved success with using data loggers, however there are many more teachers who have encountered negative experiences.

The over-riding factor that appears to have lessened the use of data loggers is the reduced confidence that teachers have in their use. This lack of confidence is due itself to many factors such as inadequate teacher training (both inservice and preservice), a lack of an abundance of teachers efficient in using data loggers who could act as mentors, the small number of data loggers available in schools and the operational complexity of some data loggers.

7.2.3 What are the implications for integrating data loggers into the science curriculum?
Data loggers have been available for use in secondary science teaching for the past two decades, however in the early days few schools owned or used them. Any use was mainly limited to teachers who were very experienced in computer technology. It was not until the use of data loggers was mandated in HSC science courses by the NSW Board of Studies in 2002 that every school was required to purchase them. The Board of Studies is responsible for setting the core curriculum by developing syllabuses for Kindergarten to Year 12 and supplies support materials for teachers and parents. The DET is responsible for implementing and maintaining the curriculum specified by the Board of Studies.

Most teachers in this study agreed with the inclusion of data loggers in the curriculum and could see the benefits of using them, however their implementation posed many problems that still persist. Many teachers found the prospect of using data loggers in
their teaching to be too difficult for various reasons, discussed in section 7.2.2 and hence gave up.

The major barriers to the implementation found during this study included:

- teacher training and confidence;
- the complexity of the model and type of data logger purchased;
- the lack of support from supply companies;
- limited amount of teacher training and professional development;
- limited numbers of data loggers available in schools; and
- classroom management issues.

These obstacles have had a significant impact on the implementation of data loggers, however it must be noted that data loggers are now in schools and are being effectively used by some science teachers. The next step is to get all science teachers to actively engage their students in meaningful science activities using data loggers. Three themes have emerged that need to be addressed: providing adequate resources, teacher professional development, and policy.

**Providing adequate resources**

**Type of data logger and purchasing**

The DET provided a funding grant of $4000 to their secondary schools to purchase equipment such as data loggers to support the implementation of the new science syllabuses. There were a number of ways that schools came to purchase their data loggers and various factors contributed to many schools not purchasing equipment that was suitable for classroom use. The DET developed a process to ensure that teachers and schools were in a position to obtain appropriate advice and guidance on purchasing data loggers. However, some schools purchased data loggers prior to the advice being available and there were no strategies in place to ensure that the funding given to schools was spent in the area for which it was designated. This resulted in many schools purchasing equipment that was not suitable for classroom use. To further compound the problem, the government department that was the major procurer of equipment for DET schools issued a contract with a supplier that was not recommended by the Science Unit. Furthermore, this supplier did not sell the data
loggers that were recommended. Currently many schools have equipment that is obsolete and inappropriate for student and classroom use.

The experience of curriculum consultants at the time lends support to the contention that many schools are unable to use the data loggers they have purchased because of changes to operating systems and changes in external ports, such as the lack of serial ports, on newer computers. Furthermore, a lack of support from suppliers resulted in some of the software purchased for control of the data loggers and data analysis being not supported on Microsoft Windows operating systems developed since Windows 95.

Since the introduction of data loggers much has changed in the related technologies. The initial list of data loggers suggested by the DET is now out of date, with many other models of data logger being available. There are now models that boast faster collection speeds, improved storage and better interfaces. There is also the requirement that data loggers are able to run on recent operating systems such as Windows XP, Macintosh OSX and, more recently, Windows Vista. Most computers purchased for school use no longer have a serial port and rely on USB or Bluetooth for connecting the computer to the data logger.

With the rapid changes in technology, schools are now in the position that they will need to update their technology on an ongoing basis. Data loggers purchased by schools are now approaching their ‘use by’ date, as other technology in schools is changed and updated. Schools were initially given funding to purchase data loggers, but they must be prepared to keep up-to-date, and to do so on a limited budget. When choosing to replace old data loggers with newer models, schools must also determine compatibility with the probes and sensors already purchased.

The DET has in the past appeared reluctant to stipulate the purchase of equipment from one source, due to legal issues arising from the size of the DET and one supplier/company having a monopoly. However, the DET could investigate the processes currently in place in other countries where one brand of data logger is preferred and tied in closely with professional development and technical support.
Alternatively, the DET could use its vast size and buying power to purchase data loggers and provide them to schools as part of the ‘roll out’ of computers to schools.

Regardless of the way that schools are supported in updating their data loggers there must be a focus on ensuring that teachers are well supported in continually upgrading their skills in not just using the data loggers, but also in effective curriculum development and implementation.

**Teacher professional development**
The major theme repeated by teachers throughout this study was the lack of appropriate training, resulting in a flow-on effect in the lack of confidence that teachers had in using data loggers with their students. This in turn influenced the way in which they used data loggers and the attitudes their students had to the use of data loggers. Furthermore, the lack of confidence resulted in data loggers not being used to their full potential as a tool for teaching and learning.

In order to increase teacher confidence there needs to be a balanced approach to professional development. It can be argued that there have been attempts to provide this professional development, however due to the significant numbers of teachers needing to update their skills, and the problems with varying equipment from school to school, it has been unsuccessful. Appropriate resourcing, as described in the previous section, may begin to alleviate many problems faced by organisations attempting to fill the void of professional development.

In order to address the issues of teacher professional development we need to elaborate on the programs already in place, preservice teacher education, inservice training and collegial support.

Discussions with teachers in their first year of teaching identified that although the use of ICT was a component of their teacher training, there was an apparent lack of training in the use of data loggers. This shortfall in training in the use of data loggers is blamed upon the dearth of university staff with expertise in their use. It is not proposed that university lecturers need to be replaced with those that have the skill, but
rather that teachers who currently have the skill are enlisted to assist in the program delivery. The new teaching standards (NSW Institute of Teachers, 2007) for preservice teacher training need to be addressed to include data logging and appropriate ICT for those training to be secondary science teachers.

Teacher inservice training has been limited in its success due to the small number of teachers participating and due to the problems associated with the variety and difference of data loggers from school to school. Professional development activities have included State-wide training through the TILT (Technology in Learning and Teaching) program and limited training through professional associations. Attempts to provide all teachers with access to professional development in using data loggers also resulted in the Department of Education producing a DVD demonstrating data logger use. Copies were provided to all government secondary schools, however the researcher found no teacher in this study who had viewed it. This may have been a problem with the distribution of the DVD in schools rather than its actual content.

The study identified that there was a severe shortage of teachers efficient in using data loggers in the classroom. This impacts on the teacher professional development activities that occur within the faculty whereby colleagues share their experiences and learning. This shortage resulted in there being limited discourse and models of best practice. Even when teachers did attend external professional development activities there was little support back at school for using the data loggers, let alone discussions on changing pedagogy appropriate for use with this new technology.

Policy

It is undeniable that the implementation of data loggers has been policy-driven. If not for the inclusion of data logger use in syllabus documents, data loggers would still be the domain of higher education and enthusiasts. Many teachers reported that they only used data loggers because of syllabus requirements and so that their students were not disadvantaged in the HSC exam through not having used one.

Currently, the use of data loggers in the junior school is minimal. Ironically, it is in the junior curriculum that teachers have the most flexibility to incorporate new technology
into the curriculum. An aim of training in the use of data loggers should be towards implementing them in the junior curriculum where there is a greater scope for their use. The use in the junior school would also result in students being familiar with them prior to starting the Stage 6 science courses.

7.3 Suggestions for further research
One area for further research that arises out of this study is an identification of the specific student learning outcomes achieved when teachers incorporate data loggers, ICT and enquiry methods in the science curriculum. This was the original interest of the researcher, however the newness of this technology and obvious lack of teachers using data loggers has meant that very few teachers were initially identified as being proficient in their use. Such a study would determine better models of best practice. To further extend the generalisation of the findings, schools from other states could be involved in the future.

Another interesting area of further research in using data loggers would be to investigate how teachers and students are using available ICT to share and discuss experimental results with other schools or localities via the Internet.

7.4 Conclusions and implications for practice
The implementation of data loggers in New South Wales secondary schools was policy driven by the inclusion of mandatory use of data loggers in science syllabuses as prescribed by the New South Wales Board of Studies. This resulted in all schools purchasing data loggers, but a range of factors has made it difficult for teachers to integrate them effectively. Teachers generally agreed that there are advantages in using data loggers in the classroom, however to date, they have had a slow history of implementation. Postulated reasons for the low level of implementation include:

- low level of teacher confidence in using the technology;
- lack of professional development;
- low level of teacher expertise in school;
- lack of resources;
- variety of equipment available for schools; and
- type of data logger.
Of major concern was the low level of confidence demonstrated by teachers in using data loggers resulting in them giving up. This is despite findings that when data loggers were used well students demonstrated a positive attitude to using them, and saw them as an appropriate and relevant use of technology.

The findings of this study highlight the need to identify an efficient method of resourcing schools with the technology so that all schools have up-to-date technology and so that professional development can be appropriately targeted. Teacher professional development must be available to ensure that all teachers have reached an acceptable level of expertise in using and incorporating new technology. An emphasis must also be placed on not just using the technology, but also on ensuring that pedagogical changes are in line with making the best use of innovative technology.
References

Curriculum Support Unit (1997). Technology in Science Education, NSW Department of School Education.


Ferry, B. (2008). Making science teaching more efficient: Applying cognitive load theory to the teaching of science. ASERA July 4-11Brisbane, University of Wollongong.


Silburn, K. (2003). Liverpool and Campbelltown Science Head Teacher Network Meeting. Liverpool and Campbelltown Science Head Teacher Network Meeting, Ingleburn RSL.


Training and Development Unit, New South Wales Department of Education. (2000). "Technology in Learning and Teaching (TILT)."


Appendix 1: Pilot study student survey

Data Logging

Name _______________________________

1. What experiments have you completed using data loggers?

2. What other measuring instruments have you used to record data?

3. How does the use of data loggers differ from the conventional methods?

4. What is the benefit of using conventional equipment over data loggers?

5. What is the benefit of using data loggers over conventional equipment?

6. From your observations. What is the difference in the way that the teacher uses data loggers in the classroom as compared to conventional methods?
Appendix 2: Results of pilot student survey
A brief summary of responses to the first student questionnaire carried out with the researcher’s own classes is shown below.

1. What experiments have you completed using data loggers? 
   *pH, Bouncing ball, velocity, acceleration, displacement, resonance, rolling trolley, gravity, Newton’s laws.*

2. What other measuring instruments have you used to record data? 
   *Rulers, pH meter, microphone, ticker tape, stop watch, pendulum*

3. How does the use of data loggers differ from the conventional methods? 
   *It electronically compiles your data*
   *Quickier, more diverse*
   *If completed properly, it will have correct results for conventional methods. Data loggers rely on computer speed, transfer rate etc.*
   *It is more accurate than conventional methods*
   *It is faster and graphs results for you instantly*
   *More accurate*
   *Its more accurate*

4. What is the benefit of using conventional equipment over data loggers? 
   *More hands on experience*
   *Straight forward, easier to understand*
   *More interactive (individually)*
   *It is more practical. Less people are involved in the experiments with data loggers. It is easier to understand the experiment.*
   *You learn how to use and interpret data yourself.*
   *More practical. The data logger lets fewer people participate in the experiment.*
   *More hands on. The data logger only lets few people participate. More entertaining.*

5. What is the benefit of using data loggers over conventional equipment? 
   *More accurate*
   *More socially interactive (group)*
   *They are more accurate, but harder to understand because we are not doing a first hand experiment.*
   *It is faster and the results are graphed instantly.*
   *The data logger is more accurate and graphs the results for you.*
   *The data logger is more accurate, technologically advanced.*

6. From your observations. What is the difference in the way that the teacher uses data loggers in the classroom as compared to conventional methods? 
   *More expensive, therefore less units available. Becomes a groovy experiment.*
   *Teachers tend to explain less things when using data loggers in comparison to conventional methods.*
We know what is being tested when using the conventional methods when using the data logger we can not really tell what we are testing. We know what’s going on when we use conventional methods but Sir sets up the experiment and usually only uses it himself. Participation.
Appendix 3: Student survey modification and application

To make the survey manageable in terms of the distribution and collection of questionnaire forms the questions were printed on one A4 sheet of paper, back to back. The length of the questionnaire was also kept to the two pages to ensure that students had enough time to complete the questionnaire before leaving the lecture theatre where they were distributed. A landscape design was used to ensure that there was adequate room for student responses to be written.

An information text box was included on the front of the questionnaire defining what data loggers were. This was in case the student did not know what a data logger was.

Text box
Data loggers are technology that allow measurement probes to be attached to a computer or graphing calculator. Data loggers are more frequently being used in the science laboratory as a measuring tool.

The first five questions were to collect general data such as the subjects being studied, the gender of the respondents and data logger usage. These questions were in the form of check boxes or single numerical answers. Students who had not used data loggers completed the questionnaire at question 5.

1. What science subjects are you currently studying?
   Physics
   Chemistry
   Biology
   Senior Science
   Earth and Environmental studies
This question was added in case there was any apparent trend in the way that data loggers were used between the science subjects.

2. Gender Male Female
This question was added in case there were any trends that appeared as a result of gender.

3. Has your teacher used a data logger with your class?
   Yes
   No
   If yes how many times? _____
This question was added to firstly determine if the student’s teacher had used a data logger with the class.

4. Have you used a data logger in class?
   Yes
   No
   If yes how many times? _____
This question was added to determine if the student had used a data logger (as compared to the previous question which was specific for teacher use)

5. Did you use data loggers in junior school?
   Yes
   No
   If yes how many times? _____

This question was added to determine the amount of usage of the data loggers in the junior school.

The remaining questions required an extended response from respondents. Each question was written into a discreet box to ensure that students were given an appropriate amount of space to record their answer. The difference in the size of the question box also guided the students in the amount of information that was required.

Questions 6–11 were questions from the original questionnaire. The ambiguous use of the term “conventional equipment” was replaced by “other laboratory equipment”.

6. What experiments have you completed using data loggers?

7. What other measuring instruments have you used to record data?

8. How does the use of data loggers differ from other methods?

9. What do you think is the benefit of using other laboratory equipment over data loggers?

10. What do you think is the benefit of using data loggers over other laboratory equipment?

11. Do you think there are any differences in the way that your teacher uses data loggers in the classroom as compared to other laboratory methods?

Question 12 was added to determine how many data loggers were available for the class to use.

12. How many data loggers are available for your class?

Question 13 was added to determine student’s preferred choice of science equipment.

13. If you had a choice would you use data loggers or other laboratory equipment?

Question 14 was added to determine if the use of data loggers had a positive effect on the enjoyment of science classes.

14. Do you think that science experiments are more enjoyable when you have used data loggers?
Data Logging Survey 2004

Thank you for taking the time to complete the survey below.

1. What science subjects are you currently studying?
   Physics ☐
   Chemistry ☐
   Biology ☐
   Senior Science ☐
   Earth and Environmental studies ☐

2. Are you Male ☐  Female ☐

3. Has your teacher used a data logger with your class?
   Yes ☐
   No ☐
   If yes, how many times? _____

4. Have you used a data logger in class?
   Yes ☐
   No ☐ if your answer is "No" there is no need to proceed further. Thank you for your time
   If yes how many times? _____

5. Did you use data loggers in junior school?
   Yes ☐
   No ☐
   If yes, how many times? _____

6. How many data loggers are available for your class? _____

Data loggers are technology that allow measurement probes to be attached to a computer or graphing calculator. Data loggers are more frequently being used in the science laboratory as a measuring tool.

Please write your responses to the following questions.

7. Describe what experiments you have completed using data loggers?

8. What other measuring instruments have you used to record data?
9. How does the use of data loggers differ from other methods of collecting data?

10. Do you think there is any benefit of using data loggers over other laboratory equipment?

11. Does your teacher uses data loggers in the classroom differently to other laboratory methods?

Thank you for your time and assistance.
Appendix 5: Pilot study teacher survey

Data Logging Questionnaire

I am currently trying to get information on best practice in the use of data loggers in science teaching. Could you please take some time to fill out the questionnaire.

With thanks

Ken Silburn

1. What data logging equipment do you have at your school? Please specify type and numbers.

2. Are you personally confident in using data loggers?

3. Do you use data loggers in the classroom?

4. If yes to the last question. How do you use them?

5a. How many staff are in your faculty?
   b. How many of your staff are proficient in using data loggers?

6. How many of your staff use data loggers in the classroom?
7. Has the use of data loggers changed the way that you teach?

8. Please indicate the levels of use of data loggers in the science curriculum of your school.
   Year 7  
   Year 8  
   Year 9  
   Year 10 
   2 Unit Physics 
   2 Unit Biology 
   2 Unit Chemistry 
   2 Unit Earth and Environmental Science 
   2 Unit Senior Science 

9. Are your students proficient in using data loggers?

10. What inservice training has your staff participated in regarding data loggers?

11. How do you think the use of data loggers has affected the way that students learn?

12. How does the use of data loggers differ from conventional methods?

13. What benefit do you see of using data loggers in the classroom?

14. Do you think that the use of data loggers has increased student understanding? In what ways
Appendix 6: Elaboration of pilot teacher survey

The initial teacher questionnaire consisted of fourteen questions printed on two sides A4. The questionnaire also included a brief introduction to the reason for the survey. Question 1 was designed to find out what data logging equipment was available for teachers to use. Teachers were asked to specify the type and number of data loggers available. This secondary information was included in the question to judge if the teacher had frequent use of the data logger and hence would remember its brand name.

1. What data logging equipment do you have at your school? Please specify type and numbers.

The literature review identified teacher confidence was identified as a major blocker in the implementation of new technology into the classroom. Question 2 was designed to find out the proportion of teachers that were confident or not confident in the use of data loggers.

2. Are you personally confident in using data loggers?

Question 3 was designed to find out the proportion of teachers actually using data loggers in the classroom.

3. Do you use data loggers in the classroom?

Question 4 was an extension of the previous question. Teachers were prompted to expand on their answer. Not just that they use them, but as to how they use them.

4. If yes to the last question. How do you use them?

Question 5 was designed to investigate if there was an adequate level of teachers at the respondents’ school who were proficient in the use of data loggers and could therefore give support at the school level for teachers in the use of data loggers.

5. What proportion of the staff in your faculty are proficient in using data loggers?

Question 6, in combination with question 5 responses, was designed to investigate the proportion of teachers who were using data loggers in the classroom, but were not proficient.

6. What proportion of your staff use data loggers in the classroom?

Question 7 was designed to investigate if the implementation of data loggers had affected the way teachers taught.

7. Has the use of data loggers changed the way you teach?
Question 8 was designed to investigate the overall use of data loggers and to determine if it was used across the school or predominantly in the senior school. It was designed as a “tick the box” response.

8. Please indicate the levels of use of data loggers in the science curriculum of your school.
   Year 7  
   Year 8  
   Year 9  
   Year 10 
   2 Unit Physics   
   2 Unit Biology   
   2 Unit Chemistry  
   2 Unit Earth and Environmental Science  
   2 Unit Senior Science 

Question 9 was designed to investigate the level of student use to gauge if students were using the data loggers or if they were only used for teacher demonstration. A high level of student proficiency would indicate that students were using the data loggers more than once.

9. Are your students proficient in using data loggers?

Question 10 was designed to investigate what training had been given to teachers. In conjunction with questions 2 and 3 it was designed to see if there was any correlation between teacher training and confidence / data logger use.

10. What inservice training has your staff participated in regarding data loggers?

Question 11 was designed as an open question to investigate if the use of data loggers had changed the way that students learn. Responses to this question may also have indicated a change in the way that teachers teach. (The incorrect use of the verb “effected” was pointed out by some teachers. This was corrected in subsequent questionnaires.)

11. How do you think the use of data loggers has affected the way that students learn?

Questions 12 and 13 were designed to investigate reasons for the use of data loggers and teacher attitude to the use of data loggers compared to conventional equipment.

12. How does the use of data loggers differ from conventional methods?

13. What benefit do you see of using data loggers in the classroom?

Question 14 was designed to investigate if the use of data loggers had affected student learning.

14. Do you think that the use of data loggers has increased student understanding?
Appendix 7: Modified teacher survey

1.1 What data logging equipment do you have at your school? Please specify numbers.

Fourier . MultiLog Numbers ____
Pasco Numbers ____
Vernier LabPro Numbers ____
Texas Instruments Numbers ____
Data Harvest Numbers ____
Other (Please specify) _________ Numbers ____

The purpose of this question was to identify the type of data loggers in use. This information, although not part of the original questions of the study, was collected to analyse any correlation between the type of data logger and the teacher success in using data loggers in the classroom. Initial surveys indicated that the type of data logger might influence the teacher’s and student’s use of the equipment and subsequent learning.

The brands of data loggers that appeared on the questionnaire were included after consultation with the District Head Teacher Science Network.

1.2 a. How many science teachers are in your faculty? _______

b. How many of your staff are proficient in using data loggers? _______

1.3 How many of your staff use data loggers in the classroom? _______

Questions 1.2 and 1.3 were designed to find the proportion of teachers proficient in schools and the proportion using data loggers.

Teachers were asked to judge the confidence level of teachers in their faculty as being confident or not confident.

1.4 Please indicate the levels of use of data loggers in the science curriculum of your school.

Year 7
Year 8
Year 9
Year 10
2 Unit Physics
2 Unit Biology
2 Unit Chemistry
2 Unit Earth and Environmental Science
2 Unit Senior Science
This question was designed to determine the use data loggers across the science curriculum.

2.1.a Do you know how to use a data logger?  
   Yes  No

b Are you personally confident in using data loggers?  
   Yes  No

Question 2.1 is similar to question 1.2 and 1.3, though it specifies the respondent.

2.2 What inservice training have you participated in regarding data loggers?

2.3.a Do you use data loggers in the classroom?  
   Yes  No

The remainder of the questionnaire was completed only by teachers who were using data loggers in the classroom. The open nature of these questions allowed for more in-depth responses.

This was the first open-ended question. Referring to “How do you use data loggers in the classroom?”

Responses to this question were coded as high, medium, and low level usage.

How has the use of data loggers changed the way you teach?

This open-ended question was coded as to whether the use of data loggers had resulted in a change of teaching (this included changes in the amount of time preparing for lessons, the interest level of classes, and the interpretation and collection of data.)

3.1 In general, are your students proficient in using data loggers?  
   Yes  No

How do you think the use of data loggers has affected the way students learn?

3.3 Do you think the use of data loggers has increased student understanding?  
   Yes  No

In what ways?

4.1 and 4.2 How does your use of data loggers differ from conventional methods?  
What benefits do you see in using data loggers in the classroom?
Appendix 8: Teacher survey
I am currently trying to get information on best practice in the use of data loggers in science teaching. Could you please take some time to fill out the questionnaire.

With thanks

Ken Silburn

1.1 What data logging equipment do you have at your school? Please specify numbers.
- Fourier . MultiLog Numbers ____
- Pasco Numbers ____
- Vernier LabPro Numbers ____
- Texas Instruments Numbers ____
- Data Harvest Numbers ____
- Other (Please specify) __________ Numbers ____

1.2 a. How many science teachers are in your faculty? _______
   b. How many of your staff are proficient in using data loggers? _______

1.3 How many of your staff use data loggers in the classroom? _______

1.4 Please indicate the levels of use of data loggers in the science curriculum of your school.
   a. Year 7
   b. Year 8
   c. Year 9
   d. Year 10
   e. 2 Unit Physics
   f. 2 Unit Biology
   g. 2 Unit Chemistry
   h. 2 Unit Earth and Environmental Science
   i. 2 Unit Senior Science
2.1a Do you know how to use a data logger?  
[ ] Yes  [ ] No

b Are you personally confident in using data loggers?  
[ ] Yes  [ ] No

2.2 What inservice training have you participated in regarding data loggers?
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________

2.3a Do you use data loggers in the classroom?  
[ ] Yes  [ ] No

If no, that is the end of the survey. Thank you for your time.

b If yes. How do you use them?
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________

2.4 How has the use of data loggers changed the way you teach?
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________

3.1 In general, are your students proficient in using data loggers?  
[ ] Yes  [ ] No
3.2 How do you think the use of data loggers has affected the way that students learn?

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________

3.3 Do you think that the use of data loggers has increased student understanding?

Yes ☐  No ☐  ☐

In what ways?

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________

4.1 How does your use of data loggers differ from conventional methods?

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________

4.2 What benefit do you see of using data loggers in the classroom?

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
Appendix 9: Teacher interview questions

The following questions were used as a basis for the teacher interviews. Questions were elaborated on where the researcher found it necessary to illicit more information from the subject.

1. What data loggers do you use with your classes?
2. What experiments or activities have you used the data logger for?
3. What classes do you use data loggers with?
4. What do you see as the advantages or benefits of using data loggers?
5. What do you see as the disadvantages of using data loggers?
6. What training have you received in using data loggers?
7. Has it changed the way that you teach?
8. Do you feel it has increased student understanding?
9. How many of the teachers in your faculty use the data loggers?
Appendix 10: Student interview questions
Structured interview

Date _______________________________

1. What experiments have you completed using data loggers?

2. What other measuring instruments have you used to record data?

3. How does the use of data loggers differ from the conventional methods?

4. What is the benefit of using conventional equipment over data loggers?

5. What is the benefit of using data loggers over conventional equipment?

6. From your observations. What is the difference in the way that the teacher uses data loggers in the classroom as compared to conventional methods?
Appendix 11: Business interview questions
The following questions were used as a basis for the interviews with business representatives. Questions were elaborated on where the researcher found it necessary to illicit more information from the subject.

1. What do you see as the advantage of data loggers for science teachers?
2. There has been a varied response to schools in using data loggers. What are the ingredients that you feel schools need to ensure success?
3. What do you see are the problems that schools and teachers have faced in using data loggers?
4. What suggestion would you make to schools about to purchase data loggers?
Appendix 12: Observation protocol

Before the observation
Thank the teacher for continuing their participation in the project.
Confirm that the lesson observation timing is appropriate and not intrusive.
Confirm where to sit in the room.
Confirm with teacher how he/she will introduce the observer and reason for observing.

Conduct an informal pre-observation interview.
Questions to ask include:
Type / level of class.
Topic being studied
Number of students
Type of data loggers
How the data loggers are used
Frequency and type of use of data loggers

During the observation
Record running notes on key lesson changes/situations and time
Questions to be answered by the observation

Is there evidence of classroom routines for completing practical work?
Are students attentive to instructions?
Is the lesson designed to be teacher or student-centred?
Is the lesson engaging (are students interested)?
Is the teacher comfortable with using the technology?
Are students comfortable with using the technology?
How much time is used in setting-up the equipment?
Are a majority of the class on task?
Do a majority of the class participate in using the technology?
How does the teacher interact with students?
Does the use of the technology add to the lesson?
Is there reference to previous use of the data logger?
Is there reference to previous practical work?
Is the practical activity at pace with the sequence of study?
Do students understand the concept being delivered?
Does the use of the data logger enhance the learning of students?
What processes/techniques did the teacher use to assist students to generate their understanding?

After the observation
Thank the teacher for allowing the observation.
Highlight positive notes from the observation.
Request information or clarification for any observation.
Appendix 13: DET ethics request

Dr Susan M Rebano  
Strategic Research Directorate  
GPO Box 33  
Level 6 Education Building  
35 Bridge Street  
Sydney NSW  
Tuesday, July 1, 2003

RE: SERAP 02.230

Dr Rebano

Please find attached copies of relevant documents required for the study Teacher support of student learning with data loggers.

   i. Research proposal  
   ii. Principal information sheet  
   iii. Principal consent form  
   iv. Student information sheet  
   v. Student consent form  
   vi. Parent information sheet  
   vii. Parent consent form  
   viii. Teacher information sheet  
   ix. Teacher consent form  
   x. Ethics application, Wollongong University  
   xi. Final approval letter, Human Research Ethics Committee, University of Wollongong

Please do not hesitate to contact me for further information on telephone 02 4633 2744 (w), 02 4872 1782 (h) or email ken.silburn@det.nsw.edu.au.

My home address for correspondence is

Ken Silburn  
48 Bong Bong Rd  
MITTAGONG  2575

Yours sincerely

Ken Silburn  
District Science Consultant 7-12  
Campbelltown and Liverpool Districts
Appendix 14: DET ethics approval

Mr Ken Silburn
48 Bong Bong Road
MITTAGONG NSW 2575

Dear Mr Silburn

SERAP Number: 02.230

I refer to your application to conduct a research project in NSW government schools entitled Teacher Support of student learning with data loggers. I am pleased to inform you that your application has been approved. You may now contact the Principals of the nominated schools to seek their participation.

This approval will remain valid until 14/10/2004.

You should include a copy of this letter with the documents you send to schools. I draw your attention to the following requirements for all researchers in NSW government schools:

- School Principals have the right to withdraw the school from the study at any time. The approval of the Principal for the specific method of gathering information for the school must also be sought.
- The privacy of the school and the students is to be protected.
- The participation of teachers and students must be voluntary and must be at the school’s convenience.
- Any proposal to publish the outcomes of the study should be discussed with the Research Approvals Officer before publication proceeds.

When your study is completed please forward your report marked to Strategic Research Directorate, Department of Education and Training, Level 6, 35 Bridge Street, Sydney, NSW 2000.

Yours sincerely

Dr Paul Brock
Director of Strategic Research
16 October 2003
26 June 2003
Mr K Silburn
48 Bong Bong Rd
MITTAGONG 2575

Dear Mr Silburn,

I am pleased to advise that the following Human Research Ethics application has been finally approved. As a condition of approval, the Human Research Ethics Committee requires that researchers immediately report anything which might warrant review of ethical approval of the protocol, including: serious or unexpected adverse effects on participants, proposed changes to the protocol, unforeseen events that might affect continued ethical acceptability of the project and discontinuation of the research project before the expected date of completion.

Ethics Number: HE03/090
Project Title: Teacher support of student learning with data loggers
Name of Researchers: Mr K Silburn:
Final Approval Date: 25 June 2003
Date for Renewal: 24 June 2004

This certificate relates to the research protocol submitted in your original application and includes all approved amendments to date.

Please note that research projects of long duration must be reviewed annually by the Committee and it will be necessary for you to apply for renewal of this application if this project is to continue beyond one year.

Yours Sincerely,

Assoc. Prof. Sue Dodds
Chairperson
Human Research Ethics Committee

cc: Dr B. Ferry, Supervisor, Faculty of Education
Re: Data logging investigation

Dear «Name1»

I am currently undertaking a study across both Campbelltown and Liverpool Districts, focusing on how secondary science teachers support students to make best use of data loggers in the science classroom and the development of descriptions of best practice in the use of data loggers.

Science Head Teachers were informed of the study at the last Network meeting.

It is envisaged that the study will cause as little disruption to the school as possible.

As I am intending to use some of the information collected as part of a doctoral study I need to ensure that consent is obtained at all levels of the study.

I have included an information package and a reply fax for consent.

Please give me a call if you require any more information on 46332744.

I hope that this will meet with your approval and thank you again for your ongoing support.

Yours sincerely

Ken Silburn
Science Curriculum Consultant
Liverpool and Campbelltown Districts
The Principal

Re: Data logging investigation

Recent changes to the NSW HSC Stage 6 Science syllabi have resulted in a shift towards the use of data acquisition and analysis technology in the science laboratory. This is equipment that can be attached to a computer to record and save scientific data. Students in science classes use data loggers to analyse data collected in various experiments.

I am currently undertaking a study focusing on how secondary science teachers support students to make best use of data loggers in the science classroom. This study will also develop descriptions of best practice in the use of data loggers in secondary science teaching.

Information will be collected by class observation, surveys and interviews with students, and surveys and interviews with teachers. The purpose of this information is to understand how students learn with data loggers in science classes. I am asking for your permission to conduct this research as outlined above. An information sheet will be provided outlining the nature and conduct of the research and any other factors that might reasonably be expected to influence the students’ willingness to participate, including information relating to procedures for storing, accessing and disposal of data.

Potential participants will also be informed that their participation is voluntary, and any decision not to participate would in no way prejudice their academic standing or relationship with the school. They are free to withdraw at any time.

The research has been reviewed by the NSW Department of Education, Employment and Training and the Human Research Ethics Committee of the University of Wollongong.

The school, staff and students’ names will not be recorded in any publications.

I have attached copies of the information that I will be giving to students, parents and teachers, and the proposed questions for the focus groups.

I hope that this will meet with your approval and thank you again for your ongoing support.

Yours sincerely

Ken Silburn
Science Curriculum Consultant
Liverpool and Campbelltown Districts
Appendix 17: Consent form principal

REPLY FAX

Attention Ken Silburn
Campbelltown District Office
FAX 46332749

Consent form: Principal

Teacher support of student learning with data loggers.

I have been given information about the Teacher support of student learning with data loggers research project and discussed the research project with Ken Silburn, who is conducting this research as part of a Doctor of Education, supervised by Dr Brian Ferry and Dr Sue Bennett in the Faculty of Education at the University of Wollongong.

I understand that the research involves class observation, surveys and interviews with students and teachers. The data collected from my school’s participation will be analysed and published in a thesis, and that the name of the school or other identifying details will not be used.

I understand that the school’s participation in this research is voluntary. The school is free to refuse to participate and I am free to withdraw permission from the research at any time. My refusal to participate or withdrawal of consent will not affect my relationship with the Department of Education or my relationship with the University of Wollongong.

If I have any enquiries about the research, I can contact Ken Silburn on 46332744 or Dr Brian Ferry 42213571 and Dr Sue Bennett on 42215738. If I have any concerns or complaints regarding the way the research is or has been conducted, I can contact the Complaints Officer, Human Research Ethics Committee, Office of Research, University of Wollongong on 42214457 or Dr Susan M Rebano of the NSW DET Strategic Research Directorate on 029561 8822.

By signing below I am indicating my consent for the school to participate in the research entitled Teacher support of student learning with data logger research project, conducted by Ken Silburn as it has been described to me in the information sheet.

Signed

.......................................................... Date

..........................................................

Name (please print)

..........................................................

School

..........................................................
Appendix 18: Information sheet teacher

Teacher support of student learning with data loggers.

Your school has been asked to be part of a study about how teachers help students to use data loggers in secondary physics. This is part of a research project conducted by Ken Silburn, as part of a Doctor of Education with the University of Wollongong.

The project will help us understand how data loggers are best used in the classroom. In order to do this we will observe classes using data loggers, survey students and teachers, and talk to teachers and groups of students about how they use data loggers.

Participation is voluntary. Even if you do decide to participate, you can withdraw your permission at any time. This will not affect your relationship with your school or the University of Wollongong.

The data collected from the project will be analysed and published in a thesis. Your name or other identifying details will not be used. All information collected will be kept for at least five years to conform with the University’s Code of Practice-Research and the Joint NHMRC/AVCC Statement and Guidelines on Research Practice (1997).

Any questions about the research can be made to Ken Silburn on 46332744 or Supervisors Dr Brian Ferry on 42213571 and Dr Sue Bennett on 42215738.

The research has been reviewed by the Human Research Ethics Committee at the University and by the Department of School Education, Employment and Training. Any concerns or complaints about the way the research can be made to the Complaints Officer, Human Research Ethics Committee, Office of Research, University of Wollongong on 42214457 or Dr Susan M Rebano of the NSW DET Strategic Research Directorate on 029561 8822.

Yours sincerely

Ken Silburn
Science Curriculum Consultant
Liverpool and Campbelltown Districts
Appendix 19: Consent form teacher

Teacher support of student learning with data loggers.

I have been given information about the Teacher support of student learning with data loggers research project and discussed the research project with Ken Silburn, who is conducting this research as part of a Doctor of Education, supervised by Dr Brian Ferry and Dr Sue Bennett in the Faculty of Education at the University of Wollongong.

I understand that, if I consent to participate in this project, I may be asked to participate in an interview and classroom observations.

I understand that the data collected from my participation will be analysed and published in a thesis, and that my name or other identifying details will not be used.

I understand that my participation in this research is voluntary. I am free to refuse to participate and I am free to withdraw from the research at any time. My refusal to participate or withdrawal of consent will not affect my relationship with the Department of Education or my relationship with the University of Wollongong.

If I have any enquiries about the research, I can contact Ken Silburn on 46332744 or Dr Brian Ferry 42213571 and Dr Sue Bennett on 42215738. If I have any concerns or complaints regarding the way the research is or has been conducted, I can contact the Complaints Officer, Human Research Ethics Committee, Office of Research, University of Wollongong on 42214457 or Dr Susan M Rebano of the NSW DET Strategic Research Directorate on 029561 8822.

By signing below I am indicating my consent to participate in the research entitled Teacher support of student learning with data logger research project, conducted by Ken Silburn as it has been described to me in the information sheet.

Signed
.........................................................................

Date
....../...../......

Name (please print)
...................................................
Appendix 20: Information sheet student

Teacher support of student learning with data loggers.

Your school has been asked to be part of a study about how teachers help students to use data loggers in secondary physics. This is part of a research project conducted by Ken Silburn, as part of a Doctor of Education with the University of Wollongong.

The project will help us understand how data loggers are best used in the classroom. In order to do this we will observe classes using data loggers, survey students and teachers, and talk to teachers and groups of students about how they use data loggers.

Participation is voluntary. Even if you do decide to participate, you can withdraw your permission at any time. This will not affect your relationship with your school or the University of Wollongong.

The data collected from the project will be analysed and published in a thesis. Your name or other identifying details will not be used. All information collected will be kept for at least five years to conform with the University’s Code of Practice- Research and the Joint NHMRC/AVCC Statement and Guidelines on Research Practice (1997).

Any questions about the research can be made to Ken Silburn on 46332744 or Supervisors Dr Brian Ferry on 42213571 and Dr Sue Bennett on 42215738.

The research has been reviewed by the Human Research Ethics Committee at the University and by the Department of School Education, Employment and Training. Any concerns or complaints about the way the research can be made to the Complaints Officer, Human Research Ethics Committee, Office of Research, University of Wollongong on 42214457 or Dr Susan M Rebano of the NSW DET Strategic Research Directorate on 029561 8822.

Yours sincerely

Ken Silburn
Science Curriculum Consultant
Liverpool and Campbelltown Districts
Appendix 21: Consent form student

Teacher support of student learning with data loggers.

I have been given information about the Teacher support of student learning with data loggers research project by Ken Silburn. Ken is conducting this research as part of a Doctor of Education, supervised by Dr Brian Ferry and Dr Sue Bennett in the Faculty of Education at the University of Wollongong.

I understand that, if I agree to be a part of this project, that I will be asked to complete a survey, participate in a focus group interview with other students, and be observed in class.

I understand that the data collected from participation in the project will be used, analysed and published in a thesis, and that my name or other identifying details will not be used.

I understand that my participation in this research is voluntary. I am free to refuse to participate and free to withdraw from the research at any time. My refusal to participate or withdrawal of consent will not affect my relationship with the Department of Education or relationship with the University of Wollongong.

If I have any enquiries about the research, I can contact Ken Silburn on 46332744 or Dr Brian Ferry on 42213571 and Dr Sue Bennett on 42215738. If I have any concerns or complaints regarding the way the research is or has been conducted, I can contact the Complaints Officer, Human Research Ethics Committee, Office of Research, University of Wollongong on 42214457 or Dr Susan M Rebano of the NSW DET Strategic Research Directorate on 029561 8822.

By signing below I am indicating my consent to participate in the research entitled Teacher support of student learning with data loggers research project, conducted by Ken Silburn as it has been described to me in the information sheet.

Signed

....................................................................... ...../...../......

Name (please print)

.......................................................................

For students under the age of eighteen parent or guardian consent is also required.

Signed

....................................................................... ...../...../......

Name: Parent/Guardian (please print)

.......................................................................
Appendix 22: Information sheet parent

Teacher support of student learning with data loggers.

Your son/daughter's school has been approached to participate in a study focusing on how teachers support students to make best use of data loggers and analysis technology in secondary physics to enhance the understanding of concepts.

Data Loggers are devices that can be attached to a computer or calculator to record and analyse real-world measurements over a period of time. Equipped with the right type of sensor, data loggers can measure almost any kind of physical quantity. Sensors currently found in schools include temperature, force, motion, light intensity, sound, pH, and voltage.

The project will develop descriptions of best practice in the use of data loggers in secondary science teaching. It will also identify different approaches taken by teachers and the purpose of these approaches.

This research involves classroom observations, surveys and interviews with students and teachers. Classroom observations will note how students use data loggers. Surveys and interviews will ask students about their use of data loggers. Examples of questions that will be asked include "How do you generate understanding through the use of data loggers? How do you use graphs to explain experimental results?"

The Teacher support of student learning with data loggers research project is conducted by Ken Silburn, as part of a Doctor of Education, supervised by Dr Brian Ferry and Dr Sue Bennett in the Faculty of Education at the University of Wollongong.

If I consent to allow my son/daughter to participate in this project, he/she will be observed in class, respond to surveys and participate in focus group interviews.

Data collected from participation in the project will be used, analysed and published in a thesis, and my son/daughter’s name or other identifying details will not be used. All primary data will be retained for a period of at least five years to conform with the University's Code of Practice-Research and the Joint NHMRC/AVCC Statement and Guidelines on Research Practice (1997).

Your son/daughter’s participation in this research is voluntary. He/she is free to refuse to participate and is free to withdraw from the research at any time. Your son/daughter’s refusal to participate or withdrawal of consent will not affect his/her relationship with the Department of Education or relationship with the University of Wollongong.

If you have any enquiries about the research, please contact Ken Silburn on 46332744 or Dr Brian Ferry on 42213571 and Dr Sue Bennett on 42215738. If you have any concerns or complaints regarding the way the research is or has been conducted, please contact the Complaints Officer, Human Research Ethics Committee, Office of Research, University of Wollongong on 42214457 or Dr Susan M Rebano of the NSW DET Strategic Research Directorate on 029561 8822.

Yours sincerely

Ken Silburn
Science Curriculum Consultant
Liverpool and Campbelltown Districts
Appendix 23: Information sheet Marker (surveys)

Teacher support of student learning with data loggers.

Recent changes to the NSW HSC Stage 6 Science syllabi have resulted in a shift towards the use of data acquisition and analysis technology in the science laboratory. In the past, high technology as a resource was found primarily at university level, however the significant reduction in the cost has made it a legitimate tool in schools.

In 2000, State Secondary schools were given a tied grant of $4000 specifically for purchasing equipment and resources required for teaching the science courses as described in the New HSC. Most science faculties invested this money in the purchase of data logging equipment. As a result most schools have access to data logging equipment, however a survey of 130 teachers showed little use of the data loggers in the classroom. Teachers claim that this was due to inexperience, lack of confidence of staff in the technology, and the limited amount of time available for training.

The Teacher support of student learning with data loggers research study will focus on how teachers support students to make best use of data acquisition and analysis technology in secondary physics to enhance the understanding of concepts. The research will be conducted by Ken Silburn, as part of a Doctor of Education, supervised by Dr Brian Ferry and Dr Sue Bennett in the Faculty of Education at the University of Wollongong.

The project will develop descriptions of best practice in the use of data loggers in secondary science teaching. It will also identify different approaches taken by teachers and the purpose of these approaches. This research involves classroom observations, surveys and interviews with students and teachers.

Within the context of this study the following are working questions:

- How do students generate understanding through the use of data loggers?
- How do students use graphs to explain experimental results?
- What examples exist of best practice in the use of data loggers in physics education?
- What tools and processes are needed to assist students to effectively use data loggers to generate their own knowledge?
- What additional support material is needed to show that understanding has occurred?

If you consent to participate in this project, you may be asked to complete a survey.

Data collected from your participation will be analysed and published in a thesis, and names or other identifying details will not be used. All primary data will be retained for a period of at least five years to conform with the University’s Code of Practice-Research and the Joint NHMRC/AVCC Statement and Guidelines on Research Practice (1997).

Your participation in this research is voluntary. You are free to refuse to participate and you are free to withdraw from the research at any time. Your refusal to participate or withdrawal of consent will not affect your relationship with the Department of Education or the University of Wollongong.

Any enquiries about the research, should be directed to Ken Silburn on 46332744 or Dr Brian Ferry 42213571 and Dr Sue Bennett on 42215738. Any concerns or complaints regarding the way the research is or has been conducted, can be directed to the Complaints Officer, Human Research Ethics Committee, Office of Research, University of Wollongong on 42214457 or Dr Susan M Rebano of the NSW DET Strategic Research Directorate on 029561 8822.

Yours sincerely

Ken Silburn
Science Curriculum Consultant
Liverpool and Campbelltown Districts

*** Please detach this sheet from the consent form and survey ***