Fanning the Flame: Investigating Guided Inquiry-Based Learning in the Secondary Science Classroom

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Christopher Sandoval declare that this thesis, is submitted in fulfilment of the requirements for the award of Master of Education, Research, in the Faculty of Arts and Social Sciences at the University of Technology Sydney. This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis. This document has not been submitted for qualifications at any other academic institution. This research is supported by the Australian Government Research Training Program.

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Abstract

There is growing concern regarding school students developing increasingly negative attitudes to science during their secondary school experiences and disengaging with senior secondary and tertiary science subjects. The implementation of guided inquiry-based learning (IBL) to deliver science curriculum is believed to be an effective method to increase attitude, engagement and participation in science. In this study, guided IBL is defined as a level of science inquiry in which students investigate scientific questions given to them by teachers, using a procedure of their own design to collect data that they analyse to create their own answers. This study investigated the frequency of use of guided IBL in science classrooms and teacher perceptions about factors that affect the implementation of guided IBL pedagogy in the delivery of the NSW science curriculum. Thirty nine participants volunteered to complete an online survey. The survey consisted of both open and closed questions and data was analysed using descriptive analysis. Findings indicate that guided IBL may currently be used more often than expected with more than half of the participants reporting that they utilise guided IBL at least once per topic per class. Participants indicate that many factors enable guided IBL including teacher professional development, teachers' positive personal beliefs toward guided IBL and available laboratory resources and equipment. And surprisingly, despite the language of inquiry permeating the new NSW science syllabuses for the Australian curriculum, these new syllabuses as well as preparation for external exams are perceived as barriers to guided IBL implementation.

Chapter 1 Introduction

1.1 Fanning the Flame

The title for this thesis has its foundation in the following William Butler Yeats quote "Education is not the filling of a pail but the lighting of a fire" (Goodreads, 2019). Over the last twenty years as a secondary science teacher, science head teacher, school senior executive and science education lecturer, I have developed a keen interest in science inquiry and have seen positive student engagement results when inquiry-based learning is implemented well. I have implemented science inquiry many times and have had the privilege to observe others successfully implement science inquiry in schools. I have likewise observed inquiry implementation attempts that have not quite succeeded and teachers "losing interest" in future implementation attempts. This has led to the consideration of two key questions. How often is inquiry used in school science classrooms? And what factors help enable or hinder science inquiry-based learning in the secondary science classroom?

This thesis begins by discussing the importance of student engagement in science and the current situation regarding engagement in science. The thesis then delves into inquiry-based learning (IBL) and in particular guided IBL as a possible way to increase student engagement and attitude to science. The reported frequency of, and factors affecting, IBL and guided IBL implementation are then discussed in detail.

1.2 The Innovation Nation

Over the last twenty years there have been repeated calls for Australia to strengthen STEM education to underpin the scientific and technological progress essential for a productive modern economy. In 1999 the Prime Minister's Science, Engineering and Innovation Council (PMSEIC) reported that Australia is not capitalising on the strengths of its science and technology innovations and innovators, and that if urgent action is not taken it will have negative consequences for the Australian economy (Goodrum, Hackling & Rennie, 2001). In 2014 the Office of Australia's Chief Scientist released its report *Science, Technology, Engineering and Mathematics: Australia's Future* (2014). The report strongly recommended an "agenda for change" within Australian Education and Training, including strong Science, Technology, Engineering and Mathematics (STEM) education "for all students – encompassing inspirational teaching, inquiry-based learning and critical thinking" (p.20) so that Australia lifts and sustains enrolments for core STEM disciplines at the senior secondary and post- secondary levels ensuring that Australia has a STEM skilled workforce.

In 2015 the Australian Government released the National Innovation and Science Agenda in response to the *Science, Technology, Engineering and Mathematics: Australia's Future* report and seeks to coordinate education, research and industry to improve Australia's "STEM skills pipeline" (Commonwealth of Australia, 2016). Part of the National Innovation and Science Agenda is an attempt to halt the steady enrolment decline in STEM subjects and to provide more educational opportunities for Australian students to get the STEM skills they need for the estimated 75% of jobs in emerging industries and to help develop the skills base needed to support Australia's economy (Commonwealth of Australia, 2016). Practical based science pedagogies such as inquiry-based learning (IBL) is one way that engagement in science can possibly be increased (Anderson, 2002; Jiang & McComas, 2015; National Research Council, 1996; National Research Council, 2000; Oppong-Nuako, Shore, Saunders-Stewart & Gyles, 2015; Tytler, 2007).

1.3 International Science Enrolment Trends

Similar demands for developments in STEM and STEM education have been made throughout the Western world. The European Commission report *Europe needs more scientists* (European Commission, 2004) clearly outlines Europe's economic need for more science and technology trained professionals and predicts a shortage of science professionals in the future. Osborne and Dillon (2008) state that many European nations reported declining numbers of students pursuing science at university. They discuss the European science situation and report that the level of economic advancement of European countries strongly correlates with extent of engagement of students in physical sciences. Moreover, they identified that students are less interested in the pursuit of science studies in more economically advanced countries (Osborne & Dillon, 2008). They also report that the proportion of STEM PhD graduates has dropped in all European countries and therefore there is an undersupply of graduates to build and sustain future economies that will be heavily reliant on science and technology skills (Osborne & Dillon, 2008). It is also interesting to note that whilst they express concern about a local European shortage of science graduates they also state that on a worldwide scale they do not believe there is a shortage of science graduates (Osborne & Dillon, 2008). USA and China are two countries that have not seen a decrease. The USA shows a slight increase in the number of natural sciences, first and doctoral degrees. China has also had a dramatic increase in the number of university natural sciences and engineering degrees, both first and doctoral degrees, between 1985 and 2005 (National Science Foundation, 2008).

The American National Science Foundation (2008) reports that the number of university natural sciences and engineering degrees, both first and doctoral degrees, for Germany and the United Kingdom has shown little to no increase between 1985 and 2005 (National Science Foundation, 2008). This is also the case for South Korea and Japan who also show little to no increase in the number of natural science and Engineering degrees, and therefore a decrease in the proportion of graduates with science degrees compared to other disciplines. Lyons and Quinn (2010) have reported similar decreases in science enrolments in England, Ireland, Scotland, Japan and Korea. They also report decreases in science enrolments in India, New Zealand, Canada and Israel (Lyons & Quinn, 2010).

It is noteworthy that Osborne and Dillon (2008) urge caution in regard to doom saying by science academics arguing "concerns about the future supply of scientists are often stoked by the scientific community who have much to gain from persuading governments to invest in research, development and training in science and technology" (p.14). Nevertheless, Osborne and Dillon (2008) also make the case that national economies and their competitiveness is underpinned by STEM capability and that the countries with the strongest, and most creative, science research and development will have a competitive economic edge over others. Therefore, we again see a need for student engagement in STEM subjects to be enhanced. Therefore the importance of IBL is increased as IBL is one way that student engagement and skills can be increased (Anderson, 2002; Jiang & McComas, 2015; National Research Council, 1996; National Research Council, 2000; Oppong-Nuako et al., 2015; Tytler, 2007).

1.4 Australian Science Enrolment Trends

There is a growing body of evidence concerning Australian student disengagement with school science and of students developing increasingly negative attitudes to science during their secondary school experiences (Ainley, Kos & Nicholas, 2008; Darby, 2005; Hackling, Goodrum & Rennie, 2001; Kennedy, Lyons & Quinn, 2014; Tytler, 2007). Goodrum, Durham and Abbs (2011) prepared a report for the Office of the Chief Scientist on *The Status and Quality of Year 11 and 12 Science in Australian Schools* in an attempt to develop a comprehensive picture of Year 11 and 12 science in Australian schools. They found that the collective number of students studying science in Year 11 and 12 has “dramatically” fallen, based on the data published by Ainley et al. (2008). There has been a gradual but large decline in the proportion of Year 12 students enrolled in physics, chemistry and biology between the years 1976 and 2007 (Ainley et al., 2008). Goodrum et al. (2011) pointed to this evidence showing that in the early nineties, 90% of students in Year 12 studied at least one science course compared to current data showing the figure has dropped to 50% of students in Year 12 studying a science course.

The number of Australian students enrolling in physics and chemistry related university courses between the years 1990 and 2000 decreased (PMSEIC, 2003). Between the years 2000 and 2006 the number of Australian students enrolling in science related university courses remained fairly constant with numbers in physics, chemistry, biology, agriculture and engineering related courses remaining steady, whilst information technology based courses had a drop in enrolments and health related courses had a rise in enrolments (Ainley et al., 2008). It is important to note that this information is for the number of students and not the proportion or percentage of students. Ainley et al. (2008) also reported a strong correlation between studying more than one science subject in Year 12 and enrolling in science-related courses at university.

What could be a cause for this decreased interest in science? Goodrum et al. (2011) found that content heavy curriculum drives science, in Year 11 and 12, to be taught in a traditional way using a transmission mode with "73% of science students indicating that they spend every lesson copying notes from the teacher while 65% never or seldom have a choice in pursuing areas of interest" (p. ii). Due to the declining numbers of students in senior secondary science subjects it has been recommended that attention needs to be directed to recapturing the interest of students in Years 7 to 10 sciences (Goodrum et al., 2011), so that they select senior subject in Years 11 and 12. This interest can be captured by enhancing student positive attitudes to science and one of the ways positive attitude to science can be increased is by utilising IBL (Jiang & McComas, 2015).

1.5 Increasing Student Participation and Engagement in Science

A large consensus within the science education literature supports a need for reform in science education with a focus on enhancing scientific literacy and student engagement in science (Fensham, 2004; Goodrum et al., 2001; Goodrum, 2006; Goodrum, Durham & Abbs, 2011; Hackling et al., 2001; Juuti & Lavonen, 2016; Tytler, 2007).

Student engagement in schools is enhanced by enthusiastic and competent teachers who deliver lessons that are both challenging and fulfilling and deal with issues that are relevant to the needs and interests of the learners (Goodrum et al., 2001). These types of lessons are likely to develop life-long commitment to learning about science (Goodrum et al., 2001). Goodrum et al. (2001) state that "The implemented science curricula, especially at high school level, are laden with content and decontextualized from, and irrelevant to, the lives and experiences of students" (p.145) and many students experience disappointment when they move to high school because of this. This is further echoed by Tytler (2007) who says that we need to rethink the content that is delivered in Australian science classrooms and deliver this content with more varied and open-ended pedagogies, such as inquiry-based learning (IBL) and project-based learning, that elicit high school students' engagement with learning.

There is also increasing international concern about the failure of recent school science curricula to engender interest in science as a career or as a lifelong interest. It is argued that science teaching pedagogy should place emphasis on IBL, especially IBL that investigates personally relevant real life issues that are of social significance therefore highlighting the important role played by science in society (Fensham, 2004; Hackling et al., 2001).

The call for enhanced use of inquiry-based pedagogies in classrooms is a worldwide phenomenon. The European Commission report *Europe needs more scientists* (European Commission, 2004) outlines many policy recommendations including changing the way science is taught in schools by making it more inquiry-oriented and relevant to the everyday experiences of students. The USA National Research Council (NRC; 1996, 2000) released their reports *National science education standards* in 1996 and *Inquiry and the National Science Education Standards: A guide for teaching and learning* in 2000. These reports strongly advocate for the use of IBL in the science classroom as a means of engaging students in science, developing scientific literacy and building the investigative, problem solving, critical and creative mindset that is the cornerstone of 21st Century skills education.

In 2014 the Office of Australia's Chief Scientist released their report *Science, Technology, Engineering and Mathematics: Australia's Future* (2014) which recommended change within Australian education with a strong STEM education for all students that includes quality teaching, IBL and critical thinking. In 2015 the Australian Government released the National Innovation and Science Agenda (Commonwealth of Australia, 2016) that targets the growth of Australian student STEM skills and improved attitude toward science through IBL and enhanced use of digital technologies in "an attempt to halt the steady enrolment decline in STEM subjects" (Commonwealth of Australia, 2016). Part of the Australian Government's response to declining STEM enrolments is the support of the *Science by Doing* program that is led by the Australian Academy of Science (Australian Government Department of Education and Training, 2016). The purpose of *Science by Doing* is to support secondary school teachers in teaching science through IBL by producing curriculum units, teacher professional development modules, interactive online resources and activities for students to increase student engagement in science and improve learning outcomes (Australian Government Department of Education and Training, 2016). With these government programs encouraging the use of IBL to build STEM skills it would therefore be worthwhile to investigate the frequency that teachers utilise IBL in their classroom. Moreover, because of the somewhat nebulous definitions around IBL, this study will focus on the frequency of use of guided IBL. Due to the importance of IBL, discussed in this chapter, to potentially engage students in science, this study will also investigate teacher perceptions of factors that enable the use of guided IBL in the science classroom.

1.6 Introduction to this Study

Utilising IBL in the science classroom is reported to be an effective method to increase attitude, engagement and participation in science. Several studies of inquiry-oriented curriculum programs have found positive results in regards to student achievement, skills acquisition, student problem solving, creativity, cognitive growth and attitude toward science (Anderson, 2002; Blanchard, Southerland, Osborne, Sampson, Annetta & Granger, 2010; Bredderman, 1983; Jiang & McComas, 2015; Wise & Okey, 1983). IBL is discussed in more detail in Chapter 2.

This study focusses on guided IBL, defined as a level of science inquiry in which students investigate scientific questions given to them by a teacher, using a procedure of their own design to collect data that they analyse to create their own answers to the question. This definition of guided IBL follows that set out in the frameworks published by Bell, Smetana and Binns (2005), Bianchi and Bell (2008) and Blanchard et al. (2010). This study focuses on guided IBL for three main reasons that will be further outlined in Chapter 2. In summary; the first reason is the published efficacy of guided IBL to increase student positive attitude toward science (Jiang & McComas, 2015). The second reason is the lack of studies researching the frequency of use of guided IBL. The third reason is the lack of studies investigating the factors that affect the implementation of guided IBL.

The aim of this study was to investigate the frequency of use of *guided* IBL in the science classroom and factors that influence the implementation of *guided* IBL in the NSW science classroom. In particular, this study investigates perceptions of teachers in regard to *guided* IBL and more specifically investigates teachers' perceptions about various factors that affect the use of *guided* IBL pedagogy in the delivery of the NSW science curriculum.

The methodology involved a survey of 39 Australian science educators who teach in the state of New South Wales. The survey consists of open and closed questions. The data was analysed using a descriptive analysis approach to best integrate the closed quantitative responses with the open qualitative responses. The survey attained information on participant tenure, experience, frequency of use of guided IBL and participant perceptions on the various factors that enable, or are barriers to, the use of guided IBL.

Findings indicate that guided IBL is used by more than half of the participants at least once per topic per class. Furthermore, 92% of participants said they use guided IBL at least once a year per class. Participant perceptions indicate that many factors enable guided IBL; including teacher professional development, teachers positive personal beliefs toward guided IBL, sufficient classroom instruction time, planning time, programming time and available laboratory resources and equipment.

Participant perceptions also indicated that the new NSW science syllabuses for the Australian curriculum and preparation for external exams are strong barriers to guided IBL implementation. This is an interesting finding considering the new Science syllabuses have a strong inquiry focus (NSW Education Standards Authority, NESA, 2017). This perception in regard to the new syllabuses being a barrier to guided IBL implementation is also one of the findings that this thesis recommends further investigation into. Further investigation is also recommended into the specific factors perceived to enable guided IBL. This could include a broader investigation of teacher perceptions as one of the limitations of this study was the small number of participants who volunteered.

This thesis provides tools for science educators to utilise when embarking on and evaluating guided IBL implementations including a guided IBL implementation cycle that is informed by this study.

1.7 Structure of this Thesis

This thesis is presented in five chapters. Chapter 1 introduces the topic, rationale and aim of the study. Chapter 2 is a literature review that delves into the research surrounding IBL and the factors that affect the implementation of IBL. Chapter 2 also highlights the lack of research into factors that affect the use of guided IBL and the frequency of use of guided IBL. Chapter 3 presents the methodology and describes the process undertaken for this study. The findings are found in Chapter 4 and details the results of the study. Chapter 5 presents the discussion and conclusion. It synthesises the findings whilst discussing implications, limitations and future directions for this research.

1.8 Summary

This first chapter overviews the importance of science education to the economy and the decreasing engagement of science students. The importance of IBL for increasing student engagement in science was briefly introduced as a prelude to a more in-depth analysis of IBL in the next chapter, the literature review.

Chapter 2 Literature Review

2.1 Introduction

In the first chapter the importance of science to the economy was outlined. It also described the worldwide concern regarding decreasing engagement, participation and retention in science disciplines within secondary and tertiary educational settings as well as the science and technology workforce. Practical based science pedagogies such as inquiry-based learning (IBL) are seen as a way to help educators engage students in science whilst building critical scientific literacy, creativity and problem solving skills (Tytler, 2007). This chapter delves into the definition and practice of IBL. It also reviews the literature surrounding the impact of IBL, the frequency of use of IBL, the types of IBL and most importantly the reported factors that enable or are barriers to the implementation of IBL. This chapter points out the small amount of research that has been conducted into guided IBL, in regard to both its frequency of use as well as the factors that affect its implementation.

2.2 Inquiry-Based Learning (IBL) in Science Education

Inquiry-based education, inquiry-based learning, enquiry based learning, inquiry-oriented science are some of the terms used by a plethora of authors and organisations (Australian Government Department of Education and Training, 2016; Bell, Smetana & Binns, 2005; Bianchi & Bell, 2008; Capps et al., 2016; Carstens & Howell, 2012; Chiapetta, 1997; Commonwealth of Australia, 2016; Crawford, 2007; Furtak,2006; Jiang & McComas, 2015; National Research Council, 1996; National Research Council, 2000, Oppong-Nuako, Shore, Saunders-Stewart & Gyles, 2015) to denote types of relevant hands-on investigative pedagogies that will help students develop knowledge and understanding of scientific ideas, as well as an understanding of the various ways scientists study the natural world and derive explanations based on evidence (NRC, 1996, p. 23). The National Research Council (1996) defines scientific inquiry as:

> a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyse, and interpret data; proposing answers, explanations, and predictions; and communicating the results (p.23).

Inquiry-based learning will look different depending on a variety of factors including but not limited to, the class context, level of scaffolding required by a class, skills that the teacher needs students to develop and student interests (Bianchi & Bell, 2008) but overall IBL in the science classroom has a strong focus on achieving the following. IBL seeks to increase student direction and student interest within relevant contexts. Students raising new and important scientifically oriented questions, then planning and conducting investigations to make observations, collect, analyse and interpret data to answer their questions. It requires students judging evidence and current knowledge, challenging and evaluating the reliability of data, communicating results, formulating explanations, drawing conclusions, constructing knowledge and developing deep understanding. By engaging in IBL students learn about the development of scientific ideas over time based on evidence and defensible conclusions with an overall emphasis on the learning process instead of answers (Abd-El-Khalick et al., 2004; Bell et al., 2005; Bevins & Price,2016; Bianchi & Bell, 2008; Capps et al., 2016; Carstens & Howell, 2012; Chiapetta, 1997; Crawford, 2007; Jiang & McComas, 2015; National

Research Council, 1996; National Research Council, 2000, Oppong-Nuako et al., 2015; Wilcox, Kruse & Clough, 2015)

Considering the amount of information and opinions in the literature in regards to IBL many authors have put forward models to aid educators in defining, understanding and implementing IBL (Bevins & Price, 2016; Bianchi & Bell, 2008; Furtak, 2006; Jiang & McComas, 2015). Whilst these models aid in IBL planning, implementation, communication and evaluation, it is important to emphasise that IBL is not designed to be a mechanical step by step linear process but a more fluid and organic process that suits the context of the school, curriculum, students and teacher (Bevins and Price, 2016).

Importantly, proponents of IBL do not intend it to be the only mode of science teaching and learning in schools. For example the National Research Council (1996) emphasise the use of inquiry but state that they "should not be interpreted as recommending a single approach to science teaching. Teachers should use different strategies to develop the knowledge, understandings, and abilities" (p.23) of their students. This is echoed by Jiang and McComas (2015) who state that "there is a time and place for high-quality didactic instruction just as there are reasons to apply low level and higher levels of inquiry. The key is to know how and when to apply any instructional modality" (p.574).

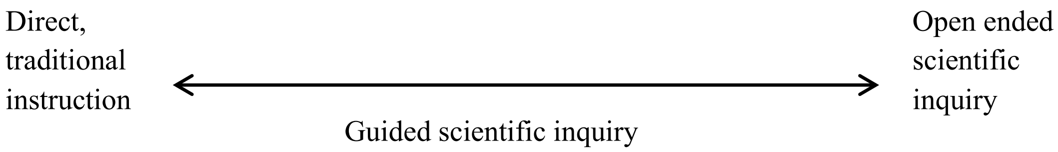
2.3 IBL Models in Science Education

Inquiry-based learning (IBL) should not be seen as an all or nothing approach to science teaching but a series of teaching activities, lessons, activities or programs of learning that ultimately develops within students the skills, knowledge, understanding, values and attitudes that they will need to take part in true open-ended scientific inquiry.

Furtak (2006) describes IBL as a guided scientific inquiry continuum that flows from traditional, direct instruction on one end of the continuum to open-ended scientific inquiry at the other end of the continuum (see Figure 2.1). In this model traditional direct instruction would encompass lecture style or transmission modes of teaching with the teacher as the deliverer of knowledge in contrast to open-ended inquiry where the students design and carry out their own investigations to gather evidence and develop their own ideas (Furtak, 2006).

Figure 2.1

Guided Scientific Inquiry Continuum (Furtak, 2006, p.455)



A four level continuum of inquiry that includes confirmation inquiry, structured inquiry, guided inquiry and open inquiry was illustrated by Bell, Smetana and Binns (2005) and Bianchi and Bell (2008) based on the work of Rezba, Auldridge and Rhea as cited in Bell et al., (2005). The level of inquiry is dependent on the level of teacher direction and student direction in regards to questions, procedures and answers for investigations. In this model, confirmation inquiry involves students following a teacher designed plan to find a known answer to a known question. For structured inquiry students are given a question and a procedure but need to develop their own answer. Guided inquiry investigates a teacher generated question using a student directed procedure to find an unknown answer. In open inquiry students design a procedure to answer a question of their own (Bianchi and Bell, 2008). Table 2.1 illustrates this model of IBL. The emphasis of this model is that students are supported through the levels of inquiry so that they gradually develop the skills needed to undertake open investigation, which is consistent with scaffolding learning in Vygotsky's zone of proximal development (Bianchi & Bell, 2008; Phillip & Taber, 2016).

Blanchard, Southerland, Sampson, Annetta and Granger (2010) detail a framework of inquiry very similar to that of Bell et al (2005). In this framework, Level 0 - verification inquiry involves students following a teacher designed plan to find a known answer to a known question (Table 2.2). This verification inquiry has the same definition as Level 1 confirmation inquiry in the Bell et al. (2005) continuum. For structured inquiry students are given a question and a procedure but need to develop their own answer. Guided inquiry investigates a teacher generated question using a student directed procedure to find an unknown answer. In open inquiry students design a procedure to answer a question of their own. In both the Blanchard et al. (2010) framework and the Bell et al. (2005) continuum we see that structured, guided and open inquiry have the same description.

Jiang and McComas (2015) define five levels of inquiry in their *openness in inquiry teaching* model based on teacher or student involvement or direction in the four inquiry components of their framework. The four components of their framework are conducting activities, drawing conclusions, designing investigations and asking questions (Table 2.3). In Level 1 the student is conducting the activity whilst the teacher draws the conclusions, designs the investigation and sets the question. In Level 4 the student conducts the investigation, draws the conclusions, designs the investigation and asks the question (Jiang & McComas, 2015). The fifth level, called Level 0, in their model indicates completely non-inquiry based teaching.

These models set a framework that teachers can use to communicate, plan and evaluate inquiry based learning programs but, as we will see later in this thesis, the fact that there are multiple models and constructs for IBL means that sometimes teachers can become confused or disoriented by the multiple meanings (Abd-El-Khalick et al., 2004; Abell, 1999; Capps et al., 2016; Crawford, 2007; Furtak, 2006; Ozel & Luft, 2013; Lotter et al., 2007; Wilcox et al., 2015; Windschitl, 2003). When we compare the three frameworks presented by Bell et al (2005), Blanchard et al. (2010) and Jiang and McComas (2015) we see many similarities, but we also see some differences (Table's 2.1, 2.2 and 2.3).

Table 2.1

Modified Version of the Four-Level Model of Inquiry (Bell et al., 2005)

	Description	Question	Method	Solution
Level 1	Confirmation	Teacher	Teacher	Teacher
Level 2	Structured	Teacher	Teacher	S
Level 3	Guided	Teacher	S	S
Level 4	Open	S	S	S

Note. Teacher means that this factor is given to the student by the teacher, S indicates a student created/designed factor, Source: Bell et al., 2005, pp.32-33

Table 2.2

Alternative Version of Levels of Inquiry (Blanchard et al., 2010)

	Description	Question	Method	Solution
Level 0	Verification	Teacher	Teacher	Teacher
Level 1	Structured	Teacher	Teacher	S
Level 2	Guided	Teacher	S	S
Level 3	Open	S	S	S

Note. Teacher means that this factor is given to the student by the teacher, S indicates a student created/designed factor, Source: Blanchard et al., 2010, p.581

Table 2.3

Levels of Openness in Inquiry Teaching (Jiang & McComas, 2015)

	Asking questions	Designing investigations	Drawing conclusions	Conducting activities
Level 0	Teacher	Teacher	Teacher	Teacher
Level 1	Teacher	Teacher	Teacher	S
Level 2	Teacher	Teacher	S	S
Level 3	Teacher	S	S	S
Level 4	S	S	S	S

Note. S, given/conducted by student and Teacher, given/conducted by teacher, Source: Jiang & McComas, 2015, p.559

These three tables show that the models are very similar but key attributes such as a different numbers of levels as well as different labels for these levels introduces inconsistencies that change the classification of these levels within the frameworks. For example the Level 3 described by Bell et al., 2005 is similar to the Level 2 described by Blanchard et al., 2010. Therefore even when we look at clearly defined frameworks for IBL, we see largely unnecessary differences that can confuse or disillusion the teacher or unsuspecting reader.

2.4 The Effect of IBL Implementation in Science Education

Historically, literature surrounding the outcomes or effectiveness of IBL implementation does not provide definitive answers due to various uncertainties. These uncertainties include questions like: What measures are appropriate to gauge positive or negative results? What effective IBL implementation looks like? What level of IBL has been implemented? What definition or model of IBL has been implemented? (Jiang & McComas, 2015). With increasing frequency, studies into the effect of IBL are taking these uncertainties into account (Jiang & McComas, 2015) to give a clearer picture of IBL. The next paragraphs will focus on the effect of IBL on three things: student attitude toward science, student achievement and science inquiry skills acquisition.

Shymansky, Kyle and Alport's study (1983) of inquiry-oriented curriculum programs found positive results in regards to student achievement, skills acquisition and attitude toward science when using inquiry-oriented instruction but the level of inquiry was not clear. A small positive effect size, in regards to student achievement, was also found by Wise and Okey (1983) in their meta-analysis when they looked at classes where teaching techniques involved more student centred inquiry lessons and guided inquiry. Bredderman's (1983) quantitative synthesis of the effects of activity based science programs, inclusive of those that would be considered inquiry based, show a positive effect on student problem solving, creativity and cognitive growth.

Blanchard et al. (2010) investigated the effect of guided IBL compared to traditional verification laboratory instruction. Their sample size included 1700 students and 24 science teachers. They found that students who undertook a guided IBL unit performed better in post-tests and delayed post-tests compared to students who undertook a similar verification laboratory instruction. This performance was based on student responses to questions vetted by a panel of five science teachers who judged the question suitability based on curriculum, student grade and question construction. It is also important to note that Blanchard et al. (2010) state that there is no optimal level of inquiry, and that it is important for the teacher to judge the context of the learning and the content to be taught then apply different levels of inquiry to best meet the needs of their students and scaffold skill development according to those needs.

Jiang and McComas (2015) found that students mainly exposed to Level 2 structured scientific inquiry had the best score for student science achievement in the 2006 PISA. They also found that students exposed to the higher levels of inquiry, Level 3 and 4, which is similar to guided and open inquiry, had the highest scores for student attitude to science (Jiang & McComas, 2015). Jiang and McComas's (2015) analysis of the PISA 2006 data shows a clear correlation between the use of IBL and higher student achievement and positive attitude toward science.

2.5 Factors Influencing the Implementation of IBL in Science Education

If policy makers and curriculum authorities want inquiry based learning to be implemented in classrooms we need to know what factors influence the implementation of IBL and more importantly what factors enable the effective implementation of IBL.

Anderson (2002) discusses dilemmas and barriers to the successful implementation of IBL and lists them in three dimensions the technical, political and cultural. Some of the barriers he lists include limited teacher skills, teacher beliefs and values, commitment to textbooks, student group work skills, inadequate teacher professional development, parental resistance, teacher - teacher conflict, limited teaching resources and views of assessment, especially the need to cover content and prepare students for examinations (Anderson, 2002).

Furtak (2006) discusses in detail the multiple meanings and interpretations of IBL as a factor that inhibits the implementation of IBL by creating difficulties for teachers trying to visualise IBL in classroom practice and then trying to implement the planned inquiry. Furtak (2006) also acknowledges time constraints, inappropriate curriculum and teacher capacity in terms of pedagogical skills and lack of professional development as inhibitors to IBL implementation. Abd-El- Khalick et al. (2004) also state that the lack of a clear meaning and framework for IBL, textbooks lacking an emphasis on inquiry, and high stakes assessment practices, especially in senior high school, that are not aligned to inquiry practices are all inhibitors to IBL implementation. This is echoed by DiBiase and McDonald (2015) who studied the values, attitudes and beliefs toward IBL of 275 North Carolina teachers and found that curriculum demands, class size, accountability and preparation for external exams, instructional time constraints and preparation time constraints impeded the use of inquiry.

Abd-El-Khalick et al. (2004) state that the creation of a well-developed chemistry curriculum and associated resources is enabling inquiry implementation in Israel. The features of this program are a series of inquiry experiments that scaffold students through the levels of inquiry, assessment tools aligned with inquiry approaches, available laboratory resources, teacher programming time and long term intensive professional development and instructional support for teachers. They go further to discuss the overall picture of science education and the outcomes of this education, possibly they argue that IBL should lead to a mindset as well as a skill set in students so that they can question the world before they begin to formulate methods to understand it (Abd-El-Khalick et al., 2004).

Pedretti, Bencze, Hewitt, Romkey and Jivraj (2008) found that prospective secondary science teachers' were positive with respect to their beliefs about science teaching, and their motivation to promote and enhance science education, but were tentative with respect to personal self-efficacy in implementing IBL, particularly early in their careers (Pedretti et al., 2008; Haigh & Anthony, 2012). Ozel and Luft (2013) discuss that this confidence and self-efficacy in beginning teachers implementing IBL could be more important than inquiry based curriculum materials or mentors that advocate inquiry but possibly one may argue that the former is influenced by the latter.

Teachers' personal beliefs about how science should be taught can be a powerful barrier or enabler of IBL implementation and is dependent on many things, particularly preservice teacher education (Lotter, Harwood & Bonner, 2007). Some of the myths surrounding IBL include arguments against IBL stating that it is minimally guided and ineffective form of instruction (Kirschner, Sweller & Clark, 2006). Kirschner et al. (2006) seem to be arguing that student centred and student independent pedagogies such as discovery learning and open inquiry are not as effective as explicit teacher centred instruction. But as we have seen in the section regarding different models of IBL, IBL is not a single unguided form of teaching but a continuum of guidance moving from confirmation and structured inquiry to guided and possibly open inquiry (Bell et al., 2005) in which students move through inquiry learning gradually gaining educational independence as the teacher removes the scaffolding (Hmelo-Silver, Duncan & Chinn, 2007). It could be possibly argued that the IBL framework, confirmation-structured-guided-open, put forward by authors such as Bell et al. (2005) is in fact an explicitly scaffolded way to teach inquiry skills in an inquiry environment and therefore is not in conflict with the ideas of Kirschner et al. (2006).

Teachers need to change their beliefs before they will change their classroom practice, according to Brown and Melear (2006). They stress the importance of creating belief constructs in teachers that are positive toward IBL if they are to implement it in their classrooms. Furthermore, they propose that authentic scientific inquiry research experiences, preferably during their teacher education courses, can strengthen teacher capacity to utilise IBL. Brown and Melear (2006) investigated, through interviews and observations, the link between inquiry-based teacher education courses and the IBL beliefs and practices of 8 secondary science teachers. They found that whilst teachers who had undergone inquiry-based teacher preparation courses before starting their career found the experience valuable, they mainly displayed and reported teacher centred pedagogy when teaching (Brown & Melear, 2006). Some of the reasons given by participants for their use of teacher centred pedagogy included student discipline, disengagement and behaviour management issues, as well as time constraints around lesson planning and programming, large class sizes and concerns about student ability (Brown & Melear, 2006). Both studies concluded that teachers believe IBL is valuable and teacher education inquiry experiences are important and valuable but teachers intend to use teacher centred pedagogy due to perceived barriers to student centred IBL pedagogy (Brown & Melear, 2006; Pedretti et al., 2008).

The importance of teacher beliefs and attitudes has also been reported in other fields of pedagogical change such as the integration of technology into student centred classroom practice. Ertmer, Ottenbreit-Leftwich, Sadik, Sendurer and Sendurer (2012) reported that teachers with a passion for student centred technology classroom pedagogy still enacted student centred pedagogy even in the face of external barriers such as a lack of resources. They also reported that the greatest barrier preventing teachers from utilising technology in a student centred way were teacher beliefs and attitudes toward student centred technology pedagogy.

The encouragement and support of school senior executive can have a large influence on the implementation of unorthodox non-traditional teaching styles such as IBL (Haigh & Anthony, 2012).

Many of the factors influencing the implementation of IBL worldwide have also been found in Australian studies. In 2001 Hackling, Goodrum and Rennie reported on a national review of the status and quality of science teaching in Australian schools (Goodrum et al., 2001; Hackling et al., 2001; Rennie et al., 2001). The review developed an ideal picture of science education and establish what needs to happen in Australian schools to shift from the actual state of science teaching and learning towards this ideal picture. One theme presented within the ideal picture for science education was that the teaching and learning of science is focussed on inquiry. To establish what is happening in Australian schools the researchers conducted focus group meetings and surveys of 296 secondary teachers 2800 students. The research discovered a gap between the ideal picture of science education, which is expected from intended curriculum of various States', and the actual picture of curriculum implementation

(Goodrum et al., 2001). Hackling et al., (2001) found teachers believe that inadequate resources and lab equipment, large class sizes, poor student behaviour, inadequate teacher preparation time, lack of professional development, textbooks with a traditional teaching orientation and inadequate instructional time due to content demands and preparation for exams were all factors that inhibited the implementation of IBL and the quality of secondary science teaching in Australian schools.

In 2006 Denis Goodrum reported on a pilot study called the Collaborative Australian Secondary Science Program (CASSP) that was conducted between 2001 and 2003. The purpose of the study was to determine the effect and effectiveness of collaborative development of student centred inquiry based teaching resources, IBL professional development and implementation of before mentioned resources (Goodrum, 2006). The pilot study involved 120 teachers in 28 schools and resulted in a greater than 50% increase in student centred inquiry based lessons in classrooms. The study highlighted the importance of the development of inquiry based resources for classroom use and the need for intensive and ongoing professional development for teachers in IBL. It also found that inquiry pedagogy was more demanding for the teachers in terms of time and expertise and students who are regarded as high achieving were less comfortable with IBL (Goodrum, 2006). The study also found that limited resources can be a barrier for IBL implementation (Goodrum, 2006). Goodrum (2006) also reported that heads of department have, in most schools, a significant influence over what happens in the school and can have a significant impact on the implementation of IBL in schools.

In 2011, Goodrum, Druhan and Abbs produced the report *The Status and Quality of Year 11 and 12 Science in Australian Schools* for the Office of the Chief Scientist. The report detailed a study that attempted to create a clear picture of senior high school science in Australian schools and utilised data from various sources including focus groups of senior secondary students, secondary science teachers and science education specialists, surveys of 1510 senior students and 99 science teachers as well as a case study of the Australian Science and Mathematics School in Adelaide. Amongst other things the report detailed numerous barriers to IBL in senior years science including content laden senior curriculums, assessment focussed on content and insufficient resources, teacher planning time and instructional time. The report also recommended adequate time for inquiry skill based assessment, decreased senior science content, the development of IBL curriculum resources, sufficient professional development in IBL implementation and adequate resources, planning time and instructional time (Goodrum et al., 2011).

Gillies and Nichols (2015) investigated the perceptions of nine primary school teachers who taught two consecutive science inquiry units to Year 6 students in relation to teaching inquiry science and the benefits and challenges of IBL. The teachers underwent two days of intensive training in IBL for two science inquiry units and then implemented the units in their classrooms. Teachers were interviewed after implementing the inquiry units and discourse analysis was conducted to identify themes in the data. The study found that teachers generally spoke positively about their experience and said that the units captured student interest and allowed for student ownership of their learning. The participants also said that heavy scaffolding and structure was required to assist the students through their inquiries. The teachers in the study also expressed concerns in regard to keeping students on track, the demands of the curriculum, their teaching programs and preparation for assessments (Gillies & Nichols, 2015) which were all related to the time available for IBL. These factors that affect the implementation of IBL, both in Australia and worldwide, have been reported for over three decades and seem to be extant amongst the beliefs of many teachers. Tables 2.4

and 2.5 illustrate the breadth of research and literature on these factors that have a negative or positive affect on the implementation of IBL.

Tables 2.4 and 2.5 are designed to summarise the literature in regard to factors affecting IBL implementation. They are also designed to compare the reported factors that affect IBL implementation. In both Tables 2.4 and 2.5 there is an in built coding system. This system links similar factors that have been reported differently based on them having a positive or negative effect. For example in Table 2.4 the code I. has been ascribed to the factor “sufficient laboratory resources”. In comparison Table 2.5 ascribes the code I. to the factor “lack of laboratory resources”. The purpose of this is to highlight that many of these factors have been reported in contrasting ways due to the relative “lack” or “abundance” of the specific factor. The code X has been used to designate factors in Table 2.5 that do not have a similar factor in Table 2.4.

Table 2.4

Factors from the Literature Linked to a Positive Effect on IBL Implementation

Factor	Author/s
A. Clear definition and model for IBL implementation	Abd-El-Khalick et al., 2004;
B. Intensive or ongoing professional development	Abd-El-Khalick et al., 2004; DiBiase & McDonald, 2015; Gillies & Nichols, 2014; Goodrum et al., 2001; Goodrum et al., 2011; Hofer & Lembens, 2019
C. Authentic inquiry research in teacher education programs	Brown & Melear, 2006
D. Teachers personal beliefs about teaching and science	Abell, 1999; Brown & Melear, 2006; Crawford, 2007; DiBiase & McDonald, 2015; Lotter et al., 2007;
E. Syllabus expectations of Inquiry teaching	Goodrum et al., 2001;
F. Adequate planning time	Abd-El-Khalick et al., 2004; Goodrum et al., 2001; Goodrum et al., 2011;
G. Internal assessment aligned with IBL	Abd-El-Khalick et al., 2004; Goodrum et al., 2001; Goodrum et al., 2011;
H. Teacher capacity building and PD in using internal assessment aligned with IBL	Abd-El-Khalick et al., 2004;
I. Sufficient laboratory resources	Abd-El-Khalick et al., 2004; Goodrum et al., 2001; Goodrum et al., 2011;
J. Provision of textbooks or curriculum resources with an IBL focus	Abd-El-Khalick et al., 2004; Goodrum et al., 2001; Goodrum et al., 2011;
K. Prepared model IBL lessons, experiments or programs	Abd-El-Khalick et al., 2004; DiBiase & McDonald, 2015; Goodrum et al., 2001;
L. Appropriate scaffolding to assist students development of inquiry skills	Bell et al., 2005; Bianchi & Bell, 2008; Gillies & Nichols, 2015; Harris & Rooks, 2010; Philip & Taber, 2016; Wilcox et al., 2015
M. Teacher collaboration	Anderson, 2002; Hofer & Lembens, 2019
N. Support and belief from supervisors, department heads and school administrators	Goodrum, 2006; Haigh & Anthony, 2012

Table 2.5

Factors from the Literature Linked to a Negative Effect on IBL Implementation

Factor	Author/s
A. Teacher and systemic misconception, misunderstanding or multiple understandings of inquiry instruction	Abd-El-Khalick et al., 2004; Abell, 1999; Capps et al., 2016; Crawford, 2007; Furtak, 2006; Ozel & Luft, 2013; Lotter et al., 2007; Wilcox et al., 2015; Windschitl, 2003
B. Lack of teacher training, development, science Pedagogical Content Knowledge (PCK), skills and practice	Anderson, 2002; DiBiase & McDonald, 2015; Furtak, 2006; Goodrum et al., 2001; Hackling et al., 2001 Ozel & Luft, 2013; Windschitl, 2003
X. Teachers lacking confidence in using IBL	Abd-El-Khalick et al., 2004; DiBiase & McDonald, 2015;
D. Teachers personal beliefs about teaching and science	Abell, 1999; Brown & Melear, 2006; Crawford, 2007; DiBiase & McDonald, 2015; Lotter et al., 2007;
D. Teacher belief that IBL is inefficient	Abd-El-Khalick et al., 2004; Lotter et al., 2007; Wilcox et al., 2015
E. Content heavy curriculum/syllabus	Bevens & Price, 2016; DiBiase & McDonald, 2015; Furtak, 2006; Gillies & Nichols, 2014; Goodrum et al., 2011; Hackling et al., 2001; Marbach & McGinnis, 2008.
E. Instructional time constraints	Abd-El-Khalick et al., 2004; Bevens & Price, 2016; DiBiase & McDonald, 2015; Furtak, 2006; Gillies & Nichols, 2014; Goodrum et al., 2011; Hackling et al., 2001
F. Planning time constraints	Abd-El-Khalick et al., 2004; Brown & Melear, 2006; DiBiase & McDonald, 2015; Goodrum et al., 2001; Goodrum et al., 2011; Hackling et al., 2001
G. Internal assessment not aligned with IBL	Abd-El-Khalick et al., 2004; Anderson, 2002; Bevens & Price, 2016; DiBiase & McDonald, 2015; Hackling et al., 2001; Marbach & McGinnis, 2008

X. External assessment not aligned with IBL	Abd-El-Khalick et al., 2004; Anderson, 2002; Bevens & Price, 2016; Hackling et al., 2001; Lotter et al., 2007; Wilcox et al., 2015
X. Preparation for high stakes senior high school external assessment not aligned with IBL	Abd-El-Khalick et al., 2004; Blanchard et al., 2010; DiBiase & McDonald, 2015; Goodrum et al., 2011; Hackling et al., 2001
I. Lack of laboratory resources	Anderson, 2002; Bevens & Price, 2016; Goodrum et al., 2001; Hackling et al., 2001
J. Commitment to non IBL textbooks	Abd-El-Khalick et al., 2004; Anderson, 2002;
J. Lack of textbooks with an IBL focus	Abd-El-Khalick et al., 2004; Hackling et al., 2001;
L. Lack of student prior skills – group work, inquiry skills	Anderson, 2002;
X. Perceived lack of student motivation	Brown & Melear, 2006; Roehrig & Luft, 2004;
L. Perceived lack of student cognitive ability/capacity	Brown & Melear, 2006; Roehrig & Luft, 2004; Wilcox et al., 2015
X. Concerns about behaviour management	Brown & Melear, 2006; Hackling et al., 2001; Haigh & Anthony, 2012; Wilcox et al., 2015
X. Parental resistance and uncertainty of IBL value	Anderson, 2002; Marbach & McGinnis, 2008
X. Parental pressure to teach traditional content based science	Abd-El-Khalick et al., 2004; Marbach & McGinnis, 2008
M. Conflict among teachers/staff in regard to IBL	Anderson, 2002; Haigh & Anthony, 2012; Marbach & McGinnis, 2008

Note: Letter codes in front of factor are used to match similar factors in Table 2.4 and 2.5. The letter X is used to denote a factor without a similar factor in Table 2.4

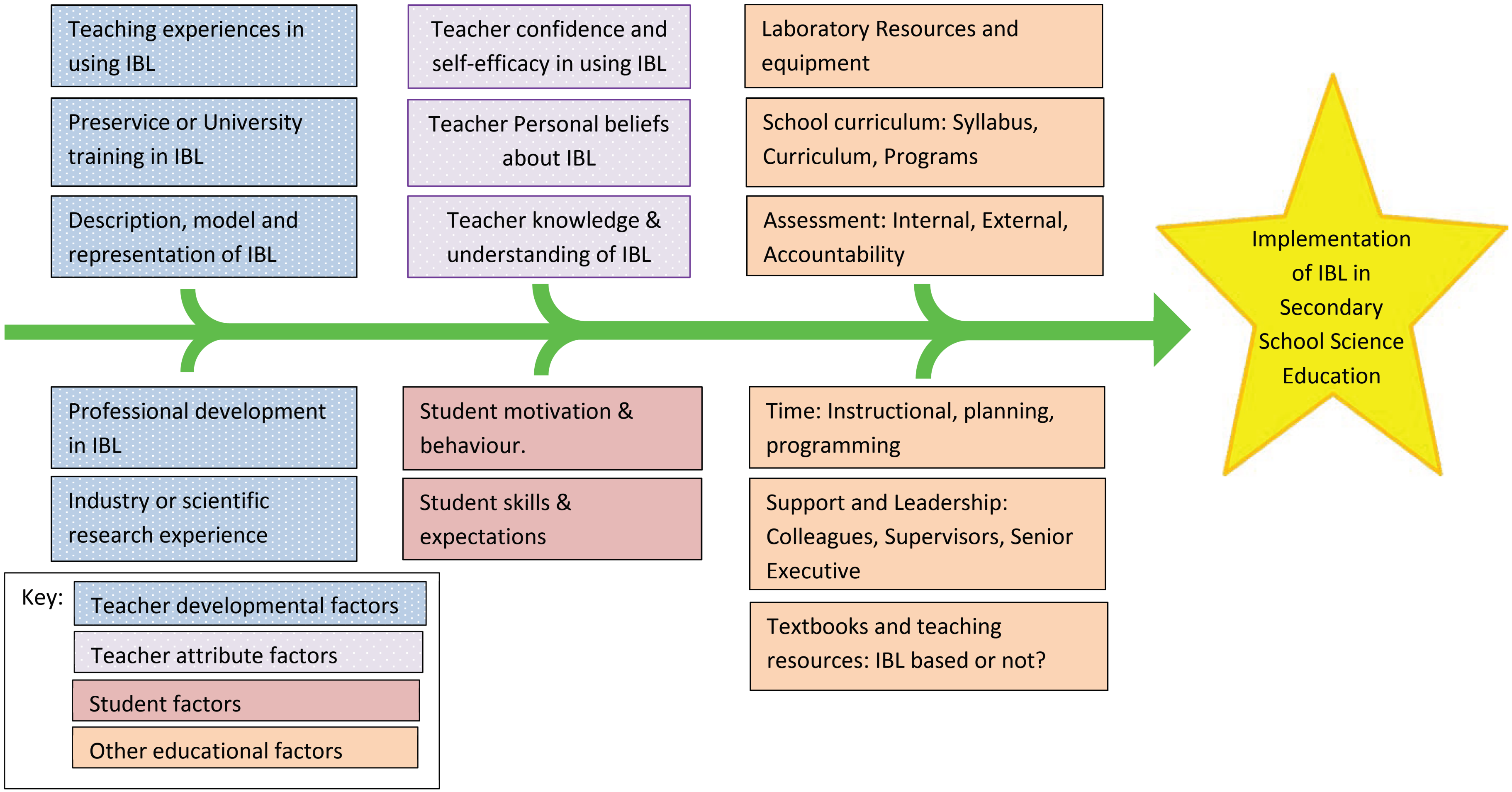
If an attempt could be made to rationalise all the factors influencing the implementation of IBL in the classroom it would look a lot like Richard Duschl's claim in Abd-El-Khalick et al., (2004). The claim that many of the factors influencing IBL implementation might stem from a core duality in science education, the duality between content-based and inquiry-based science education. That pressures on resources (teacher time, instructional time, professional development, curriculum resources, physical lab resources) and pressures from expectations (parent expectations, external examinations, internal assessment, teacher beliefs) stem from this core duality and that these opposing forces, content-based and inquiry-based, are exacerbated by the multiple definitions and expectations from the transformative pedagogies of IBL, discovery learning, project based learning and active learning.

Within the literature there are many factors that are presented as having a positive effect on IBL implementation in classrooms as well as having a negative effect on IBL implementation (Abd-El-Khalick et al., 2004; Abell, 1999; Anderson, 2002; Bell et al., 2005; Bevens & Price, 2016; Bianchi & Bell, 2008; Capps et al., 2016; Crawford, 2007; DiBiase & McDonald, 2015; Furtak, 2006; Hackling et al., 2001; Goodrum, 2006; Haigh & Anthony, 2012; Lotter et al., 2007; Marbach & McGinnis, 2008; Ozel & Luft, 2013; Philip & Taber, 2016; Roehrig & Luft, 2004; Wilcox et al., 2015; Windschitl, 2003). These factors have been listed in Tables 2.4 and 2.5. It seems that each of these factors can have a positive and/or negative effect on IBL implementation depending on the situation. This possible contrast has been highlighted in Tables 2.4 and 2.5 by indicating whether a factor has a negative and positive effect on IBL implementation. Similar factors have been coded in the two tables with the same capital letter to highlight the factors' ability to have both positive or negative affects on IBL implementation. For example, if we look at the definition of IBL instruction as a factor for IBL implementation we can see that an unclear representation, model or description for IBL can be a barrier to the planning and implementation of IBL whereas a clear description and model can be an enabler of IBL implementation (Abd-El-Khalick et al., 2004; Abell, 1999; Capps et al., 2016; Crawford, 2007; Furtak, 2006; Ozel & Luft, 2013; Lotter et al., 2007; Wilcox et al., 2015; Windschitl, 2003). Factors with a positive effect on IBL implementation will be called enablers from now on and factors with a negative effect will be called barriers from now on.

Figure 2.2 has been constructed by this researcher to represent the links between all these factors into a figure that summarises the relationships between factors, teachers and IBL implementation as well as the dual role these factors can play in the successful or unsuccessful implementation of IBL.

Figure 2.2

Summary of Factors from the Literature that Affect Implementation of all Types of IBL Implementation in Secondary School Science.



2.6 Factors Influencing the Implementation of Guided IBL

There are few studies that investigate the specific use of guided IBL and the factors that affect the use of guided IBL. For this purpose guided IBL is defined as a science inquiry or investigation in which the teacher sets the question and the students develop the procedure to gather data and answer the question. Blanchard et al. (2010) discuss the possibility that the professional development of teachers in guided IBL and teacher knowledge and skills of guided IBL might be factors that influence the efficacy of guided IBL instruction. They also discuss the possible impact of standardised tests and highlight the need for carefully constructed assessments that can adequately measure the impact of reform mandated pedagogies such as IBL.

Cheung (2011) specifically investigated teacher beliefs in regard to guided IBL implementation. The beliefs of 200 Hong Kong chemistry teachers was investigated. It was found that the teachers believed there were barriers to guided IBL implementation. These barriers included a lack or shortage of instructional time, the need to prepare for public examinations, safety concerns regarding students designing chemistry investigations, teachers low self confidence in enacting guided IBL, chemistry laboratory manuals that contained detailed procedures and students dislike, or lack of motivation, of creating their own procedures. Cheung (2011) also found that an enabler of guided IBL implementation was hands on professional development in clearly defined guided IBL lab experiments with the participants.

2.7 Frequency of Guided IBL Use

Very few studies investigate the frequency in which teachers use guided IBL. Deters (2005) reported on a study that investigated secondary school chemistry teacher pedagogies. The survey defined inquiry learning as guided inquiry, where teachers decide the question but students design the procedure. 571 teachers from the United States responded to the survey. Of these 571 teachers, 45.5% indicated that they do not use guided IBL in their classrooms. Cheung (2011) surveyed 200 Hong Kong secondary chemistry teachers out of an estimated 1000 secondary chemistry teachers currently teaching in Hong Kong, which is a great sample size. This study found that 74% of secondary chemistry teachers had implemented at least one guided inquiry lab in the preceding nine-month period. The study did not ask participants to quantify use of guided IBL beyond this one question, although the article did recommend that this would be a future area to investigate.

2.8 Gaps in Literature

The analysis of literature in this chapter suggests that research into teachers' current use of guided IBL and perceptions toward guided IBL implementation would produce valuable insights for tertiary institutions, educational researchers, government departments, syllabus developers and education departments as well as providing information in regards to the current systemic, school and personal capacities for teacher implementation of IBL. Furthermore this research is particularly timely with the implementation of new NESA science syllabuses in NSW, including the implementation of depth studies in Stage 6 syllabuses. Therefore this study gauges the impact that the new science syllabuses have had on teacher perceptions surrounding IBL implementation. Have the new syllabuses enabled guided IBL implementation or are they seen as barriers?

There may be a large burden on beginning science teachers to implement the reimagining of science in Australian schools and engage their students (Tytler, 2007).

Studies by Pedretti et al. (2008) found that although prospective secondary science teachers' responses were positive with respect to their beliefs about IBL science teaching, and their motivation to promote and enhance science education, they were tentative with respect to their personal self-efficacy, with many claiming that they would not be teaching with inquiry based approaches in their early years of teaching (Haigh & Anthony, 2012; Pedretti et al., 2008). Furthermore, there is global concern regarding the retention of qualified teachers with, 25-50% of new teachers leaving the profession early in their career (Haigh & Anthony, 2012) and in Australia approximately 25-45% of newly appointed teachers resigning in their first 5 years of teaching (Treagust, Won, Peterson & Wynne, 2015). Major reasons given for the attrition of newly qualified secondary science teachers include general challenges facing new teachers and specific challenges facing science teachers. The specific challenges facing science teachers include difficulties with classroom and time management, and teaching content matter across several science disciplines, as well as requirements for pedagogical strategies for teaching the nature of science and scientific inquiry that their science qualifications may not have prepared them for. Other challenges include maintaining learning environments including securing resources for practical tasks (Haigh & Anthony, 2012). If we can further define and measure these factors that teachers find challenging and a hindrance to implementing IBL then we could improve systems that support our teachers and the implementation of IBL in their classrooms, across schools and across the state.

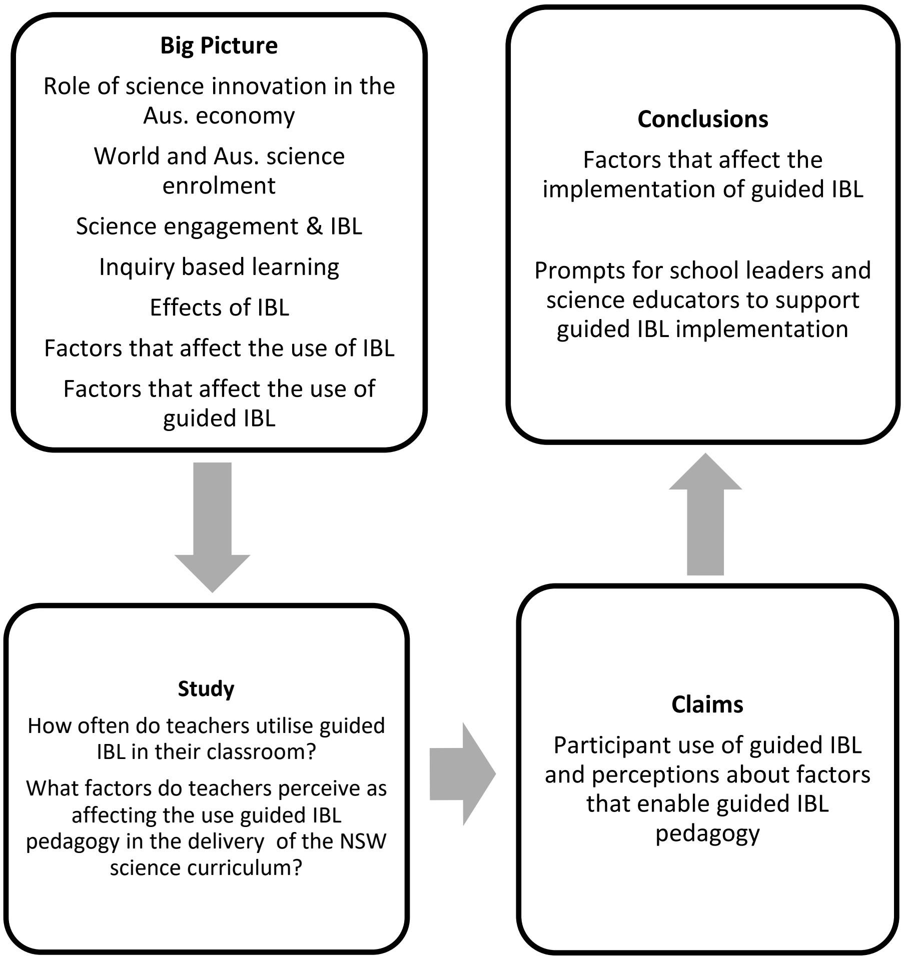
The factors in regard to time, syllabus constraints and assessment that have been reported as inhibitors to IBL implementation seem to contradict the intended curriculum outlined in NSW science syllabuses. Goodrum (2006) aptly outlined the situation in regards to Australian science education with the following statement:

> If one scans the science curriculum statements of the Australian States and Territories, one will find a consistent theme of inquiry and inquiry pedagogy pervading these documents. With the rhetoric of these policy documents and our sense of science education history, one would expect to see inquiry as an integral part of our secondary science classrooms. Unfortunately, this is not the case. Many secondary students are taught science that is perceived by them to be neither relevant nor engaging. Furthermore, traditional didactic teaching methods that offer little challenge, excitement or opportunities for engagement are common. There is a considerable gap between the intended curriculum as described in the various curriculum documents and the actual curriculum experienced by students. (p. 31)

This gap, between intended and actual curriculum, is valuable to investigate. To see if teachers still think assessment, syllabus constraints and curriculum are an impediment to IBL implementation or the enabler they are intended to be especially in the current climate of new NSW science syllabuses for the Australian Curriculum. Both the Australian Curriculum and the new NESA NSW Science syllabuses for the Australian curriculum have clear and explicit expectations of IBL use in delivery of the syllabus in the form of science inquiry skills, science as a human endeavour, values and attitudes that should underpin the development of knowledge and understanding of science (Board of Studies NSW, 2012).

Figure 2.3

Summary of Study



This study, summarised in Figure 2.3, is designed to inform ITE programs in tertiary institutions. It also aims to assist with what has been dubbed the "Re-imagining" of science education in Australian schools (Tytler, 2007), informing the implementation of IBL pedagogy by early career teachers (Goodrum et al., 2001) and informing the further implementation of IBL being called for by the Australian Government to improve science engagement and participation (Commonwealth of Australia, 2016). The focus on enabling factors could also help guide school heads of department, who have a very influential role in schools (Goodrum, 2006), and school senior executive to assist with school planning, resource allocation and professional development that best empowers teachers to utilise guided IBL.

2.9 Summary

This chapter details the literature surrounding IBL. In particular it has defined IBL and guided IBL, outlined the factors that affect the implementation of IBL and discussed the effects of IBL. The chapter discussed the frequency of use of guided IBL and the factors that affect the implementation of guided IBL highlighting the shortage of studies that specifically delve into teacher perception about guided IBL implementation. This chapter leads into the methodology in Chapter 3.

Chapter 3 Methodology

3.1 Introduction

This chapter will outline the methodology used in this study. It will look at the study design, the survey instrument, recruitment, participant demographics, data analysis and the overall process and procedure.

This study focused on science teacher perceptions surrounding guided IBL implementation and the factors that affect the implementation of guided IBL in the classroom. The aim and guiding research questions are: How often do teachers utilise guided IBL in their classroom? What factors do teachers perceive as affecting the use guided IBL pedagogy in the delivery of the NSW science curriculum?

3.2 Study Design

The main method used in this study was a survey of New South Wales Science educators (See Appendix). The survey assessed science educators' opinions about guided IBL. The sample size was dependent on the number of volunteers who chose to take part in the study.

Both quantitative closed-ended questions and qualitative open ended follow up questions were utilised to best collect data for the research question. Creswell and Creswell (2018) describe the use of both closed and open questions as a useful strategy to gain a more complete picture of the data collected and can be used to help explain quantitative research findings from follow up qualitative data collection in a survey and analysis.

3.3 Design of Survey Instrument

The survey was conducted using the web based survey platform Survey Monkey and can be viewed in the Appendix. The survey tool was designed to be approximately fifteen minutes in length as this is the reported to be the optimum length of a web based survey (Revilla & Ochoa, 2017).

A survey method was the chosen approach for several reasons. Economical and time constraints made a survey approach beneficial. The web based survey allowed for rapid collation of data in an electronic format with no need for data migration from a paper format to electronic format (Creswell & Creswell, 2018). A web based survey approach allowed for convenient and economic distribution and collection of surveys whilst also allowing participants to choose a time and place that suited their availability.

Two experienced science teaching colleagues volunteered to pilot test the survey. Once completed, the questions were discussed to judge ease of understanding and comprehension of questions.

The survey first established some demographics, in Items 1, 2 and 3 such as years of teaching experience, current position within or without schools and which NESA curriculum science syllabuses participants had recently taught.

Item 1 asked participants to answer the question “How many years have you been teaching Science?” to determine how practiced participants were in teaching science to see how much experience participants had to inform their opinion.

Item 2 asked participants to indicate “What type and level of science have you taught in the last 5 years?” to determine what syllabi have been taught and if most syllabuses and stages have been represented. Stage 6 Investigating science and Extension science was not included as these syllabi had only been in operation for 9 months at the time of the survey.

Item 3 asked the following question of participants "What position do you currently hold in your school?". This was to determine whether teachers and or head teachers were completing the survey or if other school staff or non-school professionals were doing so. This is to understand the representativeness of the data.

Page three of the survey explicitly introduced participants to a definition of guided IBL. The explicit defining of guided IBL was included to help ensure that respondents were responding to the items based on a clearly defined type of IBL to help increase validity of responses (Peytchev, Conrad, Couper & Tourangeau, 2010). As previously discussed in the literature review, IBL can take many forms and can have many meanings therefore the explicit inclusion of a definition was included to increase the validity of responses and to decrease a possible variable (Peytchev et al., 2010). Page three established Bianchi and Bell's (2005) guided inquiry level as the type of inquiry that participants should keep in mind when answering items in regard to inquiry implementation (see Appendix). The definition was clearly labelled and was placed on a page by itself to ensure people do not ignore the definition as this is a possibility raised by Peytchev et al. (2010). Item structure also intentionally included the use of the term "guided IBL" consistently in an attempt to always frame the response in relation to guided IBL and not other forms of IBL.

Item 4 followed on from the guided IBL definition and asked participants to answer the question "On average how often do you use this type of guided IBL, intentionally or unintentionally, with each of your classes?". This was to determine how frequently participants used guided IBL which was one of the research questions of the study. It was important to determine this since the survey focuses on the implementation of guided IBL in the science classroom.

Closed and open questions in regards to teacher perceptions of various factors that may affect IBL implementation were the focus of the next section of the survey. This survey pattern was utilised by Griffith and Scharmann (2008) when they were investigating the effects of the American No Child Left Behind policy and appeared to produce in depth responses from open ended probing questions that explained the previous choice in a closed question.

Item 5 and 8 did this by asking participants to indicate their agreement to a statement on a 5 point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree or 5 = strongly agree). For example Item 5, Question 1, asked "please indicate the extent to which you agree or disagree with each statement, in relation to the implementation of guided IBL in science classrooms. Guided IBL is enabled by… clear models, definitions and examples of guided IBL" and to this item participants selected 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree or 5 = strongly agree.

Statements in Items 5 and 8 were constructed to cover the factors discussed in the literature review, see Table 2.4 and Figure 2.2 for a summary of these factors. Items 5 and 8 were worded so participants had enough information to give an opinion on whether or not this factor enables or forms a barrier to guided IBL implementation. The statements were also worded in a way that tried to avoid the priming effect. In essence the priming effect relates to a participants exposure to a certain stimulus, such as words or images, that subconsciously influences their response to a subsequent stimulus (Gladwell, 2005; Kahneman, 2011). The priming effect has been found to have a large unconscious influence on peoples' opinions and responses to questions (Gladwell, 2005;

Kahneman, 2011). The balance between giving participants enough information to form an opinion and give a clear response to best meet the needs of the study whilst not wording the statements to prime and influence an opinion was difficult. Some factors such as “NESA syllabi and requirements” are a pure label of a factor and are read as “please indicate the extent to which you agree or disagree with each statement, in relation to the implementation of guided IBL in science classrooms. Guided IBL is enabled by… NESA syllabi and requirements”. Wording and reading this factors statement is unambiguous yet also written in a way that limits influence on the participants perceptions. The wording of other factors was more difficult. For example “models, definitions and examples of guided IBL” could be read by participants as meaning “Guided IBL is enabled by… *clear* models, definitions and examples of guided IBL” or “Guided IBL is enabled by… *unclear* models, definitions and examples of guided IBL”. The unconscious completion of this statement as being *clear* or *unclear* would be based on the participants experiences with this factor but the reasoning behind their response would not be known to the researcher. Therefore a clear categorisation of some factors was added to the statements in Items 5 and 8 to try and determine a clear understanding of the data. For example *clear* and *unclear* was added to “models, definitions and examples of guided IBL” so that it would be read as “please indicate the extent to which you agree or disagree with each statement, in relation to the implementation of guided IBL in science classrooms. Guided IBL is enabled by… clear models, definitions and examples of guided IBL” for Item 5 as well as “In this section, please indicate the extent to which you agree or disagree with each statement, again, in relation to the implementation of guided IBL in science classrooms. In my experience barriers to guided IBL include …unclear models, definitions and example of guided IBL” for Item 8.

Items 6, 7, 9, 10 and 11 then asked open ended questions to obtain more information about participant perceptions in regard to guided IBL implementation. For example Item 6 asked “In regard to the items in Question 5, please use the text box below if you wish to expand on one or more of your answers” and participants had a text box in which they could give their response. As previously mentioned the use of open ended probing questions that explains or allows participants to expand upon previous choices in a closed question can produce valuable in depth responses (Griffith & Scharmann, 2008).

In summary the survey was designed to quickly capture key participant demographics, it then explicitly defined guided IBL so that the participants knew what the following questions referred to. It then collected data on the frequency of use of guided IBL by the participants. The largest section of the survey asked several closed and open questions to collect participant perceptions on the factors that influence the implementation of guided IBL.

3.4 Study Participants

Study participants were NSW science educators and they were invited to take part in the study through an email mailing list. The details of this procedure begins in the next sub-section.

3.4.1 Sampling Procedure

A convenience sampling method (Creswell & Creswell, 2018) was employed in which respondents were invited primarily based on an email contact list. Whilst this is not the optimum way to sample NSW science educators (Creswell & Creswell, 2018) it was chosen due to availability. The email list involved using hidden email addresses. This means that the invitation was put forward to the email list author who then distributed the survey invitation via their email list. This was the method employed because the authors or administrators of these lists keep them confidential to protect their email recipients from unauthorised email traffic. This study was not funded so therefore this method was chosen for efficiency in terms of time and money.

The primary email contact list that was utilised was the Lachlan Macquarie College email contact list. This list contains approximately 800 email addresses of science head teachers and teachers who have attended the annual Lachlan Macquarie College Science conference as well as head teachers and teachers who are part of that network of science educators. The email list is rightly kept hidden from people who are on the list for confidentiality reasons and to reduce spam email of these addresses. It was believed that utilising this network could begin the virtual snowball effect described by Baltar and Brunet (2012). This sampling method is used to potentially capture more participants in a study utilising social networks and is also known as referral sampling. Considering that the recruitment yielded 39 participants, it is possible that this sampling method was not effective. It may have been more effective if other social network platforms were utilised but that is only a hypothesis.

Demographic results show that participants had a wide variety of teaching experience. Participant length of teaching service ranged from practicum experience only to more than 15 years of science teaching experience. Participants also had varied curriculum implementation experience including Stage 1 science to Stage 6 science. The majority of participants were still employed in schools within various positions ranging from teacher to deputy principal, some participants indicated that they worked within a corporate setting or that they were retired.

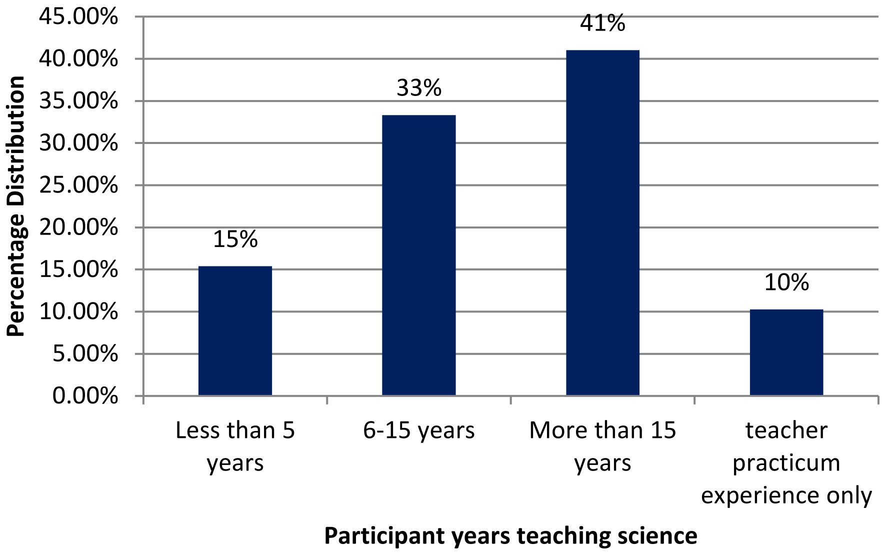
The survey commenced in December 2018. Thirty nine Participants completed the survey over the next four months. The survey was closed in March 2019.

3.4.2 Participant Demographics

Items 1 to 3 collected data on participant science teaching experience to determine representiveness and generalisability of data. Participant length of teaching service ranged from practicum experience only to more than 15 years of science teaching experience. 70% of participants had more than 6 years of teaching experience (see Figure 3.1).

Figure 3.1

Percentage Distribution of Responses to Item 1 "How many years have you been teaching science?" (n=39)

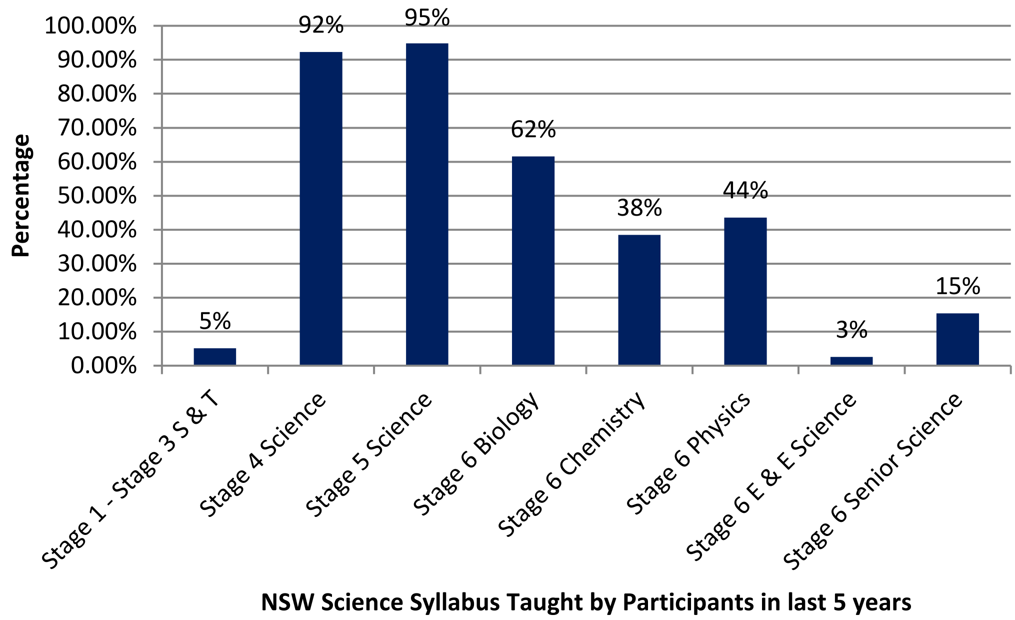


Participants also had varied science teaching experience including Stage 1 science (Years 1 and 2) through to Stage 6 science (Years 11 and 12). More than 90% of participants have indicate they have taught Stages 4 and 5 science at some point in the last 5 years (see Figure 3.2). There is also a large proportion, 61%, that have taught a

Stage 6 science syllabus with 61% of participants indicating they taught Stage 6 Biology in the last 5 years, 38% indicating Stage 6 Chemistry, 3% indicating Stage 6 earth and environmental science and 43% indicating stage 6 Physics. Whilst Stage 6 senior science will no longer be taught or assessed after 2019, it should be noted that 15% of Participants indicated teaching Stage 6 Senior Science.

Figure 3.2

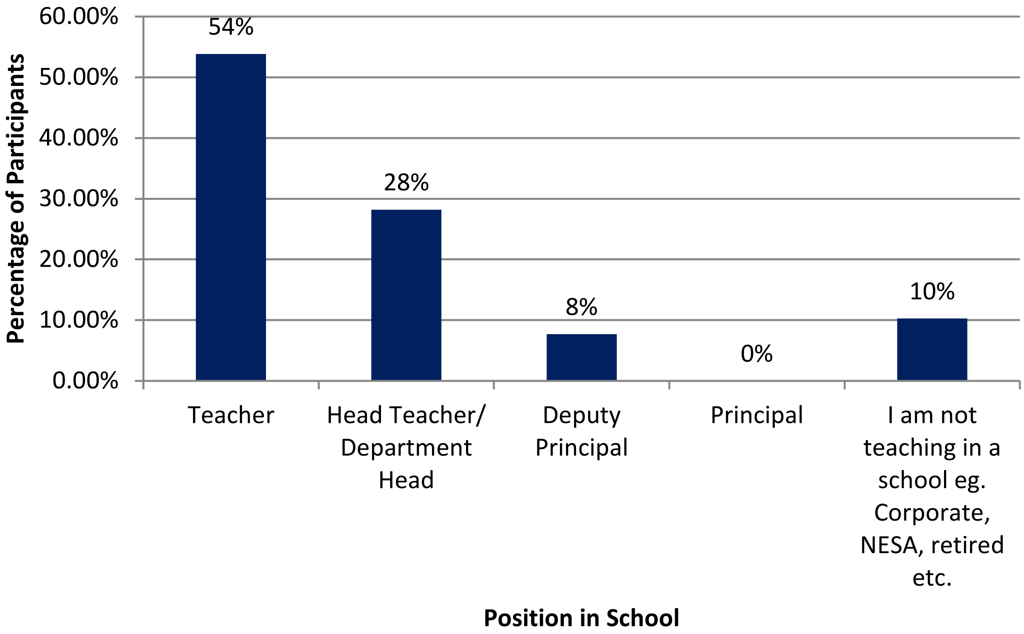
Distribution of Responses to Item 2 "What type and level of science have you taught in the last 5 years?" (n=39)



The majority of participants, 90%, were still employed in schools within various positions ranging from teacher to deputy principal, some participants, 10%, indicated that they worked within a corporate setting or that they were retired. Approximately 70% were currently teachers or head teachers (see Figure 3.3).

Figure 3.3

Percentage Distribution of Responses to Item 3 "What position do you currently hold in your school?" (n=39)



3.5 Procedure

Ethical approval for the study was obtained from the University of Technology, Sydney Research Ethics Committee and was deemed a low risk study. The ethics approval number is ETH18-3028.

Participants were approached via broad invitation email and were not coerced to take part in the study. The invitation email contained the information sheet with study information and website link. Consent was given by participants by following the website link and this was clearly stated in the information sheet. The website survey link obtained no identifiers and participants were completely anonymous. Participation was strictly voluntary and participants could withdraw at any time. Open ended response data used from participants was de-identified. No personal identifying information was collected other than years of teaching experience, what science syllabuses they have taught and what level of position they hold within education.

All information provided by participants was treated with respect, and confidentiality was maintained. Only the researcher and supervisor have access to raw survey data.

3.6 Analysis of Data

Responses to both closed and open ended questions in the survey were analysed using descriptive analysis. Qualitative descriptive studies involves the presentation of data in low interpretive everyday language (Sandelowski, 2000). Furthermore Sandelowski (2000) describes descriptive analysis as the "presentation of facts of the case in everyday language" (p.337). The data collected in Items 1, 2, 3, 4, 5 and 8 was collected and collated so that means, standard deviations and percentage distribution of responses was calculated and then analysed with responses to the open questions in Items 6, 7, 9, 10 and 11 to form a descriptive analysis.

Items 1 to 4 collected data on participant science teaching experience and how often participants utilise guided IBL on average with each of their classes to determine representiveness and generalisability of data as well as frequency of use of guided IBL. The data collected for Items 1 to 4 was entered into Microsoft excel and the percentage distribution of responses was calculated. This has been presented as percentage distribution of responses graphs with related qualitative descriptions in the participant demographics section.

Data targeting the research questions "what factors do teachers perceive enable them to use IBL pedagogy in the delivery of the NSW science curriculum?" and "what factors do teachers perceive as barriers to the use IBL pedagogy in the delivery of the NSW science curriculum?" were sought primarily through Items 5 to 11 in the survey. As mentioned earlier, Item 5 "guided IBL is enabled by…" and Item 8 "in my experience barriers to guided IBL include…" are closed question items that provided quantitative data into the perceptions of teachers toward the factors involved in the implementation of guided IBL. Data collected for Items 5 and 8 were entered into Microsoft Excel and the mean of responses and percentage distribution of responses was calculated. This has been presented as graphs of the mean of responses as well as percentage distribution of responses graphs with related descriptions.

Survey items 5 and 8 helped structure this discussion. These items were analysed by the percentage distribution of responses and the mean of the responses. The underlying research questions being studied are "what factors do teachers perceive enable them to use IBL pedagogy in the delivery of the NSW science curriculum?" and "what factors do teachers perceive are barriers to the use IBL pedagogy in the delivery of the NSW science curriculum?". Percentage distribution of responses and the means of Reponses were both used as they illustrate different trends in the data and add greater detail to the descriptive analysis.

The open ended questions in Item 6 "in regard to the items in question 5, please use the text box below if you wish to expand on one or more of your answers", Item 9 "in regard to the items in question 8, please use the text box below if you wish to expand on one or more of your answers", and item eleven "please state what you believe is the most important factor for the implementation of guided IBL in science classrooms" add qualitative details and in some cases unforeseen insights into the quantitative results. Item 7 i.e.: "in regards to the items in question 5, please use the textbox below if you wish to add other factors that you believe are enablers of guided IBL" and Item 10 i.e.:

"in regards to the items in question 8, please use the textbox below if you wish to add other factors that you believe are enablers of guided IBL" did not yield any new factors that the literature review has not already discussed.

Open ended responses to Items 6, 9 and 11 have been used throughout the analysis to help illustrate perceptions toward certain factors and responses to Items 5 and 8. Item 6 and 9 asked participants to "expand on one or more of your answers" respective to Items 5 and 8.

Open ended responses to item eleven were also thematically coded using qualitative content analysis. Codes were data-derived, meaning the codes for the open ended responses were generated from the data then applied to summarise the information in the response data to identify trends and patterns (Morgan, 1993; Sandelowski, 2000). Responses to item eleven were coded against the data derived codes to determine the frequency of certain themes in these responses. This is presented in Table 4.2 in the results section.

3.7 Summary

This section outlined the method used in this study to investigate guided IBL. The method involved a survey that was completed by thirty nine volunteers. The survey included open and closed questions that gathered data on participant demographics related to science teaching, frequency of guided IBL use and participant perceptions regarding the factors that influence the implementation of guided IBL in science education. The next two chapters present the findings of the study and the implications and conclusions of the study.

Chapter 4 Findings

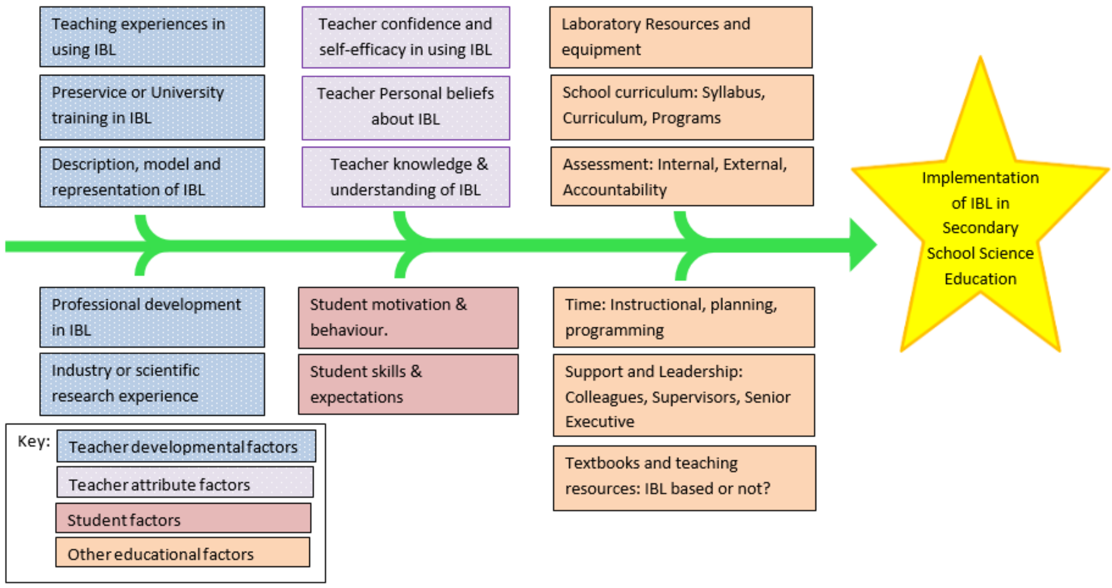
4.1 Introduction

A large part of the literature review in chapter two focussed on inquiry-based learning (IBL) and the factors that enable or act as barriers to IBL implementation. The aim of this study is to investigate teacher perceptions about the factors that enable them to use *guided* IBL pedagogy in the delivery of the NSW science curriculum. Chapter 3 detailed the methodology used in this study.

This chapter begins by reporting on the frequency of use of guided IBL by participants in their classrooms. It then moves to a summary of participant perceptions in regard to the enablers and barriers toward guided IBL implementation in the delivery of NSW secondary science curriculum. Detailed data that informed these findings will be presented afterward in the bulk of the results section. Results will be presented using the headings found within the structure of Figure 2.2, presented earlier in Chapter 2. Figure 2.2 has been replicated in Figure 4.1 below to assist the reader.

Figure 4.1

Reproduction of Figure 2.2, Summary of Factors That Impact IBL Implementation in Secondary School Science



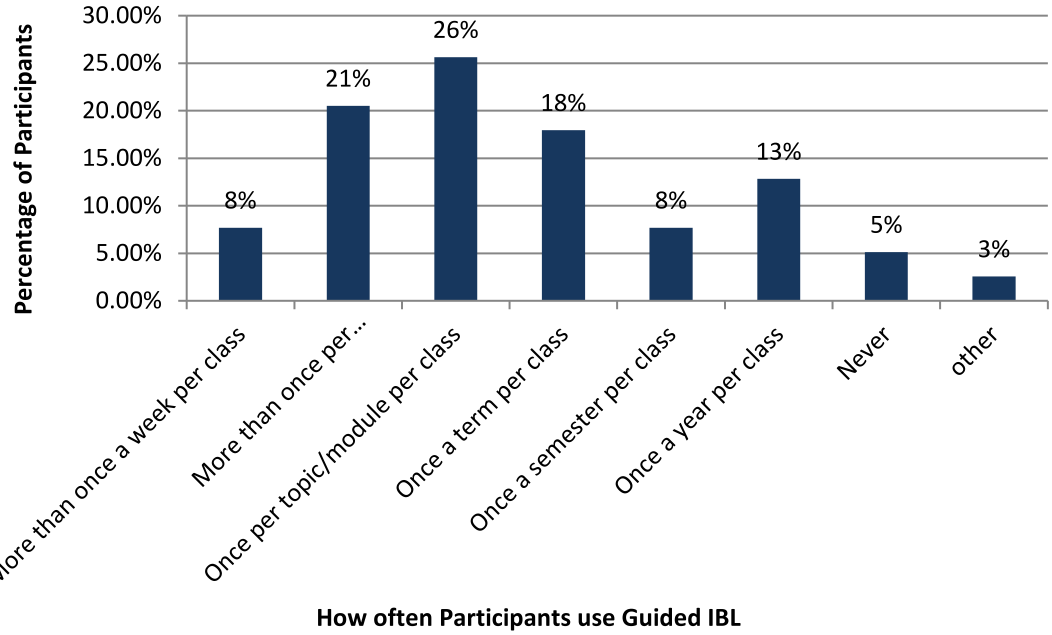
Data investigating the research question "What factors do teachers perceive enable them to utilise guided IBL in the delivery of NSW secondary science curriculum?" will be presented using the structure outlined by the framework in Figure 4.1. Survey Items 5 and 8 are also used to organise the following qualitative descriptive analysis into the factors that may enable or be barriers to guided IBL implementation (see Appendix). Item 7 i.e.: "in regards to the items in question 5, please use the textbox below if you wish to add other factors that you believe are enablers of guided IBL" and Item 10 i.e.: "in regards to the items in question 8, please use the textbox below if you wish to add other factors that you believe are enablers of guided IBL" did not yield any new factors. Therefore utilising the structure of Figure 4.1 provides a suitably comprehensive way to structure the reporting of findings.

4.2 Frequency of Use of Guided IBL

Item 4 investigated how often participants utilise guided IBL on average with each of their classes. More than 90% of participants said they use guided IBL at least once a year per class (see Figure 4.2).

Figure 4.2

Percentage Distribution of Responses to Item 4 "On average how often do you use this type of guided IBL, intentionally or unintentionally, with each of your classes?"



More than half of participants (55 %) reported that they utilise guided IBL at least once per topic/module per class. These results are show that the use of guided IBL pedagogy may be more common than has been reported in previous literature (Cheung, 2011; Deters, 2005). Item 4 was placed in the survey after participants were given a clear definition of guided IBL (see Appendix). Understanding of this clear definition was assumed, but in hindsight, a question testing understanding would have been beneficial to validity.

4.3 Teacher Developmental Factors

Figure 2.2 contains all of the factors discussed in the literature review that can act as enablers or barriers to implementation of all types of IBL in science classrooms. Figure 2.2 groups these factors into teacher developmental factors, teacher attribute factors, student factors and other educational factors.

Participant perceptions from this study regarding the impact of "teacher developmental factors" on *guided* IBL implementation within the delivery of NSW secondary science curriculum will be presented in this section. These factors include:

- A clear description, model or representation of IBL
- Preservice, Initial Teacher Education, training in IBL
- Professional development in IBL
- Industry or scientific research experience
- Teachers past experiences in using IBL

4.3.1 Participant Perceptions in Regard to Teacher Developmental Factors

Responses to survey Items 5, 6, 8, 9 and 11 (see Appendix) indicate that participants believe that a clear description, model or representation of guided IBL, professional development in guided IBL and teacher past experience in using guided IBL **are enablers** of guided IBL implementation.

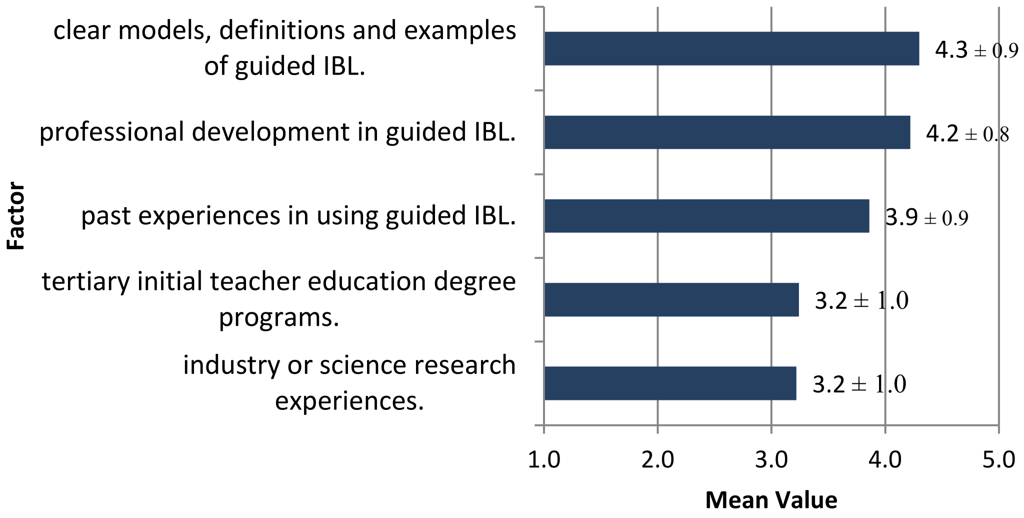
Responses to these five items also indicate that participants believe that an unclear description, model or representation of guided IBL, a lack of professional development in guided IBL and a teachers negative past experiences in using guided IBL **are barriers** to guided IBL implementation.

Survey results indicated that preservice teacher education programs and industry or scientific research experience **are not seen as clear barriers or enablers** to guided IBL implementation. This finding is further discussed in sub-section 4.3.7.

Figure 4.3 shows the mean scores for Item 5 “In this section, please indicate the extent to which you agree or disagree with each statement, in relation to the implementation of guided IBL in science classrooms. Guided IBL is enabled by…”. Figure 4.4 shows the mean scores for Item 8 “In this section, please indicate the extent to which you agree or disagree with each statement, again, in relation to the implementation of guided IBL in science classrooms. In my experience barriers to guided IBL include …”. Items 5 and 8 asked participants to indicate their agreement to these statements on a 5 point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree or 5 = strongly agree).

Figure 4.3

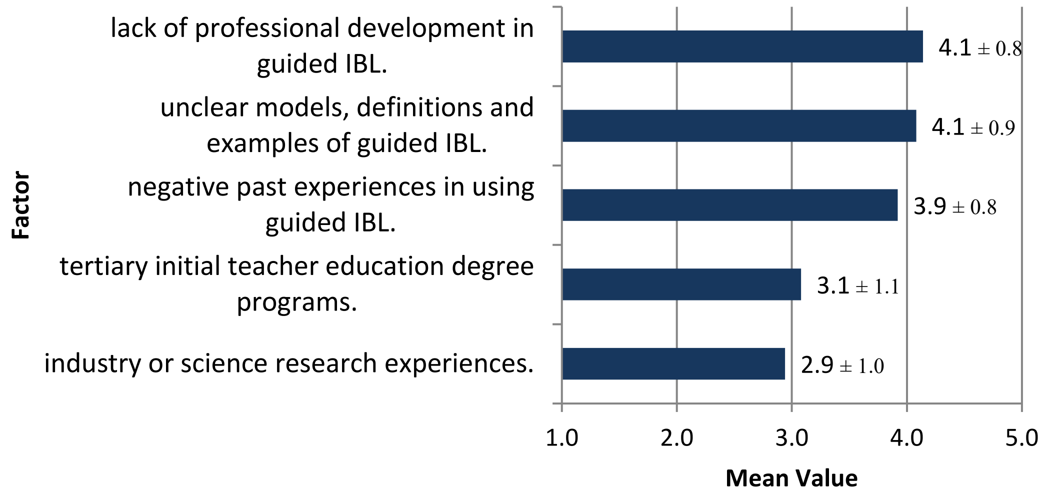
Mean Value of Responses (and Standard Deviations) for Item 5 "guided IBL is enabled by…"



The data in Figure 4.3 indicates that two developmental factors; clear models, definitions and examples of guided IBL and professional development in guided IBL are enablers of guided IBL. This is indicated by large mean scores for this item, located in the agree to strongly agree range, in regard to these factors and therefore, there was agreement that these factors are enablers of guided IBL.

Figure 4.4

Mean Value (and Standard Deviation) of Responses for Item 8 "In my experience barriers to guided IBL include …"



The data in Figure 4.4 indicates that unclear models, definitions and examples of guided IBL and a lack of professional development in guided IBL both had mean values in Item 8 in the agree range even with the standard deviation taken into account. The mean scores and standard deviations for these factors in item eight indicate participants perceive these factors as barriers to guided IBL implementation.

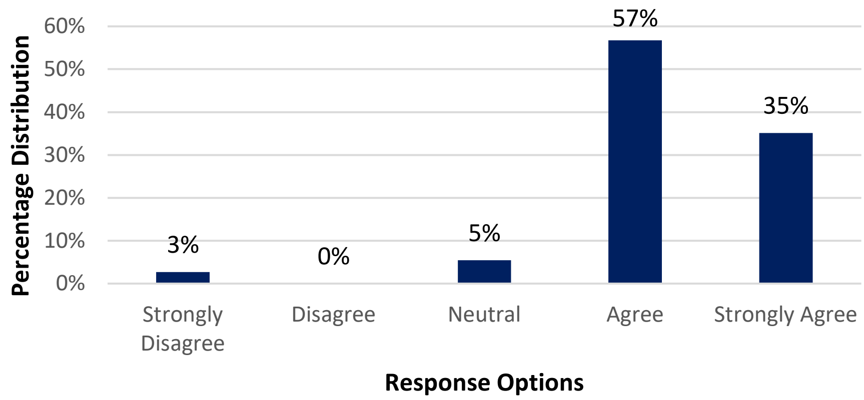
The mean scores and standard deviations to Items 5 and 8 in Figure 4.3 and Figure 4.4 indicate that past experiences in using guided IBL is both an enabler and barrier to guided IBL implementation. If past experiences are negative, then they act as a barrier, and if past experiences are positive then this positive experience of guided IBL implementation is an enabler of guided IBL implementation.

4.3.2 Professional Development in Guided IBL

Participants agree that professional development is a key factor for implementing guided IBL as seen in Item 5 results which show 92% agreement that guided IBL is enabled by professional development (see Figure 4.5).

Figure 4.5

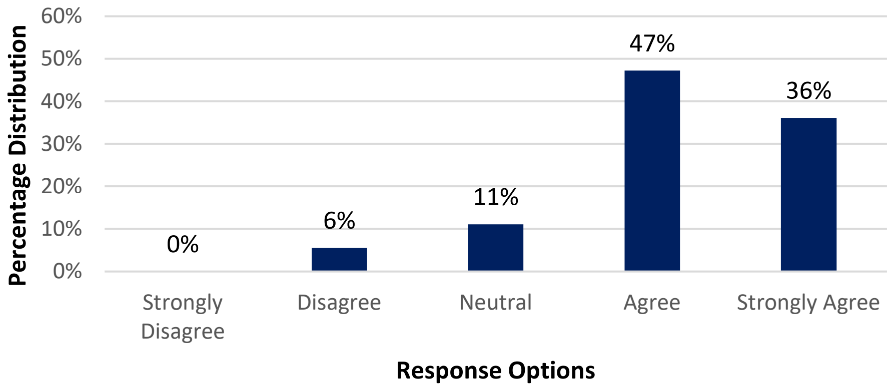
Percentage Distribution of Responses to Item 5 "guided IBL is enabled by professional development in guided IBL." (n=37)



This perception is further verified in item eight which shows that 83% of participants agree that a lack of professional development in guided IBL is a barrier to implementation (see Figure 4.6).

Figure 4.6

Percentage Distribution of Responses to Item 8 "in my experience barriers to guided IBL include a lack of professional development in guided IBL." (n=36)



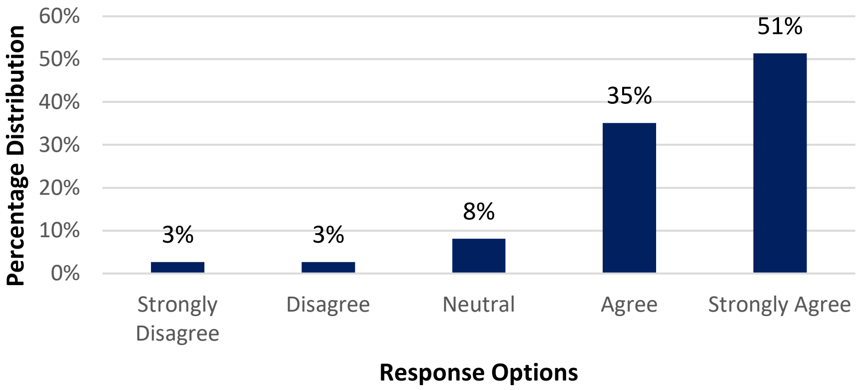
These results in regard to guided IBL are supportive of studies reported on by Goodrum (2006) and Goodrum et al. (2011) that investigated the implementation of IBL in Australian schools. The importance of professional development in IBL pedagogy was also expressed by several other authors (Abd-El-Khalick et al., 2003; Anderson, 2002; Furtak, 2006). These studies highlighted the need for ongoing professional development of teachers in IBL pedagogy and expertise development. The participants in this study agree that professional development in guided IBL pedagogy is an enabler to implementation and that the lack of professional development is a barrier.

4.3.3 Definition, Models and Examples of Guided IBL

The literature review in Chapter 2 introduced the problem created by having multiple definitions, frameworks or models for IBL. Participants agree (86% agreement) that a clear model, definition or example of guided IBL contributes to IBL implementation and an unclear model can be a barrier (78% agreement).

Figure 4.7

Percentage Distribution of Responses to Item 5 "guided IBL is enabled by clear models, definitions and examples of guided IBL." (n=37)



The results to Item 5 show agreement to the statement that guided IBL is enabled by clear models, definitions and examples of guided IBL with 86% of participants selecting agree or strongly agree (see Figure 4.7).

Figure 4.8

Percentage Distribution of Responses to Item 8 "in my experience barriers to guided IBL include unclear models, definitions and examples of guided IBL." (n=36)

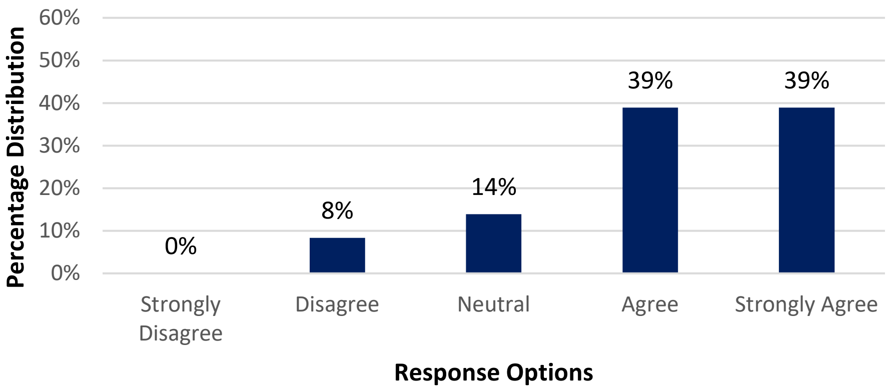


Figure 4.8 shows participant perceptions about unclear models, definitions and examples of guided IBL. The results to Item 8 in Figure 4.8 show agreement, 78% of

participants choosing agree or strongly agree, to the statement “In my experience barriers to guided IBL include unclear models, definitions and examples of guided IBL.” No further comments in regards to IBL definitions, models or examples were made in the open Items 6, 9 or 11.

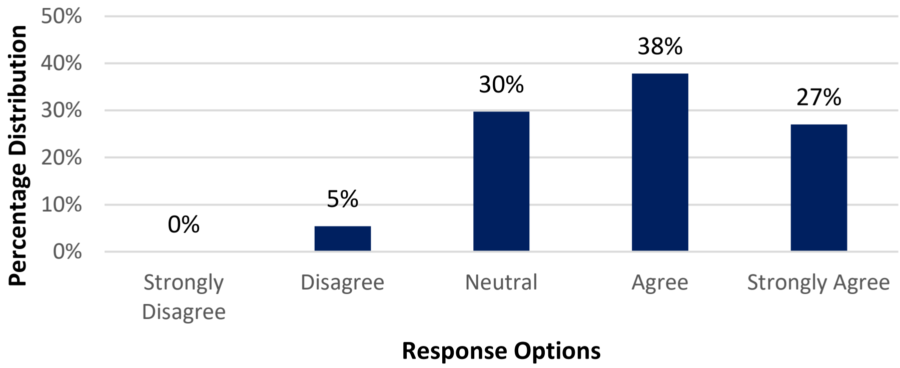
These results support the reasoning that has led many researchers to put forward models to aid educators in defining, understanding and implementing IBL (Bevins and Price, 2016; Bianchi & Bell, 2008; Furtak, 2006; Jiang & McComas, 2015). These models aid in the planning, implementation, communication and evaluation of IBL units of work and more specifically these results suggest that having a clear model, such as guided IBL is beneficial and supportive in the implementation of IBL in the NSW secondary science classroom. These results support the statements made by Abd-El-Khalick et al. (2003) and Furtak (2006) who argue that the multiple meanings and interpretations of IBL are a factor that inhibits the implementation of IBL by creating difficulties for teachers trying to plan for the use of IBL in classroom practice.

4.3.4 Teachers’ Past Experiences in Using Guided IBL

Participants have overall agreement (combined agree and strongly agree 65% and 72%) that a teacher’s past experiences of guided IBL is a factor affecting guided IBL implementation.

Figure 4.9

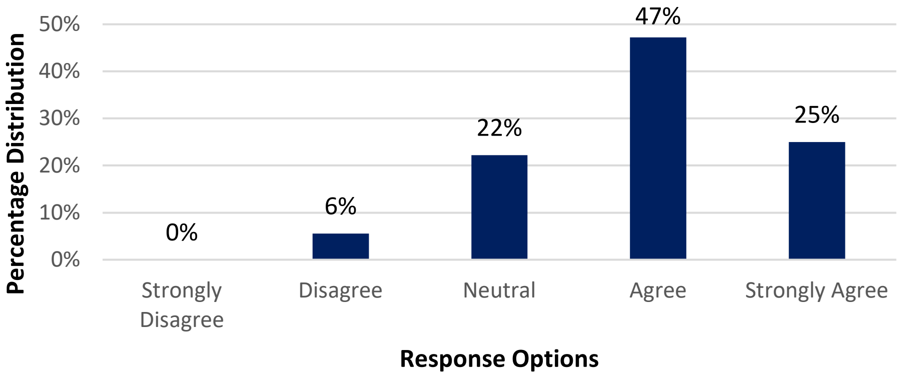
Percentage Distribution of Responses to Item 5 "Guided IBL is enabled by a teacher's past experiences in using guided IBL." (n=37)



The results to Item 5 show 65% agreement to the statement that guided IBL is enabled by a teacher's past experiences in using guided IBL (see Figure 4.9). The results to Item 8 also show 72 % agreement to the statement "In my experience barriers to guided IBL include negative past experiences in using guided IBL" (see Figure 4.10). Participant responses indicate that positive past experiences in guided IBL implementation are an enabler to further implementation and the reverse is also believed, in that negative past experiences in guided IBL implementation are a barrier to further implementation. This would be a perception that could be investigated further in a subsequent study in regards to identifying the nature of these negative experiences. For instance, was the experience a negative one due to other factors identified in this study such as student behaviour, lack of resources, lack of professional development etc.? Or was the negative experience due to other factors?

Figure 4.10

Percentage Distribution of Responses to Item 8 "In my experience barriers to guided IBL include negative past experiences in using guided IBL." (n=36)



These results were further verified in Item 6 "in regard to the items in question 5, please use the text box below if you wish to expand on one or more of your answers" and Item 11 "please state what you believe is the most important factor for the implementation of guided IBL in science classrooms" with comments such as "Past experiences in IBL will enable better understanding and encourage colleagues to use it in classrooms" (Item 6 sample response 7) and "The teacher needs to be persistent, even if they fail they need to collect feedback from student and peers and try again" (Item 11 sample response 21).

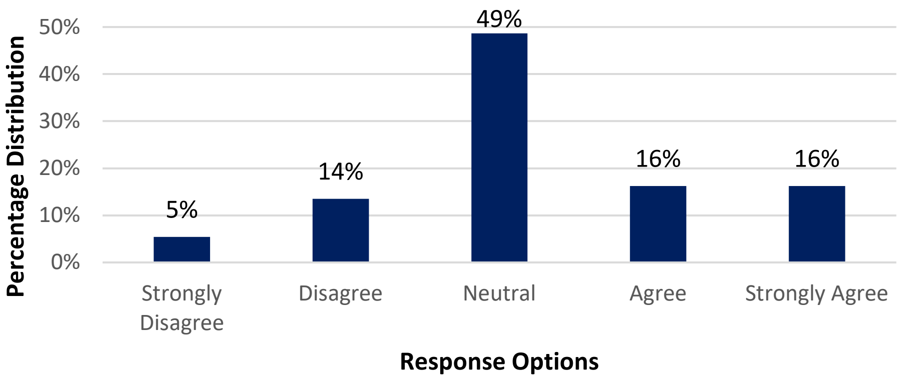
This impact of identified factors on the experiences of teachers is discussed by Gillies and Nichols (2014) who investigated teacher perceptions in relation to teaching inquiry science and the benefits and challenges of IBL. After intensive training in IBL and then implementing IBL in their classrooms it was found that teachers generally spoke positively about their experience but also expressed concerns in regard to keeping students on track, the demands of the curriculum, their teaching programs and preparation for assessments which were all related to the time available for IBL. The effect of these additional factors is verified in this study and will be addressed in subsequent sub-sections of this chapter.

4.3.5 Preservice Training in Guided IBL and Industry or Science Research Experience

A large proportion, 49%, of participants in this study believed that initial tertiary teacher education (ITE) programs are *neither enablers nor barriers* to implementation of guided IBL. This is also the case with industry or science research experience, with the majority of study participants, 46%, believing that prior industry or science research experience are not enablers nor barriers to guided IBL implementation.

Figure 4.11

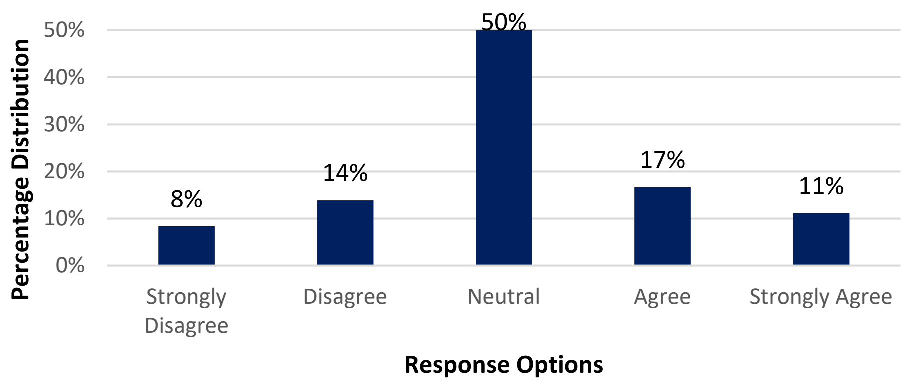
Percentage Distribution of Responses to Item 5 "guided IBL is enabled by tertiary initial teacher education degree programs." (n = 37)



The results to Items 5 and 8 show a trend towards neutrality (see Figure 4.11 and 4.12). This neutrality is demonstrated by neutral being the predominant response (49%) in Item 5 i.e.: ITE is an enabler of guided IBL, and 32% of participants agreeing (agree or strongly agree) that ITE is an enabler of guided IBL and 19% disagreeing (disagree or strongly disagree) that ITE is an enabler of guided IBL. This is almost mirrored in Item 8 i.e.: barriers to guided IBL implementation include, with 50% of participants choosing neutral, 28% agreeing and 22% disagreeing. No further comments in regards to ITE programs were made in the open Items 6, 9 or 11.

Figure 4.12

Percentage Distribution of Responses to Item 8 "in my experience barriers to guided IBL include tertiary initial teacher education degree programs." (n=36)



In regard to industry or science research experience, the results to Items 5 and 8 also show a trend towards neutrality with similar percentages agreeing (35%), disagreeing (19%) and the majority being neutral (46%) in Item 5 and 31% disagreeing, 22% agreeing and the majority being neutral at 47% (see Figures 4.13 and 4.14). No further comments in regards to prior industry or science research experience were made in Items 6, 9 or 11.

Figure 4.13

Percentage Distribution of Responses to Item 5 "guided IBL is enabled by industry or science research experiences." (n=37)

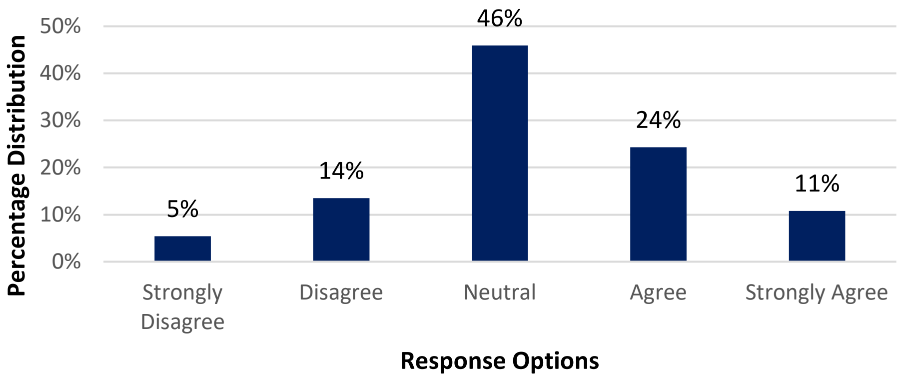
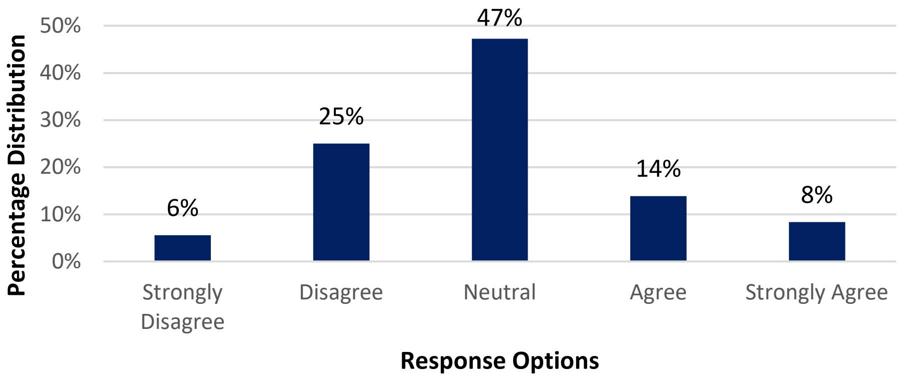


Figure 4.14

Percentage Distribution of Responses to Item 8 "in my experience barriers to guided IBL include industry or science research experiences." (n=36)



The importance of quality preservice initial teacher education (ITE) programs that are inclusive of inquiry methods has been argued by many scholars (Anderson, 2002; Brown & Melear, 2006; DiBiase & McDonald, 2015; Furtak, 2006; Goodrum et al., 2001; Hackling et al., 2001; Ozel & Luft, 2013; Windschitl, 2003). The results of this study suggest that participants believe that ITE programs are neither enablers nor barriers to guided IBL implementation. This is a similar result to two studies introduced in the literature review. Brown and Melear (2006) and Pedretti et al. (2008) concluded that teacher education inquiry experiences are important and can strengthen teacher capacity to utilise IBL. However they also report that teachers, in these research studies, still intend to use teacher centred pedagogy due to perceived barriers to IBL pedagogy such as student discipline, ability, disengagement and behaviour management issues, as well as time constraints around lesson planning and programming. This tension between intended and enacted pedagogies (Brown & Melear, 2006; Pedretti et al., 2008) may be one reason that participants in this study perceive ITE programs as neutral to the implementation of guided IBL.

4.4 Teacher Attribute Factors

Figure 2.2 contains all of the factors discussed in the literature review that can act as enablers or barriers to the implementation of all types of IBL in science classrooms. Figure 2.2 groups these factors into teacher developmental factors, teacher attribute factors, student factors and other educational factors.

Participant perceptions regarding the impact of "teacher attribute factors" on *guided* IBL implementation within the delivery of NSW secondary science curriculum will be presented in this section. These factors include:

- Teachers personal beliefs toward IBL
- Teachers knowledge of IBL
- Teacher confidence in using IBL

4.4.1 Participant perceptions in regard to teacher attribute factors

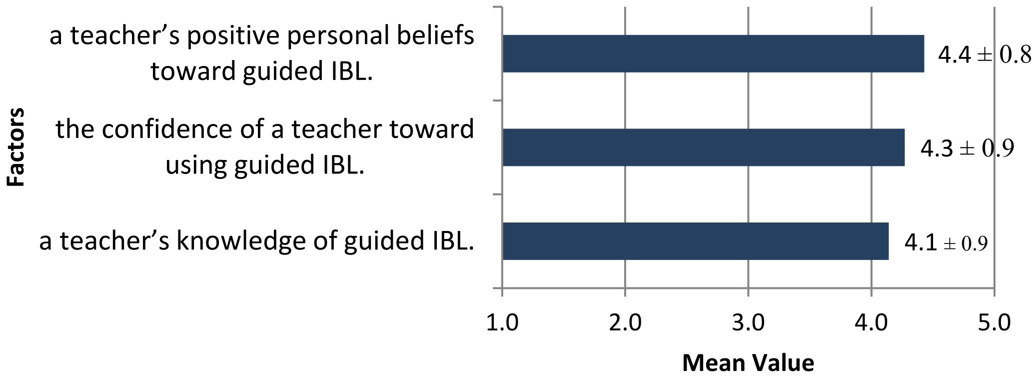
Responses to survey Items 5, 6, 8, 9 and 11 indicate that participants believe that teachers' positive personal beliefs toward guided IBL, teacher knowledge of guided IBL and teacher confidence in using guided IBL **are enablers** to guided IBL implementation.

Responses also indicate that participants believe that teachers' negative personal beliefs toward guided IBL, teacher lack of knowledge and lack of teacher confidence in using guided IBL **are barriers** to guided IBL implementation. These factors will be further discussed in the following sub-sections.

Figure 4.15 shows the mean scores for Item 5 "In this section, please indicate the extent to which you agree or disagree with each statement, in relation to the implementation of guided IBL in science classrooms. Guided IBL is enabled by….". Item 5 asked participants to indicate their agreement to this statement on a 5 point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree or 5 = strongly agree).

Figure 4.15

Mean Value of Responses (and Standard Deviations) for Item 5 "guided IBL is enabled by…"

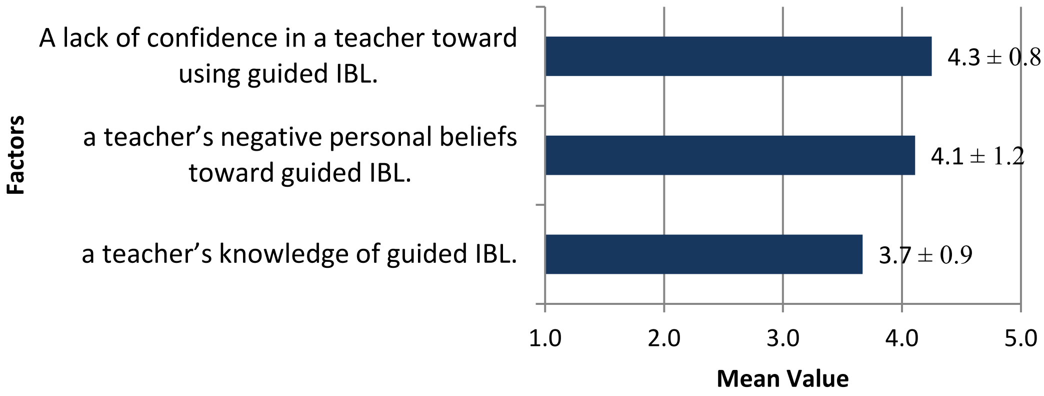


The data in Figure 4.15 indicates that three items; a teachers positive personal beliefs toward guided IBL, the confidence of a teacher toward using guided IBL and a teachers knowledge of guided IBL had large mean values. This indicates a mean score from participants in the agree to strongly agree range and therefore agreement that these factors are enablers of guided IBL.

Figure 4.16 shows the mean scores for Item 8 "In this section, please indicate the extent to which you agree or disagree with each statement, again, in relation to the implementation of guided IBL in science classrooms. In my experience barriers to guided IBL include …" (see Appendix). Item 8 asked participants to indicate their agreement to this statement on a 5 point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree or 5 = strongly agree).

Figure 4.16

Mean Value (and Standard Deviation) of Responses for Item 8 "In my experience barriers to guided IBL include …"



The data in Figure 4.16 indicates that a lack of confidence in a teacher toward using guided IBL and a teachers negative personal beliefs toward guided IBL. This indicates a mean score in this item from participants in the agree to strongly agree range and therefore, agreement that these factors are barriers to guided IBL implementation.

4.4.2 Teachers' Personal Beliefs Toward IBL

The results of this study suggest that participants believe that a teacher's personal positive beliefs about guided IBL are strong enablers of guided IBL implementation. The results to Item 5 show agreement (combined agree and strongly agree 92%) to the statement that guided IBL is enabled by a teacher's positive personal beliefs toward guided IBL (see Figure 4.17). The results to Item 8 also show agreement (combined agree and strongly agree 86%) to the statement "In my experience barriers to guided IBL include a teacher's negative personal beliefs toward guided IBL" (see Figure 4.18).

Figure 4.17

Percentage Distribution of Responses to Item 5 "guided IBL is enabled by a teacher's positive personal beliefs toward guided IBL" (n=37)

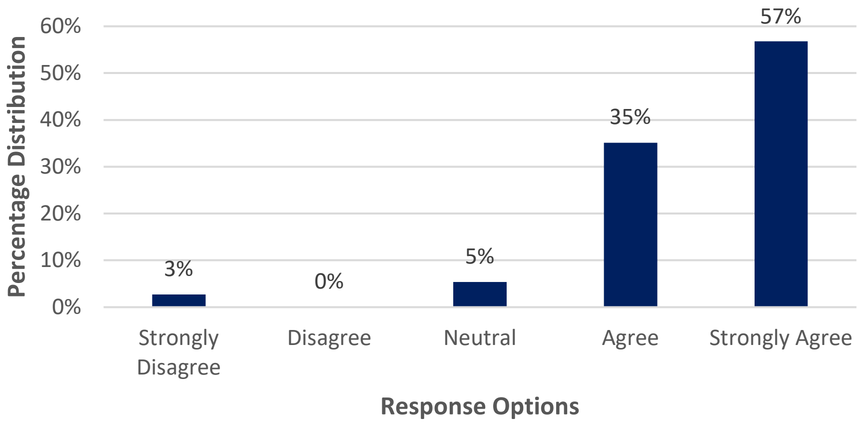
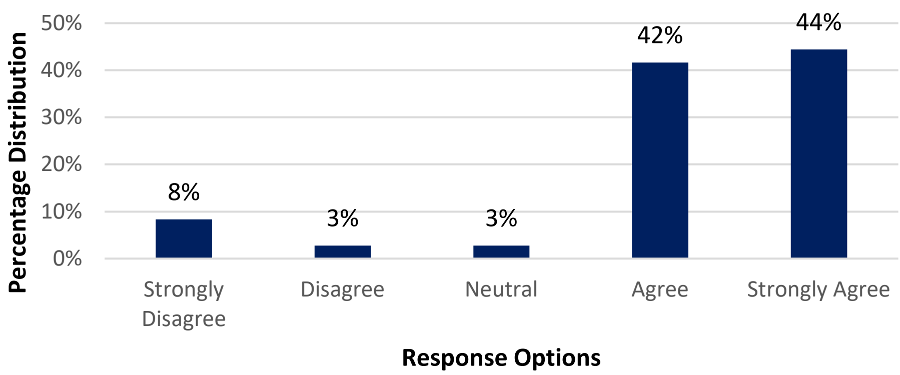


Figure 4.18

Percentage Distribution of Responses to Item 8 "in my experience barriers to guided IBL include a teacher's negative personal beliefs toward guided IBL." (n=36)



These results were further verified in Item 6: "in regard to the items in question 5, please use the text box below if you wish to expand on one or more of your answers" and Item 11 "please state what you believe is the most important factor for the implementation of guided IBL in science classrooms". Sample comments such as "It's an individual decision. If you are passionate about IBL, you will use even if your colleagues are not using it" (Item 6 sample response 11) seem to reiterate the importance of teacher belief. Other comments in Item 11 such as "teacher enthusiasm and understanding of IBL" (Item 11 sample response 27) and

> The teacher needs to be persistent, even if they fail they need to collect feedback from students and peers and try again. There is no one size fits all you need to work out what works for you and your teaching style. (Item 11 sample response 21)

highlight the importance of teacher personal beliefs in IBL implementation, especially because item eleven asked participants to identify the most important factor in guided IBL implementation. This finding supports earlier research that highlights the importance of teacher personal beliefs regarding science teaching and the positive and negative effects these beliefs can have on IBL implementation (Abell, 1999; Brown & Melear, 2006; Crawford, 2007; DiBiase & McDonald, 2015; Lotter et al., 2007).

These results strongly state that the beliefs of teachers are important for pedagogical changes in schools. Continued research into the origins of teacher beliefs and opinions would be warranted by these results. Furthermore, research into successful pedagogical change implementations would also be beneficial to science education research. Possibly even an organisational psychology approach to change management in regards to teaching and pedagogical change would be beneficial since the motivations of teachers are an important factor to successful pedagogical implementation. For example, Kegan and Lahey (2011) propose that even when people have sincere commitments to change, competing commitments result in a state of inertia that appears to be opposition or resistance. They propose that it is vital to understand these underlying conflicting commitments for successful change to take place. The purpose of this study is to continue to understand and identify which factors may be 'competing commitments' in regard to guided IBL implementation.

4.4.3 Teachers' Knowledge of IBL

The results of this study suggest that participants believe that a teacher's knowledge of guided IBL is both an enabler and barrier to guided IBL. The results to Item 5 show agreement to the statement that guided IBL is enabled by a teacher's knowledge of guided IBL (see Figure 4.19). The results to Item 8 also show agreement to the statement "In my experience barriers to guided IBL include a teacher's knowledge of guided IBL" (see Figure 4.20).

Figure 4.19

Percentage Distribution of Responses to Item 5 "guided IBL is enabled by a teacher's knowledge of guided IBL" (n=37)

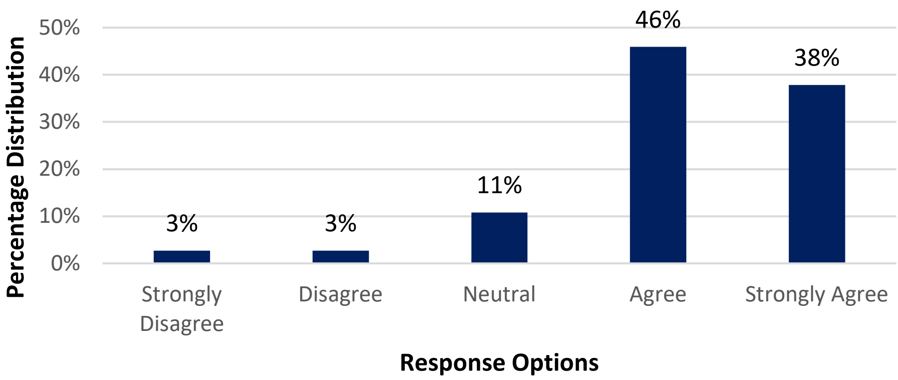
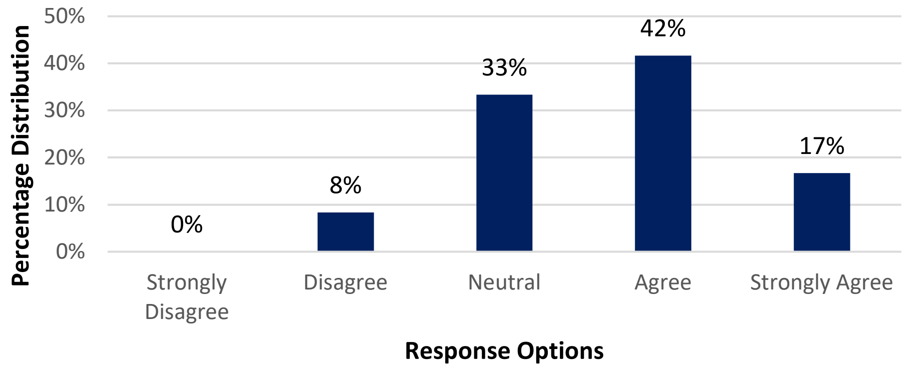


Figure 4.20

Percentage Distribution of Responses to Item 8 "in my experience barriers to guided IBL include a teacher's knowledge of guided IBL" (n=36)



The results suggest that participants believe that a teacher's knowledge of guided IBL is both an enabler and barrier to guided IBL, which at first seems contradictory. Considering the contradictory nature of these results, possible comments may have proven helpful but no further comments in regards to teacher's knowledge of guided IBL were made in Items 6, 9 or 11. In the absence of comments discussion will need to progress with some assumptions. Is it possible that participants have read this in Item 8 and interpreted it to mean a lack of teacher knowledge? This is a good possibility since this item appeared in the survey after three items that had the words "negative", "lack" and "unclear" and before an item that again repeated the word "lack". This possibility is supported by research conducted by Tourangeau, Couper and Conrad (2004) which found that answers to items are not only affected by nearby items in a list survey but, importantly, they can also be dependent on nearby items in a survey.

It is then assumed that participants agreed that teacher knowledge of IBL is an important factor in IBL implementation. This is supported by research that shows that teacher misunderstanding or lack of knowledge of IBL has a negative effect on IBL implementation (Abd-El-Khalick et al., 2004; Abell, 1999; Capps et al., 2016; Crawford, 2007; Furtak, 2006; Ozel & Luft, 2013; Lotter et al., 2007; Wilcox et al., 2015; Windschitl, 2003).

4.4.4 Teacher Confidence in Using Guided IBL

Participant responses indicate that teacher's confidence in using guided IBL can be both an enabler and also a barrier to using guided IBL depending on the level of confidence (see Figures 4.21 and 4.22). The results to Item 5 show agreement (combined agree and strongly agree 84%) to the statement that guided IBL is enabled by the confidence of a teacher toward using guided IBL (see Figure 4.21). The results to Item 8 also show agreement (combined agree and strongly agree 86%) to the statement "In my experience barriers to guided IBL include a lack of confidence in a teacher toward using guided IBL." (See Figure 4.22).

Figure 4.21

Percentage Distribution of Responses to Item 5 "guided IBL is enabled by the confidence of a teacher toward using guided IBL" (n = 37)

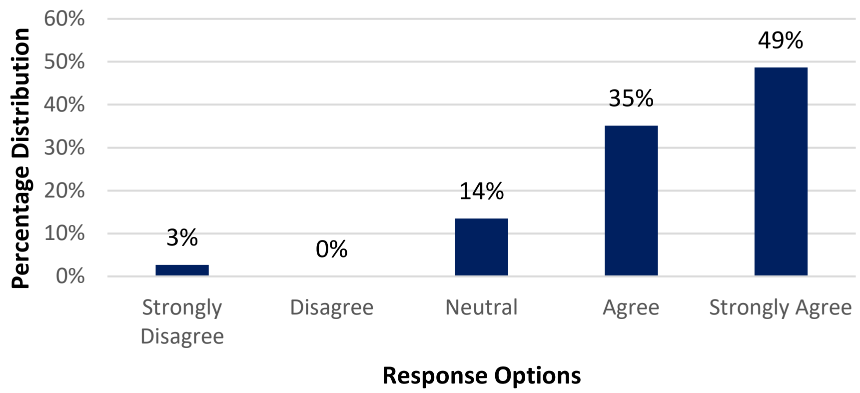
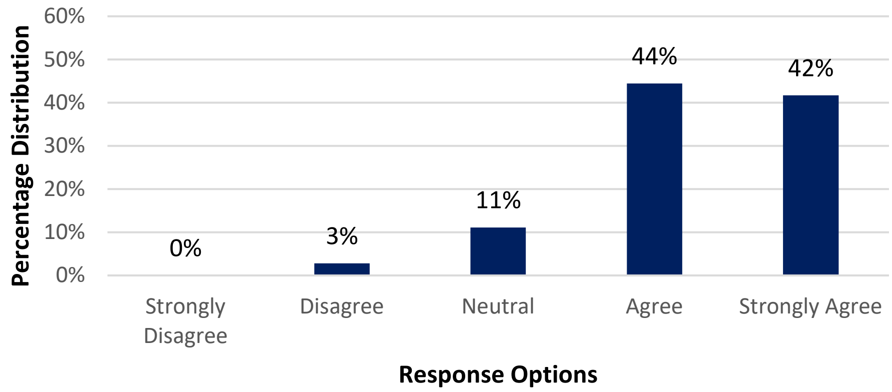


Figure 4.22

Percentage Distribution of Responses to Item 8 "in my experience barriers to guided IBL include a lack of confidence in a teacher toward using guided IBL" (n = 36)



These results were further verified once in Item 6 "in regard to the items in question 5, please use the text box below if you wish to expand on one or more of your answers" with the comment "Students have to be explicitly taught the skills needed for Inquiry Based learning, this depends on the teacher's confidence, support from other staff/community, and the student's engagement and ability" (Item 6 sample response 14) which supports the conclusion that teacher confidence affects guided IBL implementation.

4.5 Student Factors

Figure 2.2 contains all of the factors discussed in the literature review that can act as enablers or barriers to the implementation of all types of IBL in science education. Figure 2.2 groups these factors into teacher developmental factors, teacher attribute factors, student factors and other educational factors.

Participant perceptions regarding the impact of "student factors" on *guided* IBL implementation within the delivery of NSW secondary science curriculum will be presented in this section. These factors include:

- Student and parent expectations
- Student behaviour and motivation
- Student prior knowledge and skills

4.5.1 Participant Perceptions in Regard to Student Factors

Responses to Items 5, 6, 8, 9 and 11 indicate that participants believe Student behaviour, motivation, prior knowledge and skills can be enablers and barriers to guided IBL implementation. Student and parent expectations are not seen as clear barriers or enablers to guided IBL implementation. These factors will be discussed further in the following sub-sections.

Figure 4.23 shows the mean scores for Item 5 "In this section, please indicate the extent to which you agree or disagree with each statement, in relation to the implementation of guided IBL in science classrooms. Guided IBL is enabled by….". Figure 4.24 shows the mean scores for Item 8 "In this section, please indicate the extent to which you agree or disagree with each statement, again, in relation to the implementation of guided IBL in science classrooms. In my experience barriers to guided IBL include …". Item 5 and 8 asked participants to indicate their agreement to this statement on a 5 point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree or 5 = strongly agree).

Figure 4.23

Mean Value of Responses (and Standard Deviations) for Item 5 "guided IBL is enabled by…"

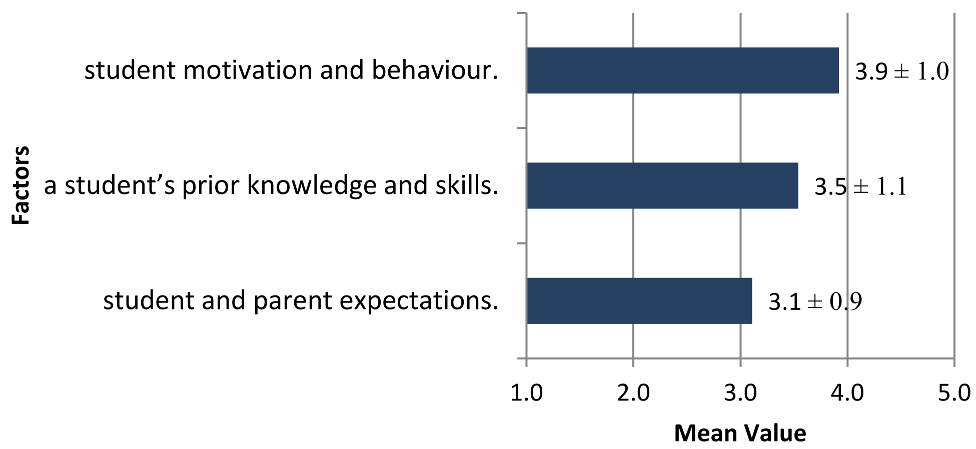
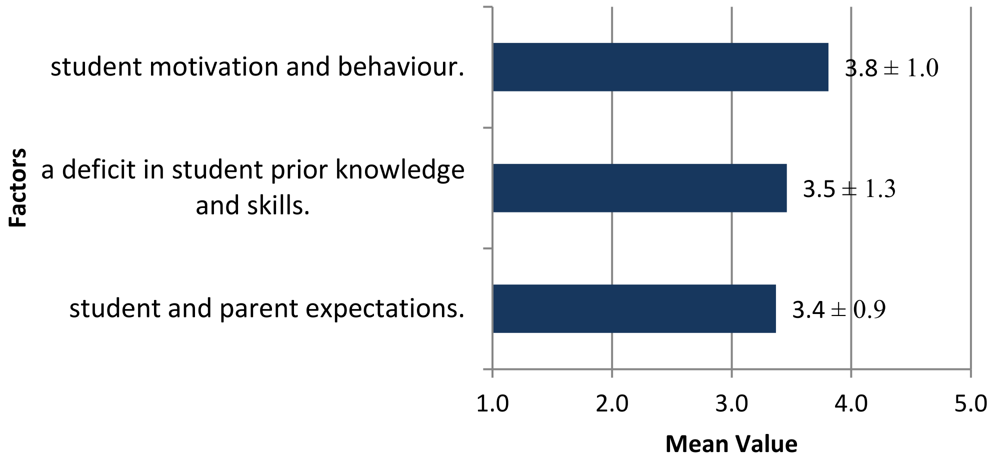


Figure 4.24

Mean Value (and Standard Deviation) of Responses for Item 8 "In my experience barriers to guided IBL include ..."



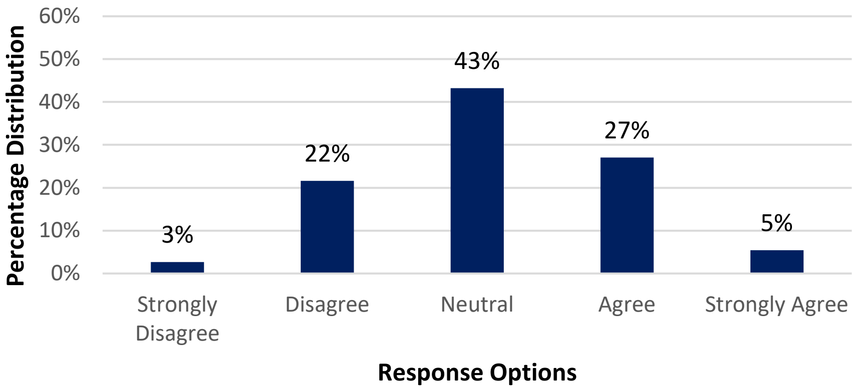
The data in Figures 4.23 and 4.24 does not indicate participant agreement that these three student factors are enablers or barriers to guided IBL implementation. The percentage distribution of results for these factors gives greater detail and indicates a slightly different result, as discussed in the following sub-sections.

4.5.2 Student and Parent Expectations

In regard to the impact of student and parent expectations being enablers to the implementation of guided IBL, participant responses trended toward neutrality (43%) with similar agree (27%) and disagree (22%) responses and only 8% strongly agreeing or disagreeing disagreement (see Figure 4.25).

Figure 4.25

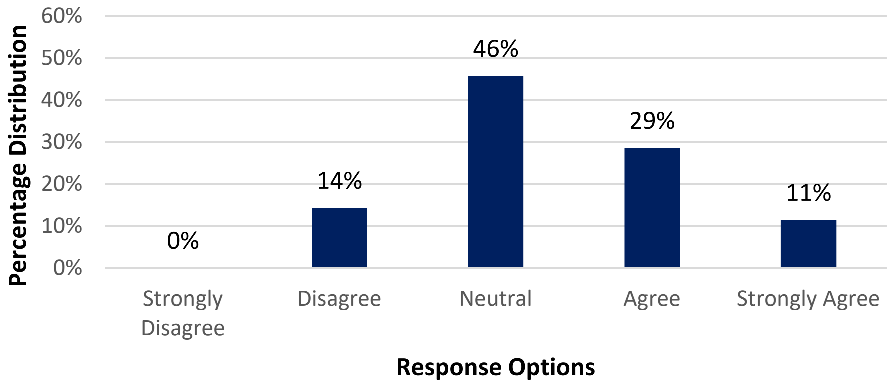
Percentage Distribution of Responses to Item 5 "guided IBL is enabled by student and parent expectations" (n = 37)



In regard to the impact of student and parent expectations being barriers to the implementation of guided IBL participant responses again trended toward neutrality (46%) with similar agreement (32% combined agree and strongly agree) and disagreement (25% combined disagree and strongly disagree) (see Figure 4.26).

Figure 4.26

Percentage Distribution of Responses to Item 8 "in my experience barriers to guided IBL include student and parent expectations" (n=37)



The following comment tends to describe parent and student expectations as having a negative impact on guided IBL implementation "Parents and students do not care about IBL, unless its importance is explained to them. Many students get anxious when we do not follow the textbook" (Item 6 sample response 12). This response was the only open response linked to parent and student expectations. Considering this lone comment in the context of the results in Items 5 and 8 it is not enough to interpret this factor as having an effect on guided IBL implementation. The comment could initiate further future investigation into the effect of parent and student expectations on guided IBL implementation.

4.5.3 Student Behaviour and Motivation

Participants agree that student behaviour and motivation can be both an enabler and barrier to guided IBL implementation.

The results to Item 5 show agreement (65% combined strongly agree and agree) to the statement that guided IBL is enabled by student behavior and motivation (see Figure 4.27).

Figure 4.27

Percentage Distribution of Responses to Item 5 "guided IBL is enabled by student motivation and behaviour" (n=37)

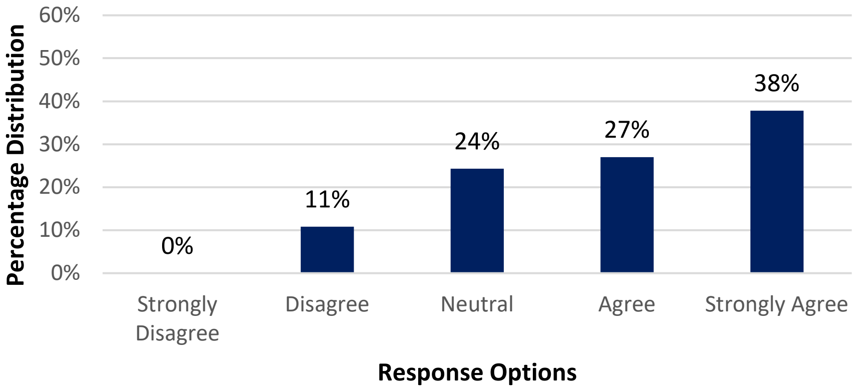
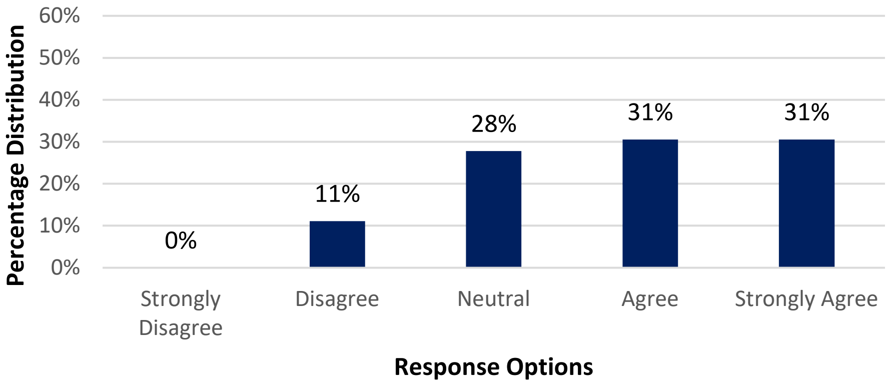


Figure 4.28

Percentage Distribution of Responses to Item 8 "in my experience barriers to guided IBL include student motivation and behaviour" (n=37)



The results to Item 8 also show agreement (62% combined strongly agree and agree) to the statement “In my experience barriers to guided IBL include student behavior and motivation” (see Figure 4.28). The implied assumption is that participants saw item eight as a question that was asking whether “poor” student behaviour and motivation is a barrier to guided IBL implementation. This assumption is somewhat further verified in Item 6 with comments like “Student motivation is very important along with planning time” (Item 6 sample response 12).

4.5.4 Student Prior Knowledge and Skills

Participant responses to this factor trend slightly towards agreement that student prior knowledge and skills are both an enabler and also a barrier to guided IBL.

The results to Item 5 show both agreement (46% combined strongly agree and agree) and 41% neutrality to the statement that guided IBL is enabled by student prior knowledge and skills (see Figure 4.29) although responses are varied.

The results to Item 8 are similar showing both agreement (45% combined strongly agree and agree) and neutrality (31%) to the statement that student prior knowledge and skills are barriers to guided IBL implementation (see Figure 4.30) although responses are varied.

Figure 4.29

Percentage Distribution of Responses to Item 5 "guided IBL is enabled by a student's prior knowledge and skills" (n=37)

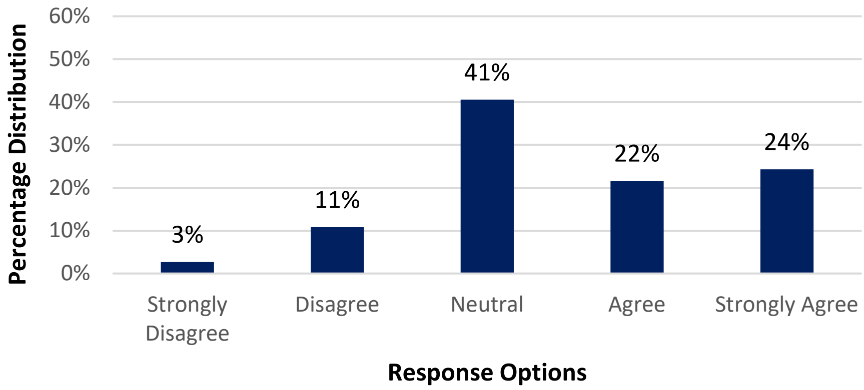
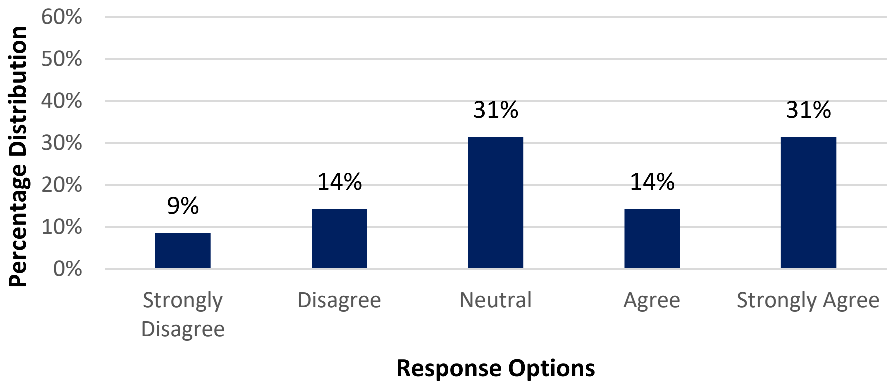


Figure 4.30

Percentage Distribution of Responses to Item 8 "in my experience barriers to guided IBL include a deficit in student prior knowledge and skills" (n=36)



Item 6 results tend to indicate that a deficit in student knowledge and skills is a barrier to guided IBL implementation, as seen in comments such as "Content and skills have to be taught first. There is very little time after this" (Item 6 sample response 16) and "Overcrowded curriculum and demands of assessment tasks etc., students lacking knowledge and skills becomes a major factor in running enquiry based lessons" (Item 6 sample response 2). Comments such as this support the results in Items 5 and 8 and slightly trend toward the conclusion that student prior knowledge and skills do affect the implementation of guided IBL.

4.6 Other Educational Factors

Figure 2.2 contains all of the factors discussed in the literature review that can act as enablers or barriers to implementation of all types of IBL in science classrooms. Figure 2.2 groups these factors into teacher developmental factors, teacher attribute factors, student factors and other educational factors.

Participant perceptions regarding the impact of "other educational factors" on *guided* IBL implementation within the delivery of NSW secondary science curriculum will be presented in this section. These factors include textbooks and teaching resources, laboratory resources and equipment, NESA syllabi and requirements, external and state wide assessments, internal school assessments, whole school programs and curriculum, classroom and instructional time, programming and planning time as well as science teaching colleagues, supervisors and senior executive.

4.6.1 Participant Perceptions in Regard to Other Educational Factors

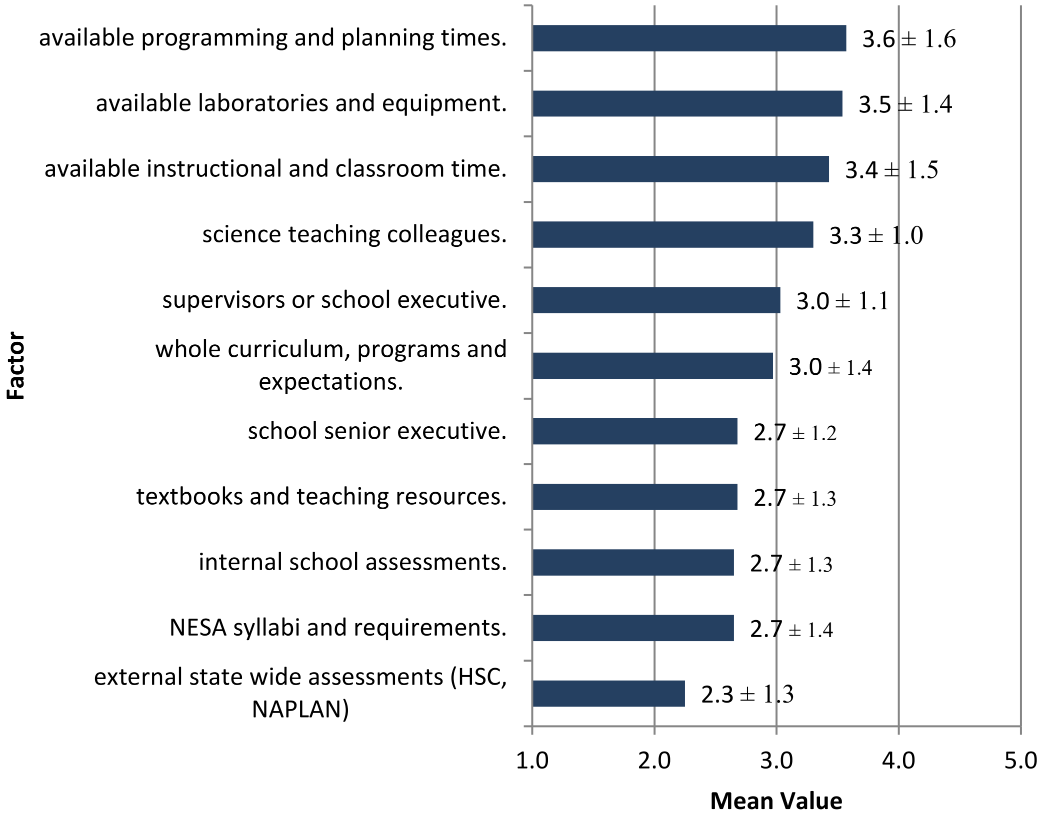
Responses to Items 5, 6, 8, 9 and 11 indicate that participants believe that available laboratory resources and equipment, available classroom and instructional time, available programming time and available planning time are **enablers and barriers** to guided IBL implementation, depending on the availability of the factors. Participants also believe that two factors; NESA syllabi and requirements as well as external and state wide assessments **are barriers** to guided IBL implementation.

Results also indicate that participants believe that textbooks and teaching resources, internal school assessments, whole school programs and curriculum, Science teaching colleagues, supervisors and senior executive **are not clear barriers or enablers** to guided IBL implementation. These factors will be discussed further in the following sub-sections.

Figure 4.31 shows the mean scores for Item 5 “In this section, please indicate the extent to which you agree or disagree with each statement, in relation to the implementation of guided IBL in science classrooms. Guided IBL is enabled by….”. Item five asked participants to indicate their agreement to this statement on a 5 point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree or 5 = strongly agree).

Figure 4.31

Mean Value of Responses (and Standard Deviations) for Item 5 "guided IBL is enabled by…"



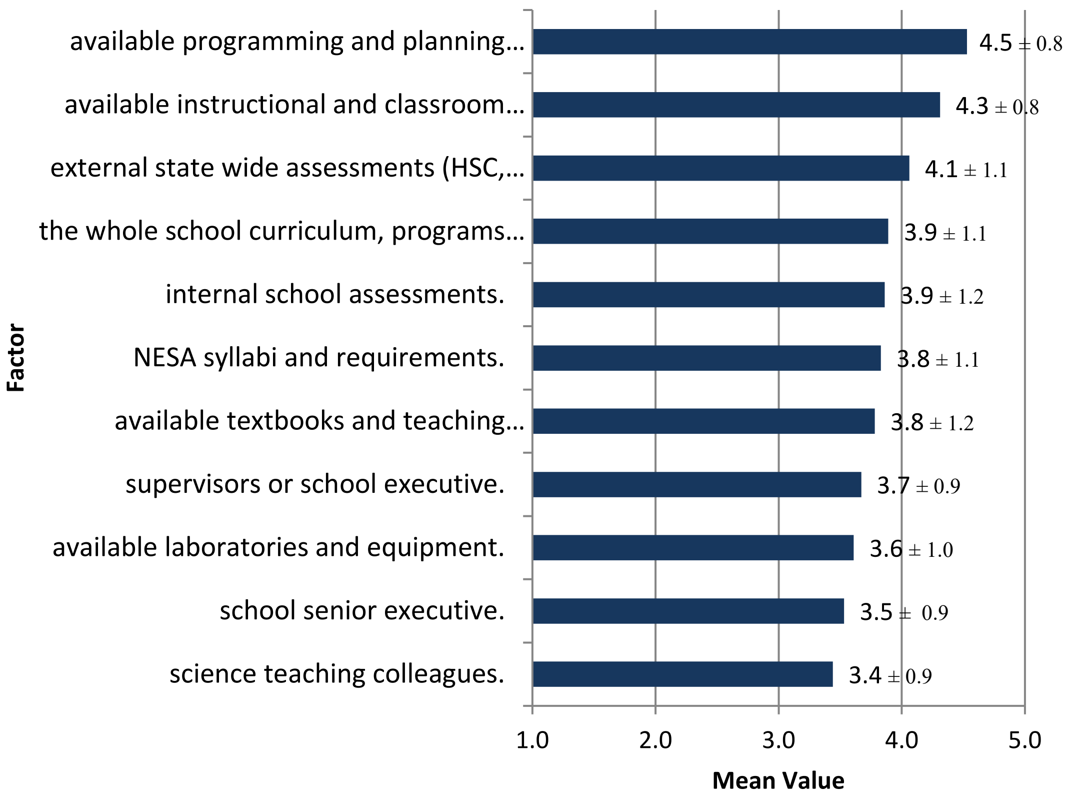
The data in Figure 4.31 indicates that two educational setting factors; student motivation and behaviour and available programming and planning times had item mean score from participants closer to the agree range and therefore possible agreement that these factors are enablers of guided IBL.

Figure 4.31 also indicates that the educational setting factor of external state wide assessments (HSC, NAPLAN) had a low mid-range mean value of 2.3. This indicates a mean score from participants closer to the disagree range and therefore possible disagreement that this factor is an enablers of guided IBL implementation, therefore it is possibly a barrier to guided IBL implementation.

Figure 4.32 shows the mean scores for Item 8 "In this section, please indicate the extent to which you agree or disagree with each statement, again, in relation to the implementation of guided IBL in science classrooms. In my experience barriers to guided IBL include …". Item 8 asked participants to indicate their agreement to this statement on a 5 point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree or 5 = strongly agree).

Figure 4.32

Mean Value (and Standard Deviation) of Responses for Item 8 "in my experience barriers to guided IBL include …"



The data in Figure 4.32 indicate that three educational setting factors; available programming and planning time, available instructional and classroom time and external state wide assessments had item mean scores from participants in the agree to strongly agree range and therefore agreement that these factors are **barriers** to guided IBL implementation.

4.6.2 Textbooks and Teaching Resources

Participant perceptions indicate that textbooks and teaching resources do not influence guided IBL implementation. The results to Item 5 show 49% of participants disagree (strongly disagree and disagree), 25% agree (strongly agree and agree) and 27% are neutral to the statement that guided IBL is enabled by textbooks and teaching resources (see Figure 4.33). The results to Item 8 also show 51% agreement, 22% neutral and 17% disagreement to the statement "In my experience barriers to guided IBL include available textbooks and teaching resources." (See Figure 4.34).

Figure 4.33

Percentage Distribution of Responses to Item 5 "guided IBL is enabled by textbooks and teaching resources" (n = 37)

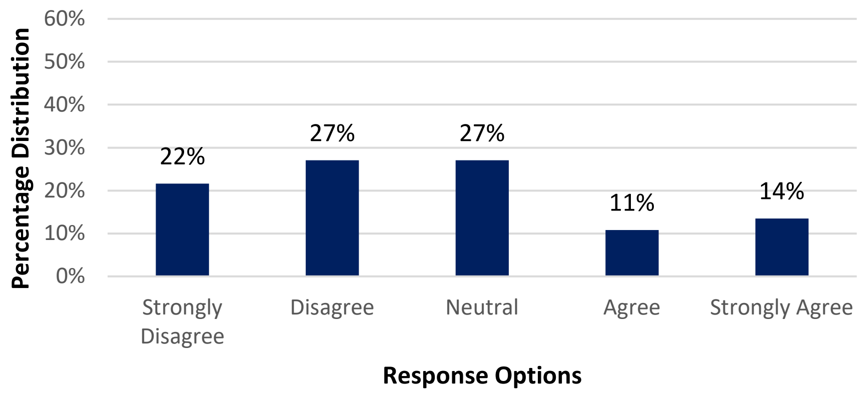
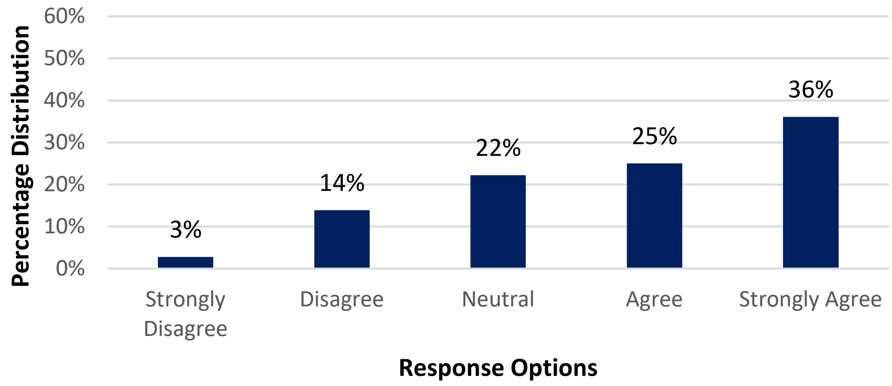


Figure 4.34

Percentage Distribution of Responses to Item 8 "in my experience barriers to guided IBL include available textbooks and teaching resources" (n = 36)



In 2006 Goodrum reported on a pilot study called the Collaborative Australian Secondary Science Program (CASSP) and in 2011 Goodrum, Druhan and Abbs produced the report *The Status and Quality of Year 11 and 12 Science in Australian Schools*. Both reports recommended that IBL implementation would be supported by the development of inquiry-based resources for classroom use. The data in Figures 4.33 and 4.34 seem to indicate a balanced view toward available textbooks and teaching resources being neither barriers or enablers to guided IBL implementation. A closer look indicates that available textbooks and teaching resources might be slight barriers to the implementation of guided IBL. This data may somewhat indicate that textbooks and teaching resources supportive of guided IBL would enable IBL implementation but the data is not conducive to a solid conclusion.

4.6.3 Laboratory Resources and Equipment

Participants agree (65% and 55%) that available laboratories and equipment affect guided IBL implementation. The results to Item 5 show 65% agreement (strongly agree and agree) to the statement that guided IBL is enabled available laboratories and equipment (see Figure 4.35). The results to Item 8 also show 55% agreement (strongly agree and agree) to the statement "In my experience barriers to guided IBL include available laboratories and equipment." (See Figure 4.36).

Figure 4.35

Percentage Distribution of Responses to Item 5 "guided IBL is enabled by available laboratories and equipment" (n=37)

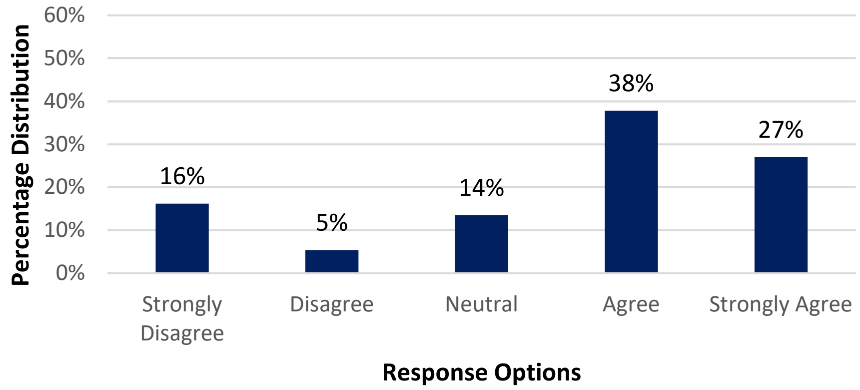
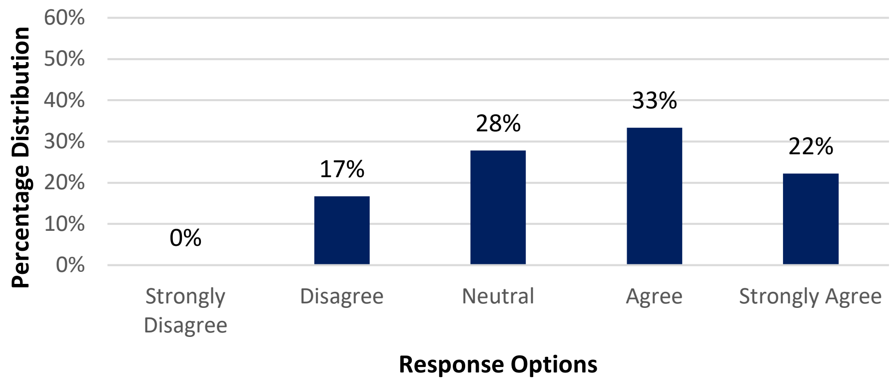


Figure 4.36

Percentage Distribution of Responses to Item 8 "in my experience barriers to guided IBL include available laboratories and equipment" (n = 36)



These results seem contradictory. Comments in Item 6 “in regard to the items in question 5, please use the text box below if you wish to expand on one or more of your answers” seems to indicate that Item 5 has been interpreted in a positive way by participants and Item 8 in a negative way. An example comment such as “I find limited resources and time decrease the likelihood of guided IBL” (Item 6 sample response 8) indicates a lack of resources is a barrier to guided IBL implementation. This participant that stated Item 6 sample response 8 also selected “disagree” for Item 8 “In my experience barriers to guided IBL include available laboratories and equipment”. This would indicate that participants interpreted Item 8 (see Appendix) in a way that means “in my experience barriers to guided IBL include *the lack of* available laboratories and equipment.”

A multitude of authors have discussed and reported on the need for available resources to enable the successful implementation of IBL in science (Anderson, 2002; Bevens & Price, 2016; Goodrum et al., 2001; Goodrum, 2006; Goodrum et al., 2011). Participant perceptions in this study support this argument in regard to guided IBL implementation being enabled by sufficient laboratory resources and equipment.

4.6.4 Classroom and Instructional Time

Participant perceptions indicate that available instructional and classroom time is a factor that affects guided IBL implementation. Whilst the results to Item 5 show partial contradictory agreement (combined strongly agree and agree = 60%) and disagreement (combined strongly disagree and disagree = 30%) to the statement that guided IBL is enabled by available instructional and classroom time (see Figure 4.37) the results to Item 8 provide clarification showing agreement (combined strongly agree and agree =

91%) to the statement "In my experience barriers to guided IBL include available instructional and classroom time." (See Figure 4.38).

Figure 4.37

Percentage Distribution of Responses to Item 5 "guided IBL is enabled by available instructional and classroom time" (n=37)

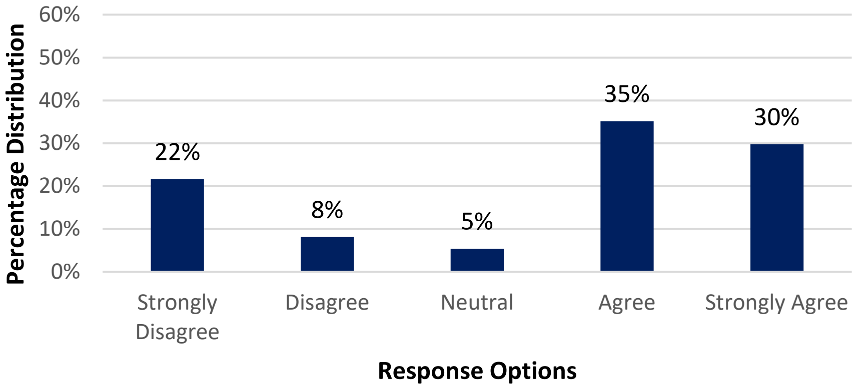
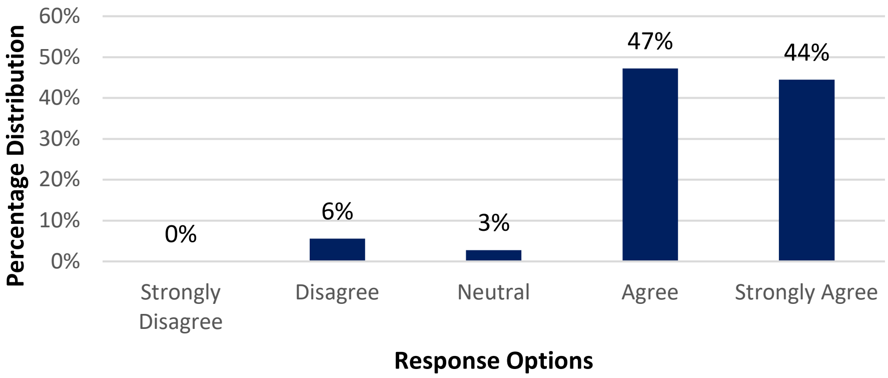


Figure 4.38

Percentage Distribution of Responses to Item 8 "in my experience barriers to guided IBL include available instructional and classroom time" (n=36)



Comments in Item 6 “in regard to the items in question 5, please use the text box below if you wish to expand on one or more of your answers” and Item 9 “in regard to the items in question 8, please use the text box below if you wish to expand on one or more of your answers”, further confirm the quantitative analysis, with comments such as “The HSC and senior syllabuses place huge content burdens on instructional time” (Item 9 sample response 1), “IBL is more difficult in the stage 6 due to time constraints as well as syllabi constraints” (Item 6 sample response 1), “NESA syllabuses do not allow for adequate instructional time in Stage 6” (Item 6 sample response 4) and “The new HSC syllabuses for chemistry and physics are content heavy meaning that anything more than normal practicals is hard to do” (Item 6 sample response 5). These comments indicate that available classroom time is a factor that affects guided IBL implementation.

These comments also create a link between available instructional time and syllabus demands. For example the following comment creates this link between syllabus requirements and available instructional time and the impact of this link on guided IBL enactment:

> The biggest barrier to IBL is syllabus demands and the time needed to truly incorporate Inquiry into lessons. By the time students research, plan, experiment, repeat, reflect, redo and analyse results you have used up several teaching hours. Every hour becomes very precious in Stage 6 with a definitive time frame that cannot be changed. (Item 9 sample response 12)

This link between syllabus demands, instructional time and guided IBL enactment will be discussed further in the next subsection and in Chapter 5.

4.6.5 NESA Syllabi and Requirements

The results to Item 5 show varied disagreement (strongly disagree and disagree = 51%), neutrality (22%) and agreement (strongly agree and agree = 27%) to the statement that guided IBL is enabled by NESA syllabi and requirements (see Figure 4.39). In comparison, the results to item eight show more agreement (strongly agree and agree = 56%) than disagreement (strongly disagree and disagree = 14%) to the statement "In my experience barriers to guided IBL include NESA syllabi and requirements" (see Figure 4.40).

Figure 4.39

Percentage Distribution of Responses to Item 5 "guided IBL is enabled by NESA syllabi and requirements" (n=37)

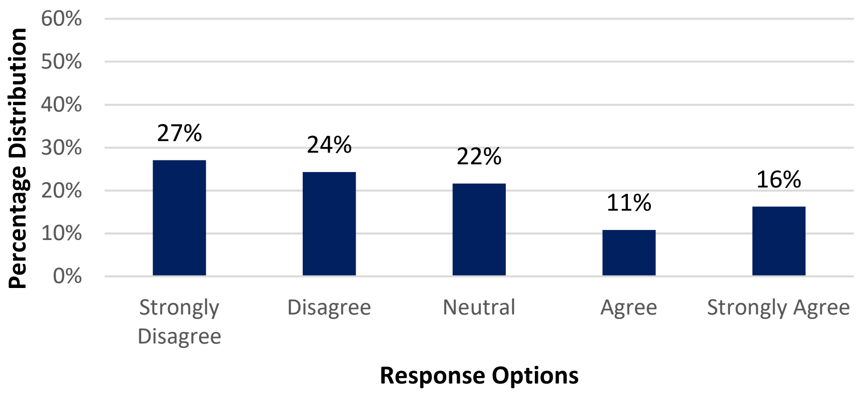
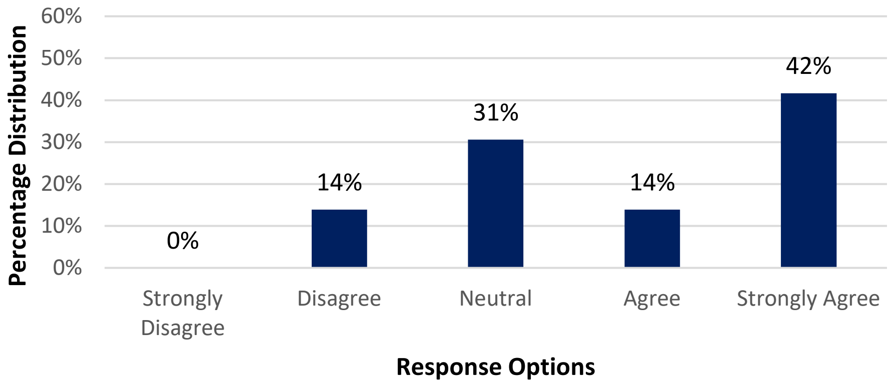


Figure 4.40

Percentage Distribution of Responses to Item 8 "in my experience barriers to guided IBL include NESA syllabi and requirements" (n=36)



Results for Item 5 and 8 appear to indicate that NESA syllabi and requirements are a barrier to guided IBL implementation. These results were supported by comments in Item 6 "in regard to the items in question 5, please use the text box below if you wish to expand on one or more of your answers" (see Appendix). Responses to Item 6 indicated that NESA syllabi and requirements are barriers to guided IBL implementation. Examples include "The new HSC syllabus is awful and does nothing to support IBL or practicals. The depth study is a joke as it is crammed into a content heavy syllabus" (Item 6 sample response 10) and "The new stage 6 syllabuses are content heavy and are not good for allowing IBL" (Item 6 sample response 6).

Responses to Item 9 "in regard to the items in question 8, please use the text box below if you wish to expand on one or more of your answers" indicated a similar theme with comments such as "The new stage 6 syllabus is a large barrier to IBL" (Item 9 sample response 7) and "The New stage syllabus is a large barrier toward Inquiry and practicals in general. The new syllabi are content heavy and the depth study does nothing to relieve this, it has just been added to the content" (Item 9 sample response 8).

In 2011 Goodrum et al., reported on *The Status and Quality of Year 11 and 12 Science in Australian Schools*. The report detailed a study that attempted to create a clear picture of Australian senior high school science and utilised data from focus groups, surveys and a case study. The report detailed numerous barriers to IBL in senior years science including content laden senior curriculums, assessment focussed on content and insufficient instructional time. The report also recommended adequate time for inquiry skill based assessment and decreased senior science content.

In 2018, NSW schools started to deliver the new NESA senior science syllabuses. These new syllabuses are designed with an emphasis on student inquiry, with inquiry questions throughout each module and mandatory depth studies in both the preliminary and HSC modules for all senior science courses. However, participant comments in this study suggest that NESA syllabuses are barriers to guided IBL implementation. Further investigation into this factor would be an interesting area of further research.

4.6.6 External State Wide Assessments

Participants agree (strongly agree 53% and agree 11% = 64%) that external state wide assessments are barriers to guided IBL implementation they also disagree (combined strongly disagree 42% and disagree 17% = 59%) that external state wide assessments are enablers of guided IBL implementation. The results to Item 5 show disagreement (combined strongly disagree and disagree = 59%) to the statement that guided IBL is enabled by external state wide assessments (HSC, NAPLAN) (see Figure 4.41). Conversely, the results to Item 8 show agreement (strongly agree and agree =

64%) to the statement “In my experience barriers to guided IBL include external state wide assessments (HSC, NAPLAN)” (see Figure 4.42).

Figure 4.41

Percentage Distribution of Responses to Item 5 “guided IBL is enabled by external state wide assessments (HSC, NAPLAN)” (n=37)

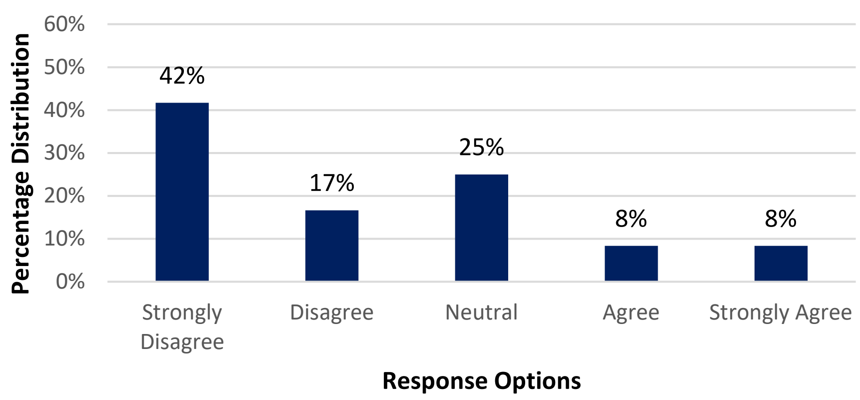
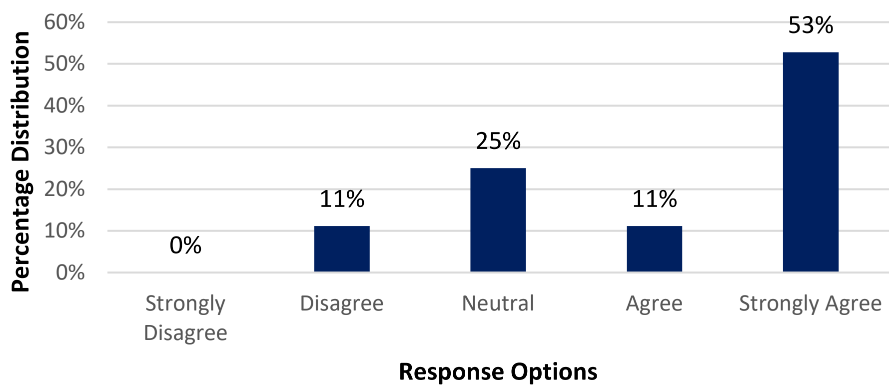


Figure 4.42

Percentage Distribution of Responses to Item 8 “in my experience barriers to guided IBL include external state wide assessments (HSC, NAPLAN)” (n=36)



These results were further verified in Item 9 “in regard to the items in question 8, please use the text box below if you wish to expand on one or more of your answers” with comments like “The HSC does not value guided inquiry” (Item 9 sample response 2), “HSC content demands limit guided IBL and genuine investigations” (Item 9 sample response 6) and

> NESA/external exams like the HSC do not seem to test much IBL at all, so it's up to the teachers to see the importance of the skills learnt. I think that when teachers embrace IBL and teach these long term skills needed in research labs for example, the students benefit a lot in the future, but this would not necessarily be reflected in the HSC exams. Therefore it is hard for teachers to justify spending a lot of time on IBL. (Item 9 sample response 10)

The combined results from Items 5, 8 and 9 indicate that participants perceive external state wide assessments (HSC, NAPLAN) as barriers to guided IBL implementation. This is similar to participant perceptions regarding the science syllabuses and syllabus requirements in sub-section 4.6.5. This is a surprising result considering these new syllabuses in NSW are designed with an emphasis on student inquiry, with inquiry questions throughout all senior science courses (NESA, 2017). Participant comments seem to indicate it is the amount of perceived content and not the content itself that is the barrier to guided IBL implementation. Furthermore, participants seem to consider that the senior science syllabuses are too large or lengthy to allow time for guided IBL enactment to take place. Considering the new NSW science syllabuses appear designed to enable student inquiry the findings from this study should be further investigated in future studies.

4.6.7 Programming and Planning Time

Participant responses indicate that programming and planning time is a factor that affects the implementation of guided IBL. The results to Item 5 (see Appendix) show overall agreement (strongly agree 43% and agree 22% = 65%) to the statement that guided IBL is enabled by available programming ad planning time (see Figure 4.43). The results to Item 8 also show agreement (strongly agree 64% and agree 31% = 95%) to the statement "In my experience barriers to guided IBL include available programming and planning time" (see Figure 4.44).

Figure 4.43

Percentage Distribution of Responses to Item 5 "guided IBL is enabled by available programming and planning time" (n=37)

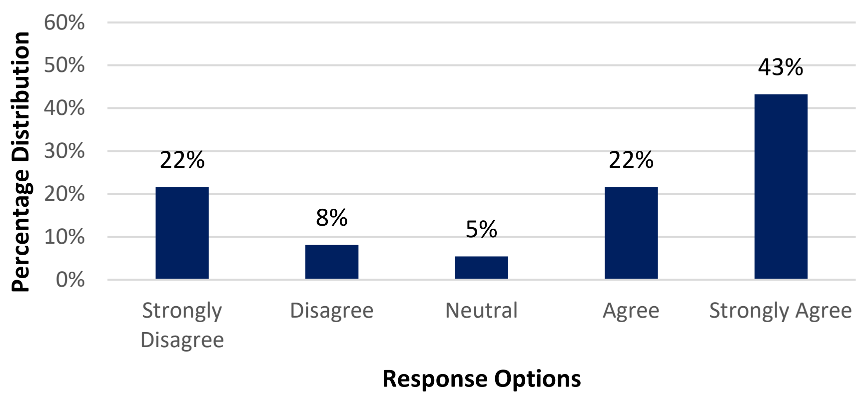
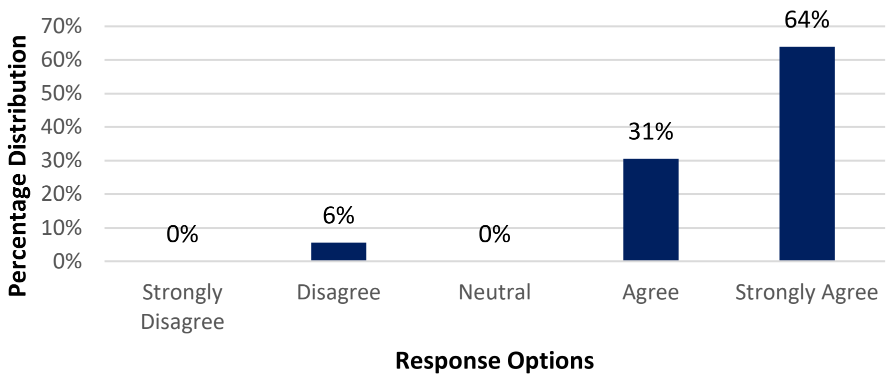


Figure 4.44

Percentage Distribution of Responses to Item 8 "in my experience barriers to guided IBL include available programming and planning time" (n=36)



These results in Item 8 seem confusing at first but the comments to Item 9, seem to indicate that Item 8 was perceived by participants to state that "a lack of programming and planning time is a barrier" or "current (insufficient) programming and planning time is a barrier". Item 9 comments include examples such as "planning time is not available and is needed to help plan Inquiry type lessons" (Item 9 sample response 3). Looking closely at the raw data it showed that the participant that stated Item 9 sample response 3 also selected "strongly agree" for Item 8 " In my experience barriers to guided IBL include available programming and planning time". Therefore this indicates that Item 8 was perceived by this participant to mean "a *lack* of programming and planning time is a barrier".

Another participant seemed to also state a conflicting comment. This comment was "Time factors are always there impinging on preparation of lessons especially if IBL is to be used more regularly, i.e. once a week" (Item 9 sample response 14). This participant that stated Item 9 sample response 14 also selected "agree" to Item 8, therefore the comment seems to contradict the Item 8 response and it is possible that

Item 8 was again interpreted to mean a *deficit* in available programming and planning time.

The combined results from Items 5, 8 and 9 indicate that participants find available programming and planning time as an enabler to guided IBL implementation and a lack of available programming and planning time as a barrier to guided IBL implementation.

4.6.8 Internal School Assessments

Participant results to Item 5 show a variety of perceptions in regard to the statement that guided IBL is enabled by internal school assessments with 51% disagreement (combined strongly disagree and disagree), 16% selecting neutral and 33% agreeing (combined agree and strongly agree) (see Figure 4.45). In comparison, the results to Item 8 show more agreement (strongly agree and agree = 64%) to the statement "In my experience barriers to guided IBL include internal school assessments." (See Figure 4.46).

Figure 4.45

Percentage Distribution of Responses to Item 5 "guided IBL is enabled by internal school assessments" (n=37)

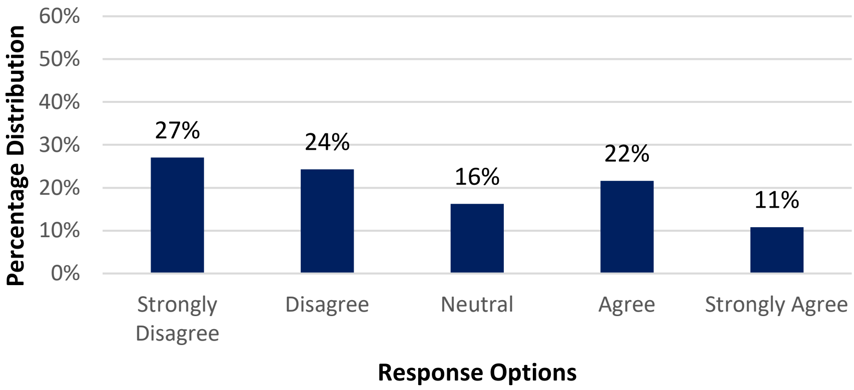
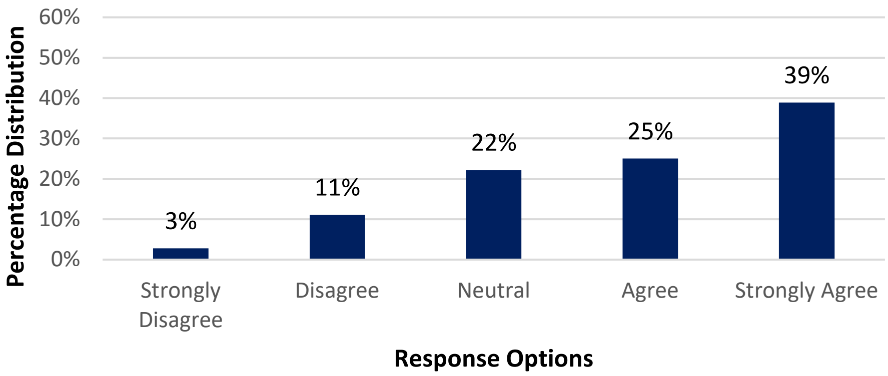


Figure 4.46

Percentage Distribution of Responses to Item 8 "in my experience barriers to guided IBL include internal school assessments" (n=36)



Therefore the trends in the data indicate that participants view internal school assessments as a slight barrier to IBL implementation. Comments were not provided in any open responses in regard to internal school assessments. Possibly this question could have delved into formal compared to informal faculty created assessments, instead of using the term school assessments. Pilot testing of the survey did not pick up this ambiguity.

4.6.9 Whole School Programs and Curriculum

Participant results to Item 5 show varied disagreement (41% combined disagree and strongly disagree), neutrality and agreement (49% combined agree and strongly agree) to the statement that guided IBL is enabled by whole school curriculum, programs and expectations (see Figure 4.47). These results to Item 5 are inconclusive as to agreement or disagreement. Alternatively, there is a clear trend in responses to Item 8 which show agreement (64% combined agree and strongly agree) that whole school curriculum, programs and expectations are a barrier to IBL implementation see Figure 4.48 and following comments.

Figure 4.47

Percentage Distribution of Responses to Item 5 "guided IBL is enabled by the whole school curriculum, programs and expectations" (n=37)

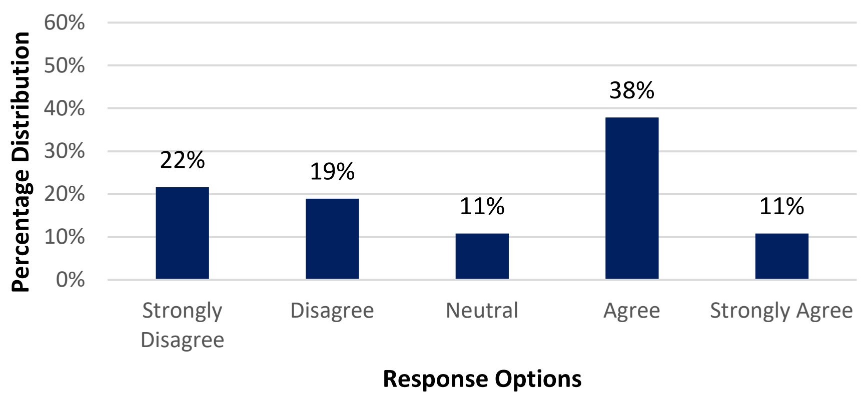
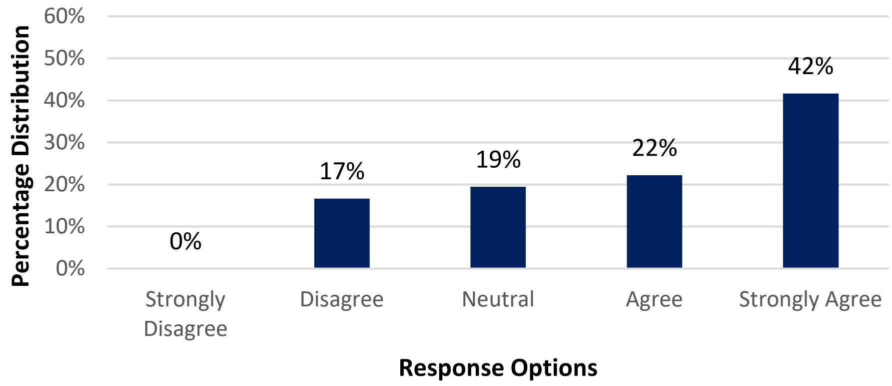


Figure 4.48

Percentage Distribution of Responses to Item 8 "in my experience barriers to guided IBL include the whole school curriculum, programs and expectations" (n=36)



Item 6 "in regard to the items in question 5, please use the text box below if you wish to expand on one or more of your answers" contributes more clarity to the results of Item 8. Open responses indicated that whole school programs do not enable guided IBL implementation. The following comments indicates that other priorities may conflict with guided IBL implementation "School programs focus on literacy and numeracy and not things like Inquiry based learning" (Item 6 sample response 3), "Our school priorities leave little room for exploring IBL with classes" (Item 9 sample response 4) and "internal school priorities place more value on literacy and numeracy then thinking and Inquiry skills" (Item 9 sample response 11). Whilst these open question responses indicate that whole school priorities may conflict with participants' opportunities to implement guided IBL, analysis of all the data (Figure 4.47) does not support that conclusion. It could be that some schools may have whole school programs or priorities that support the use of pedagogies such as guided IBL whilst other schools may have priorities that may inhibit guided IBL.

4.6.10 Science Teaching Colleagues, Supervisors and Senior Executive

Participant results trend toward neutrality in regard to the impact of their science teaching colleagues, supervisors and school senior executive to the implementation of guided IBL (see Figures 4.49 and 4.50). The results to Item 5, in relation to science teaching colleagues, supervisors and school senior executive, have been averaged in Figure 4.49 due to similar responses, a similar theme and in the interest of conciseness. This averaging was repeated for Item 8, for the same reasons, in Figure 4.50.

Figure 4.49

Average Percentage Distribution of Responses to Item 5 in Relation to Science Teaching Colleagues, Supervisors and School Senior Executive (n=37)

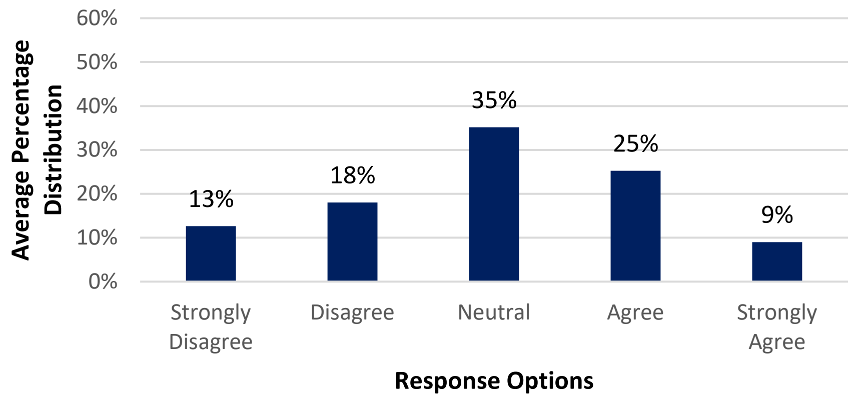
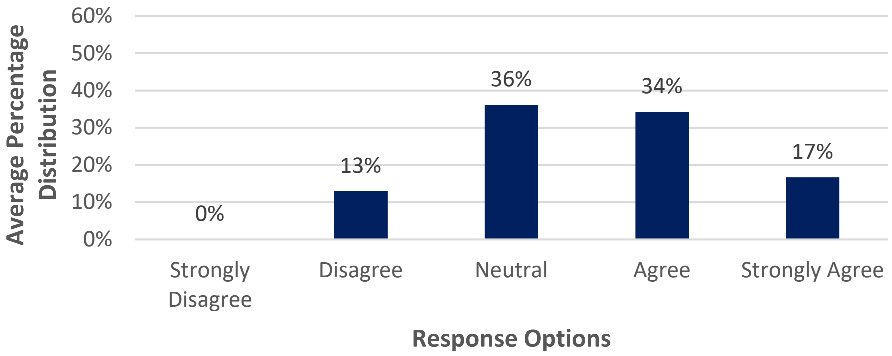


Figure 4.50

Average Percentage Distribution of Responses to Item 8 in Relation to Science Teaching Colleagues, Supervisors and School Senior Executive (n=36)



In regard to the impact of science teaching colleagues being barriers or enablers of guided IBL implementation, participants' survey responses to items five and eight trended toward neutrality (35% and 42%). This data shows that teacher participants perceive science teaching colleagues are not factors that affect guided IBL implementation. These results, in regards to colleagues effect on guided IBL implementation, were further supported by a comment in item six "in regard to the items in question 5, please use the text box below if you wish to expand on one or more of your answers". This comment stated "It's an individual decision. If you are passionate about IBL, you will use even if your colleagues are not using it" (Item 6 sample response 17).

This neutrality can also be seen in regard to supervisors and school executive being barriers or enablers to the implementation of guided IBL, with participant responses trending toward neutrality (32% and 31%) in Items 5 and 8. There were no participant responses to the open questions in Items 6, 9 and 11 (see Appendix) in relation to supervisors' effect on guided IBL implementation. Therefore data in Item 8 shows participants perceive that supervisors or school executive are relatively neutral to guided IBL implementation.

A similar trend can be seen in regard to school senior executive being neutral to the implementation of guided IBL with participant responses to Items 5 and 8 trending toward neutrality (38% and 36%). Therefore, the overall data shows participants believe that supervisors or school executive do not affect the implementation of guided IBL.

4.7 What are the Most Important Factors for Guided IBL Implementation?

In this section the mean values for all of the factors tested in Items 5 and 8 will be presented to give a general comparison between all of these factors. This data will be viewed with the results of Item 11. Item 11 asked participants to "state what you believe is the most important factor for the implementation of guided IBL in science classrooms".

Figure 4.51 shows the mean scores for Item 5 "In this section, please indicate the extent to which you agree or disagree with each statement, in relation to the implementation of guided IBL in science classrooms. Guided IBL is enabled by….". Item 5 asked participants to indicate their agreement to this statement on a 5 point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree or 5 = strongly agree).

The data in Figure 4.51 indicate responses to items linked to three teacher attribute factors, Teachers personal beliefs toward IBL, Teacher confidence in using IBL and Teachers knowledge of IBL, all had large mean values of 4.43, 4.27 and 4.14 respectively. This indicates a mean score from participants in the agree to strongly agree range and therefore agreement that these factors are enablers of Guided IBL.

Figure 4.51 also shows participants strongly agree (mean between 4 and 5) that two teacher developmental factors are enablers of Guided IBL. These two teacher developmental factors are clear models, definitions and examples of guided IBL as well as professional development in guided IBL with mean responses of 4.3 and 4.22 respectively.

Figure 4.51

Mean Values of Responses to Survey Item 5 "guided IBL is enabled by…"

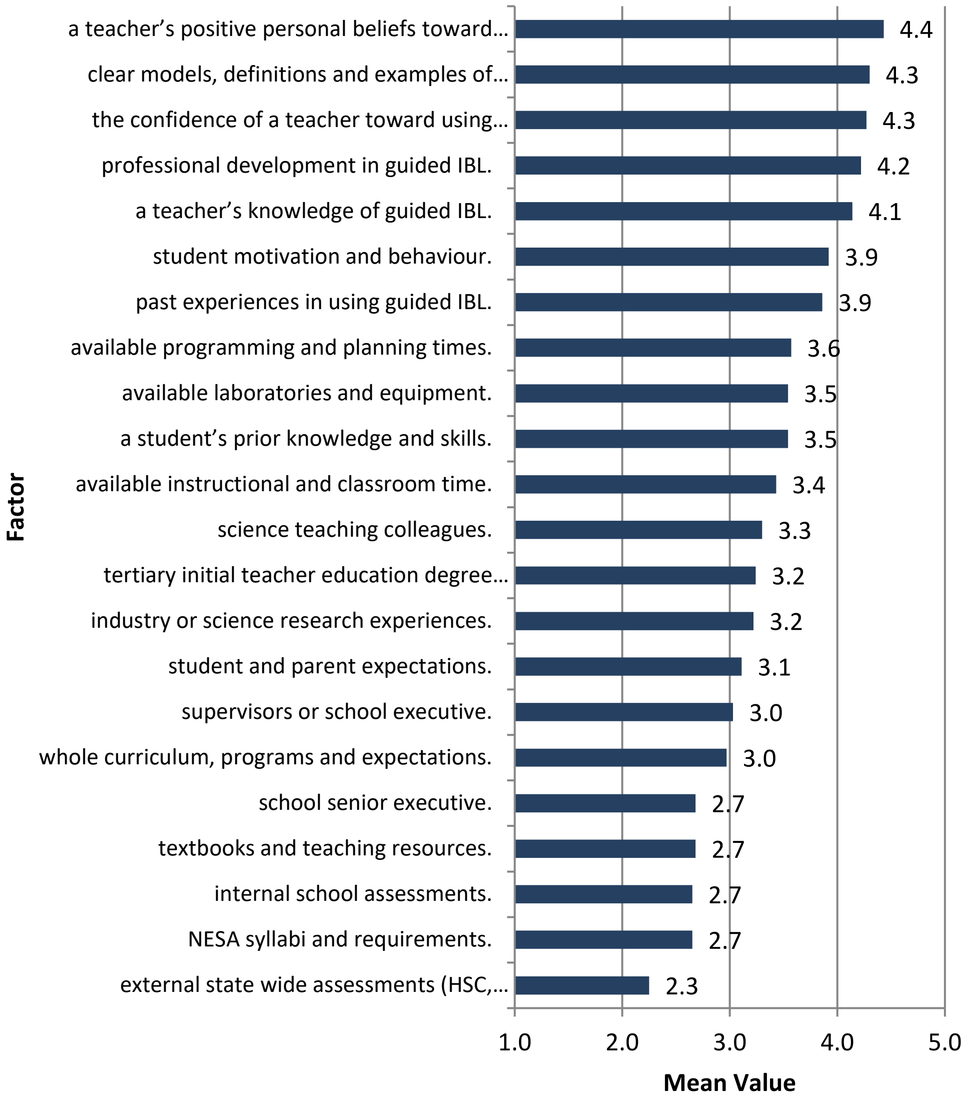


Figure 4.52 shows the mean scores for Item 8 "In this section, please indicate the extent to which you agree or disagree with each statement, again, in relation to the implementation of guided IBL in science classrooms. In my experience barriers to guided IBL include …". Item 8 asked participants to indicate their agreement to this statement on a 5 point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree or 5 = strongly agree).

Figure 4.52

Mean Values of Responses to Survey Item 8 "In my experience barriers to guided IBL include ..."

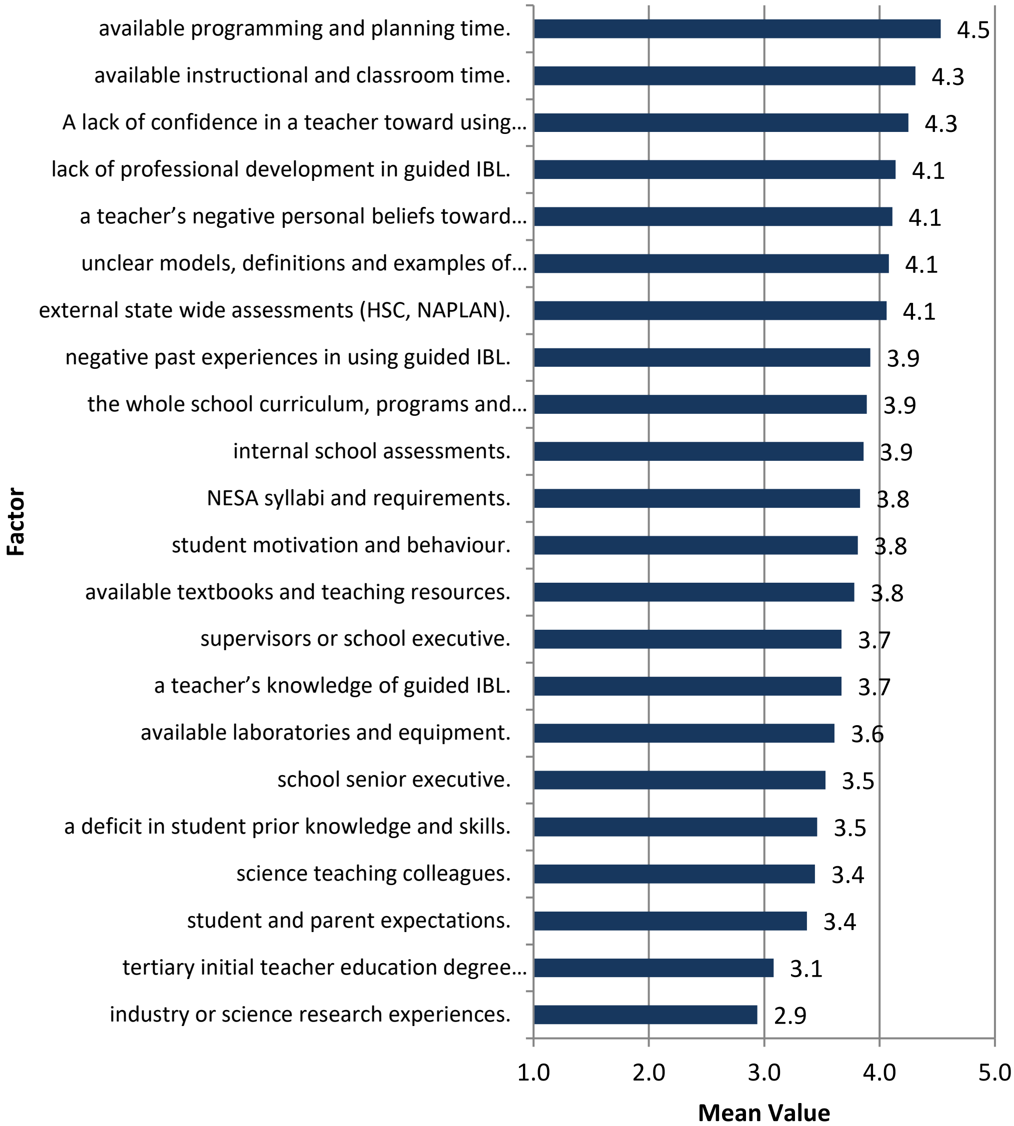


Figure 4.52 shows that, on average, participants agree to strongly agree (mean between 4 and 5) that seven factors are barriers to guided IBL implementation in the secondary science classroom. These factors are:

- available programming and planning time (mean = 4.5)
- available instructional and classroom time (mean = 4.3)
- a lack of confidence in a teacher toward using guided IBL (mean = 4.3)
- lack of professional development in guided IBL (mean = 4.1)
- a teachers negative personal beliefs toward guided IBL (mean 4.1)
- unclear models, definitions and examples of guided IBL (mean = 4.1)
- external state wide assessments (HSC, NAPLAN) (mean = 4.1)

Item 11 asked participants to "state what you believe is the most important factor for the implementation of guided IBL in science classrooms". The open ended nature of this item led to a variety of answers (see Table 4.1). Responses were grouped by common themes. Out of 39 participants, 27 responded to this question.

Table 4.1

Item 11 Response Themes and Count

Theme/Response group	Theme response count
Instructional time	7
Teacher confidence, attitude or positive belief	7
Syllabus or external exam as a barrier	4
Student motivation, knowledge or skills	3
Professional development and planning time	3
Resources and equipment	2
Numerous factors	1

Considering that Item 11 asked participants to identify the most important factor in guided IBL implementation the responses are intriguing. Seven participants stated that instructional time is the most important factor. For example Item 11 response 11 states

"Time - Instructional time in a content heavy stage 6 is burdensome and destroys the ability to do practicals" (Item 11 sample response 11). Seven participants also stated that teacher confidence, positive belief and attitude are the most important factors. One participant mentioned:

> The teacher needs to be persistent, even if they fail they need to collect feedback from student and peers and try again. There is no one size fits all you need to work out what works for you and your teaching style. (Item 11 sample response 21)

Four participants stated that external exams and syllabuses are barriers. A good example of this theme is Item 11 response 5, which states "The HSC and senior syllabuses are not supportive of guided inquiry" (Item 11 sample response 5).

Three participants stated that student motivation, knowledge or skills in the most important factor. Item 11 response 9 states "Students need to 'buy-in' and without this the lesson(s) are doomed to leave them confused and the teacher frustrated" (Item 11 sample response 9).

Three participants stated that professional development or planning time is the most important factor and two participants stated that resources and equipment are the most important factors. One participant stated that there are "too many factors".

The responses to these items verify the findings presented earlier and also present a possible new approach to investigating these factors in future studies. If schools are not able to improve all of these factors it may be worth knowing which factors are perceived to be most important and therefore focussing time and resources into those areas.

When the results from Items 5, 8 and eleven are combined, they indicate that the most important factors for guided IBL implementation are: available instructional time in the classroom to implement guided IBL, a positive attitude, confidence and belief in teachers to enact guided IBL and professional development in understanding and applying guided IBL.

4.8 Summary

Table 4.2 is a summation of the results and analysis of data related to the research aim of investigating teacher perceptions about the factors that enable them to use guided IBL pedagogy in the delivery of the NSW science curriculum.

The factor column in Table 4.2 has factors stated without positive or negative descriptions. Many of the factors analysed in the results section could be worded with positive or negative connotation, but in the interest of succinct reporting, they have been stated in neutral terms. For example the label "Models, definitions and examples of guided IBL" could have a positive connotation such as "Clear models, definitions and examples of guided IBL" and a negative connotation "Unclear models, definitions and examples of guided IBL".

The enabler and barrier column has 3 variants; agree, neutral and disagree. Agree, neutral and disagree represents overall participant perceptions that the factor can be an enabler or barrier, dependent on the circumstances discussed above. These labels represent a synthesis of all the information in Chapter 4. For further information on each factor please refer to the relevant sub-section in Chapter 4.

Table 4.2

Summary of Participant Perceptions in Regard to Enablers and Barriers of Guided IBL Implementation

Factor	enabler	barrier
Models, definitions and examples of guided IBL	Agree	Agree
Professional development in guided IBL	Agree	Agree
Industry or science research experience	Neutral	Neutral
Initial teacher education programs	Neutral	Neutral
Teacher personal beliefs	Agree	Agree
Teacher confidence	Agree	Agree
Teacher Knowledge	Agree	Agree
Teacher Past experience	Agree	Agree
Textbooks and teaching resources	Neutral	Neutral
Laboratory resources and equipment	Agree	Agree
NESA syllabi and requirements	Disagree	Agree
Internal School assessments	Neutral	Agree
External state wide assessments (HSC, NAPLAN)	Disagree	Agree
Whole school programs and curriculum	Neutral	Agree
Classroom and instructional time	Agree	Agree
Programming and planning time	Agree	Agree
Science teaching colleagues	Neutral	Neutral
School Executive	Neutral	Neutral
Student and parent expectations	Neutral	Neutral
Student behaviour and motivation	Agree	Agree
Student prior knowledge and skills	Agree	Agree

This chapter described the findings of the study. It started with a summary of key findings that address the questions: ‘How often do teachers utilise guided IBL in their classroom?’ and ‘What factors do teachers perceive as affecting the use guided IBL pedagogy in the delivery of the NSW science curriculum?’ It then provided detailed descriptive analysis of findings by categories centred around perceived factors. The next chapter discusses insights, implications, limitations and further research before concluding the thesis.

Chapter 5 Discussion and Conclusion

5.1 Introduction

This chapter will distil the research findings from this study and discuss how they add to the literature base in regard to guided inquiry-based learning (IBL) in school science education. This chapter will also outline limitations of the study and discuss the study's implications for teaching, school leadership and areas for future study.

5.2 Summary of Research Findings

5.2.1 Enablers of Guided IBL Implementation

The research findings of this study indicate that teacher professional development, teacher past experience, teacher knowledge and teacher confidence in using guided IBL are enablers of guided IBL implementation within the delivery of NSW secondary science curriculum. They also show that a clear description, model or representation of guided IBL as well as a teachers positive personal beliefs toward guided IBL, are enablers of guided IBL implementation within the delivery of NSW secondary science curriculum.

Findings indicate that having available laboratory resources and equipment to support guided IBL, as well as available classroom and instructional time to implement guided IBL, are enablers of guided IBL implementation. Participants indicate that student behaviour, motivation, prior knowledge and skills can also be enablers of guided IBL implementation.

Having available programming time to program guided IBL into science programs and available planning time to develop guided IBL into units of work, are also perceived by participants as enablers of guided IBL implementation.

5.2.2 Barriers to Guided IBL Implementation

Participants indicate that NESA syllabi and requirements as well as external state wide assessments (HSC, NAPLAN) are barriers to guided IBL implementation within the delivery of NSW secondary science curriculum.

An unclear description, model or representation of guided IBL and a lack of professional development in guided IBL are barriers to guided IBL implementation. A teacher's lack of knowledge of guided IBL, a teachers negative past experiences in using guided IBL, a teachers negative personal beliefs toward guided IBL and confidence in using guided IBL were also perceived as barriers to guided IBL implementation.

Participants indicated a lack of available laboratory resources and equipment, a lack of available classroom & instructional time, insufficient programming time and a lack of planning time as barriers to guided IBL implementation. They also stated that student behaviour, motivation, prior knowledge and skills are being barriers to guided IBL implementation.

5.3 Factors that Fan the Flame

The results of this study have produced a framework focussing on guided IBL implementation in NSW secondary school science education. This framework, as shown in Figure 5.1, synthesises the research findings into a single representation. The arrow in the framework represents a teacher's intention to use guided IBL in the delivery of the curriculum. The blocks represent factors that study participants agree can enable or pose a barrier to guided IBL implementation. The blocks are coloured to indicate whether the factor is a barrier or whether the factor can be an enabler or barrier depending on the circumstances. The orange blocks represent factors that can be enablers or barriers. The red blocks indicate that the factors are only perceived to be barriers. The blocks have been placed to infer a brick wall and therefore represent a barrier. The movement of the arrow through the barrier represents facilitation of guided IBL implementation. The flame represents implementation of guided IBL in school science education.

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Figure 5.1

Framework Emerging from this Study Showing Teacher Perceptions of Factors that Affect Implementation of Guided IBL in Secondary School Science

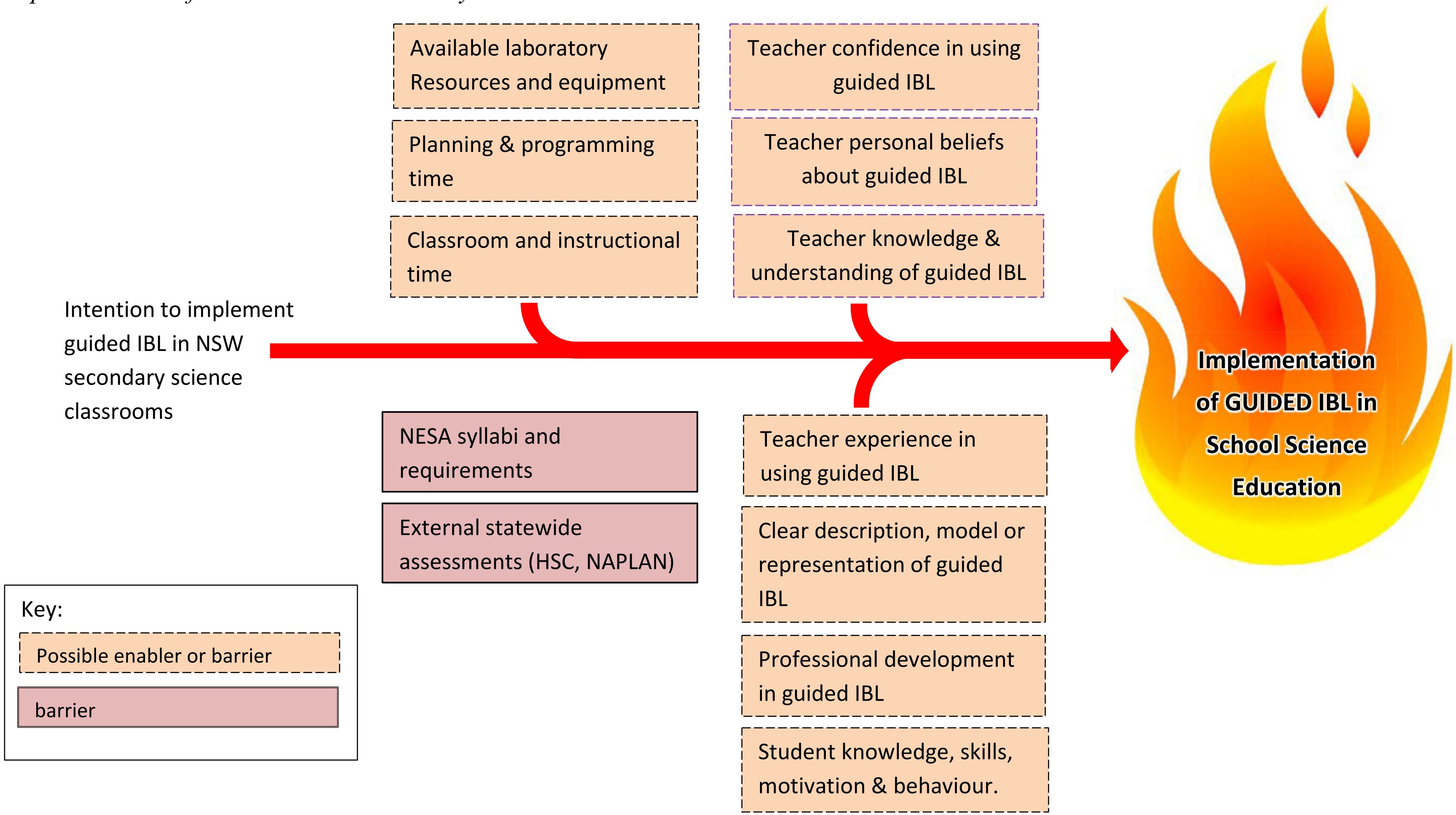


Figure 5.1 indicates that ten factors can be either enablers or barriers to guided IBL implementation. It also shows that two factors are perceived by participants to be only barriers, NESA syllabi and requirements and external statewide assessments are viewed as barriers.

Ten factors in Figure 5.1 can be either barriers or enablers. These ten factors can be enablers if they are present, positive or ample these same factors can be barriers if they are absent, negative or deficient. This is ability of a factor to be a barrier or an enabler is a very important point to note. It means that effort, time or resources put in place to improve a factor will possibly change that factor from a barrier to an enabler. For instance, if time and money is utilised to improve available laboratory resources and equipment this may have a large impact on the implementation of guided IBL implementation.

The two factors that are perceived by participants to be only barriers, external statewide assessments and NESA syllabi and requirements, are two important factors. In 2017 new NESA science syllabuses, for the Australian Curriculum, were created with a focus on scientific skills, values and attitudes toward science and a large overall emphasis on inquiry. This syllabus focus on inquiry should also have an impact on the HSC and increased testing of inquiry skills within that external examination. Considering the time and resources utilised to create these new science syllabuses it would possibly be a very important endeavour to help teachers shift their perceptions of the Syllabuses as barriers to guided IBL implementation to being an enabler of guided IBL implementation. After all, the syllabus does have a large emphasis on Inquiry. It could be that the syllabus content perceived by teachers does not quite align with what the actual syllabuses are. Results from this study suggest that participants perceive the new NESA senior science syllabuses as a barrier because of a perception that it is content heavy and therefore syllabuses may not allow for sufficient instructional/classroom time to also pursue guided IBL implementation. Furthermore, the results indicate that the HSC external examination does not assess the skills produced by guided IBL implementation and therefore teachers may perceive a risk in using classroom time to implement guided IBL when they could use this time for more traditional teaching methods like direct instruction.

5.4 Significance

The literature review established the importance of science education and engagement with science in Australian school students. It was also argued that IBL is a method of achieving increased engagement in science and positive attitudes toward science (Anderson, 2002; Jiang & McComas, 2015). A surprising result in Item 4 of the study was that more than half of participants (55 %) reported that they utilise guided IBL at least once per topic/module per class and 90% use guided IBL at least once per class per year. These results show that the use of guided IBL pedagogy may be more common than has been thought, as it is believed that IBL is not an established practice in science education (Hofer & Lembens, 2019) yet the results in this study indicate a different picture of IBL in NSW science education. The results of this study are surprising considering that Deters' (2005) investigation of 571 American high school chemistry teacher found that 45% do not use guided IBL in their classrooms and Cheungs' (2011) survey of 200 Hong Kong secondary chemistry teachers found that 74% of secondary Hong Kong chemistry teachers had implemented at least one guided inquiry lab in the preceding nine-month period. Participants gave no identifying information so there is no reason to think that they would inflate their reported usage of guided IBL in the survey. It is possible that once participants were given the definition of guided IBL they reflected on their practice and came to the conclusion that they use guided IBL without being aware that they are. Whilst Item 4 gauged participant reported use of guided IBL, it is important to remember the participant size in this study limits the generalizability of this result, a larger scale study could seek more information on this point to see how many teachers across NSW, Australia or globally, utilise guided IBL as a specifically defined type of IBL. However, the results do raise some interesting questions. Is guided IBL more common than previously reported? Are teachers using guided IBL without knowing they are using it? The findings suggest that teachers may be utilising guided IBL without explicitly labelling it or knowing the terminology surrounding it. If teachers are utilising guided IBL without specifically labelling it as guided IBL then possibly this intrinsic inclination of teachers to use guided IBL creates a strong foundation that educational systems would only need to feed and nurture by creating the "right" conditions that would enable an inferno of inquiry.

What are the "right" conditions for guided IBL? The literature review identified factors that numerous authors have identified as affecting the implementation of IBL. These factors that affect IBL implementation and associated references are summarised in Tables 2.4 and 2.5. This study tested these factors identified in the literature review within the context of *guided* IBL implementation in NSW secondary science education. Table 5.1 compared each factor against the results of this study. This comparison, in Table 5.1, highlights similarities and differences between the literature relating to IBL implementation and the results of this study on guided IBL.

Table 5.1

Factors Affecting (Generic) IBL and Guided IBL Implementation

Factors affecting IBL implementation (from Literature review)	Factor affects *guided* IBL implementation Results of this study
Models, definitions and examples of guided IBL	Yes
Professional development in guided IBL	Yes
Teacher personal beliefs	Yes
Teacher confidence	Yes
Teacher Knowledge	Yes
Teacher Past experience	Yes
Laboratory resources and equipment	Yes
Syllabi and curriculum requirements	Yes
External state wide assessments	Yes
Classroom and instructional time	Yes
Programming and planning time	Yes
Student behaviour and motivation	Yes
Student prior knowledge and skills	Yes
Whole school programs and curriculum	Partial
Internal School assessments	Partial
Industry or science research experience	No
Initial teacher education programs	No
Textbooks and teaching resources	No
Science teaching colleagues	No
School Executive	No
Student and parent expectations	No

Many authors discuss and describe the enabling effect of a clear model, definition and understanding of IBL (Abd-El-Khalick et al., 2004; Abell, 1999; Capps et al., 2016;

Crawford, 2007; Furtak, 2006; Ozel & Luft, 2013; Lotter et al., 2007; Wilcox et al., 2015; Windschitl, 2003). They also discuss the barrier effect of multiple unclear definitions of IBL. The current study has found that participants do agree with this literature in that a clearly defined model or structure for guided IBL is an enabler for implementation. This factor would understandably also affect the knowledge and understanding a teacher has for inquiry instruction and this study also agreed with these authors that a clear understanding and knowledge of guided IBL is an enabler for implementation.

This study found that participants perceive professional development in guided IBL as an enabler in implementation. This result agrees with the literature surrounding IBL implementation that ongoing or intensive professional development in IBL has a positive impact on implementation (Abd-El-Khalick et al., 2004; DiBiase & McDonald, 2015; Gillies & Nichols, 2014; Goodrum et al., 2001; Goodrum et al., 2011).

This study did have a different view on the importance of inquiry instruction in initial teacher education (ITE) programs when compared to the existing literature. This study found that participants do not perceive ITE programs as being a barrier or enabler to guided IBL implementation. It was surprising to find that participants in this study did not perceive ITE as a possible barrier or enabler to guided IBL implementation. It would be thought that a thorough education in guided IBL and its implementation during ITE courses would be an enabler of guided IBL implementation. Brown and Melear (2006) discussed the importance of authentic inquiry research in teacher education programs in assisting with IBL implementation. Brown and Melear (2006) found that ITE students were appreciative of authentic inquiry instruction in their course and believed it was useful. The current study does not agree with this in regard to guided IBL implementation. There could be many factors at play with this discrepancy. It could be that because a large proportion of the participants in this study had more than 6 years' experience teaching science in schools, 74% have more than 6 years' experience, that they then in turn perceive ITE courses as a neutral factor in guided IBL implementation.

Abd-El-Khalick et al. (2004) as well as DiBiase and McDonald (2015) report that teachers lacking confidence in using IBL is a factor that can be a barrier to IBL implementation. This study found that this is also the case for *guided* IBL implementation. In this study, teachers perceived that having confidence in guided IBL is an enabler but also that a lack of confidence is a barrier to guided IBL implementation. Teacher personal beliefs surrounding science teaching and different pedagogies as well as the efficiencies and efficacies of IBL can be a significant positive or negative factor in regard to IBL implementation (Abd-El-Khalick et al., 2004; Abell, 1999; Brown & Melear, 2006; Crawford, 2007; DiBiase & McDonald, 2015; Lotter et al., 2007; Wilcox et al., 2015). This study has confirmed that this is also the case in regard to *guided* IBL implementation. Responses to Items 5 and 11 in this study indicated the possibility that this factor is one of the more important or over riding factors in regard to implementation, in that responses seem to indicate a strong positive belief system in regard to guided IBL can possibly overcome deficiencies in many other factors. The highest mean score in Item 5 of this study was linked to this factor "guided IBL is enabled by a teachers positive personal beliefs to guided IBL". Item 11 asked participants to identify the most important factor in regards to IBL implementation and the theme with the highest count was related to teacher attitude and positive belief. These responses echo the findings from studies into other pedagogical implementations. Ertmer et al. (2012) reported that teachers with a passion for student centred technological pedagogies would still enact these pedagogies in the classroom even in the face of barriers such as a lack of resources. Brown and Melear (2006) also found that teachers with strong belief structures in regard to student centred inquiry were the teachers who in fact implemented student centred inquiry instruction. This is an area that could use further investigation especially examining ways to foster positive guided IBL belief systems in teachers.

Many authors have stated that a content-heavy curriculum or syllabus is a barrier in regards to IBL implementation. This content heavy curriculum also contributes to creating instructional time constraints which is a barrier to IBL implementation (Abd-El-Khalick et al., 2004; Bevens & Price, 2016; DiBiase & McDonald, 2015; Furtak, 2006; Gillies & Nichols, 2014; Goodrum et al., 2011; Hackling et al., 2001; Marbach & McGinnis, 2008). This study agrees that these two factors are a barrier to guided IBL implementation. The remarkable thing is that this study has also shown that the new Australian NSW NESA science syllabuses are considered barriers to guided IBL implementation, even though they have explicit syllabus expectations that students understand and implement scientific inquiry and investigations that could be ideally taught within the construct of guided IBL pedagogy. For example in the NSW NESA Senior Stage 6 Biology Syllabus (NESA, 2017) it clearly states that students are expected to "develop inquiry question(s) that require observations, experimentation and/or research to aid in constructing a reasonable and informed hypothesis" (p.22). Students are also expected to plan their own scientific investigations and "justify the selection of equipment, resources chosen and design of an investigation" (p.23). These two syllabus points are asking students to demonstrate a capacity to design an inquiry question and conduct an inquiry method that they have planned. This is exactly what guided and open IBL pedagogy allows students to learn and demonstrate. The fact that participants perceive the new NSW Science syllabuses as being barriers to guided IBL implementation is a significant finding that demands urgent future investigation. Furthermore, this study has found that participants perceive the NSW Higher School Certificate (HSC) senior science course exams, which are state-wide external high stakes exams, are a barrier to guided IBL implementation. Considering that these exams are supposed to assess students' capacity to demonstrate the requirements of the senior stage 6 science syllabuses, which have inquiry skills heavily embedded within them, this is a critical finding which also warrants further investigation.

The literature states that school leaders, faculty leaders, teaching colleague beliefs and teacher collaboration are potential influencers of IBL implementation in schools (Anderson, 2002; Goodrum, 2006; Haigh & Anthony, 2012; Marbach & McGinnis, 2008). The results of this study indicate that science teaching colleagues and school executive are not a factor in enabling guided IBL implementation or being a barrier to guided IBL implementation. Firstly, it is surprising to find that participants' opinions are neutral toward colleagues and supervisors being a factor in guided IBL implementation. Considering school executive usually have a large influence on individual school goals and targets as well as school finances and professional development, the perceived neutrality of this factor is a surprise. This result could have come about because access to professional development and adequate laboratory resources were treated as a separate factor to school and faculty leadership within the survey and therefore it is possible that participants thought if these factors are satisfactory then school and faculty leadership is less significant. Secondly, as teaching colleagues can influence internal school assessments, resource booking and faculty programming as well as the negative potential influence of peer pressure or internal faculty conflict, it was surprising to find that science teaching colleagues were also perceived as a neutral factor. Furthermore, Hofer and Lembens (2019) discussed the positive influence of collegial reflection and discussion in regard to IBL professional development, understanding and enactment. This studies neutral indication toward colleagues might be explained by the open ended responses indicating that an individual teachers' belief structure would, and could, override many other factors, including negative colleagues, if the will to enact guided IBL was present.

The potential influencing nature of parental expectations and possible parental expectations to teach traditional content based science has been mentioned in the literature as a factor that can influence IBL implementation (Abd-El-Khalick et al., 2004; Marbach & McGinnis, 2008). Participants in this study did not indicate that they perceive parent expectations as an enabler or barrier to guided IBL implementation.

The quality of textbooks or textbooks with an inquiry focus have been mentioned in the literature as being factors that influence IBL implementation (Abd-El-Khalick et al., 2004; Anderson, 2002; Goodrum et al., 2001; Goodrum et al., 2011; Hackling et al., 2001). In this study, participants indicated that textbooks and teaching resources are not barriers to, or enablers of, guided IBL implementation. It is possible that participants have not seen or used textbooks that have an inquiry focus and therefore do not see textbooks as a contributory factor. It could be that participants who enact guided IBL in their classrooms design their own texts and resources irrespective of the textbooks they use.

5.5 Implications of the study

The findings from this study indicate factors that could enable the implementation of *guided* IBL, as discussed in previous sections. Communicating these factors to science educators, academics and school leaders in a user-friendly format is a worthwhile goal.

Indeed, communicating the importance of these factors may enhance successful implementation of guided IBL in the future.

A series of guiding questions (see Table 5.2) have been organised from the research findings, and literature to help school executive, faculty leaders and science educators start an evaluation process before undertaking an attempt to implement guided IBL. The questions in Table 5.2 link closely to the wording of the factors found within the survey items of this study. Those factors that participants perceive as enablers or barriers have a corresponding question in Table 5.2. The questions can be used during or after guided IBL implementation to assist with evaluating the process.

These evaluation questions have been created using the results of this study. To enhance the reliability of these questions they are also aligned to the literature surrounding IBL implementation, see table 2.4 for a summary on factors and their effect on IBL implementation. These evaluation questions have been developed through numerous iterations and transformations during discussions with school senior executive, education academics, science head teachers and science educators.

Table 5.2

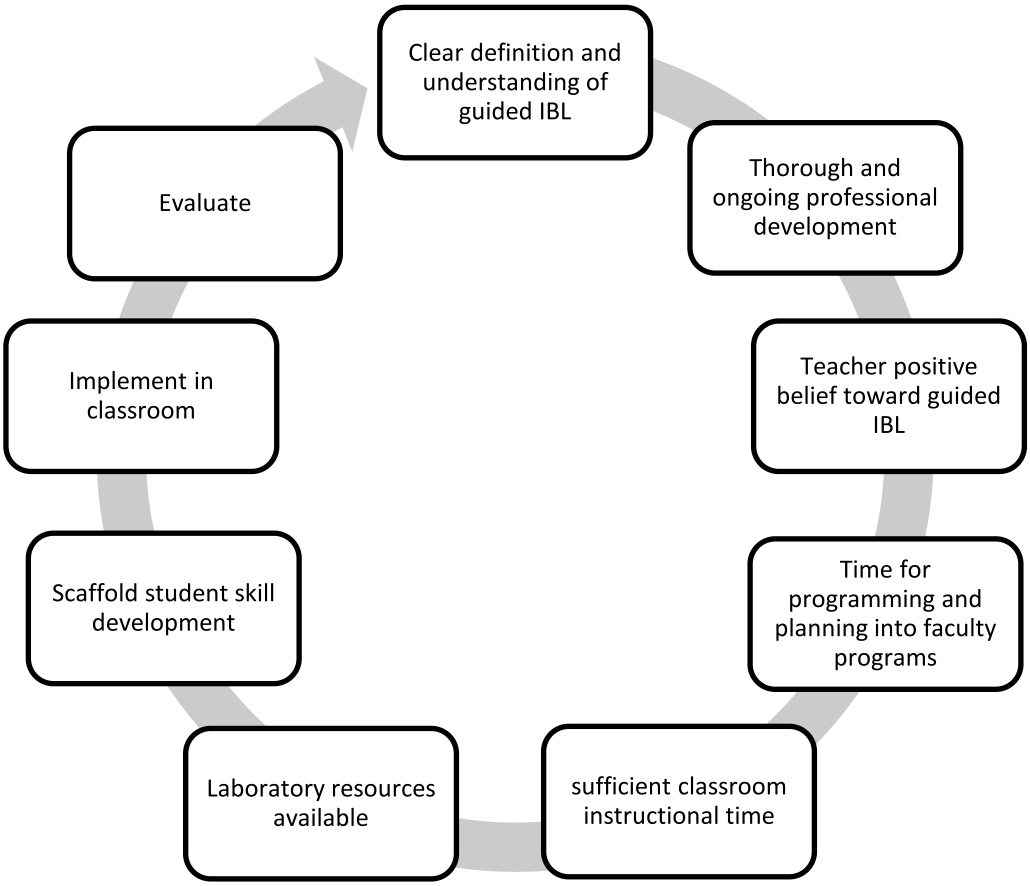
Guiding Questions for Consideration when Embarking on and Evaluating Guided IBL Implementation

Questions
Is there a clear definition, model or representation of guided IBL in place?
Do teachers have a thorough knowledge and understanding of guided IBL?
Has professional development on guided IBL implementation been provided?
Do the teachers implementing guided IBL have positive personal beliefs about guided IBL pedagogy?
Are adequate laboratory resources and equipment available?
Has time for programming guided IBL into official programs been provided?
Has time for planning guided IBL into units of work and class activities been provided?
Do teaching and learning programs provide enough time for guided IBL to be implemented successfully?
Do students have the knowledge, skills, motivation & behaviour to allow guided IBL to be implemented, keeping in mind that guided IBL is one part of a larger scaffolded approach?
Do teachers understand the importance of guided IBL in developing student inquiry skills to meet the needs of external exams? Problem solving
Do teachers understand that guided IBL implementation can help meet mandatory syllabus and curriculum requirements?

Communicating to school leaders and teachers about the factors that enable guided IBL implementation is a step toward improving these factors and therefore may help improve implementation success. Using these prompts during an evaluation process before attempting to implement guided IBL may allow inhibiting factors to be improved before an implementation cycle commences, though this would require further study. For example the prompt may make staff realise a standard definition for guided IBL needs to be constructed or found before the implementation can begin. Therefore, awareness would help in evaluating the situation to assist with planning as part of an implementation cycle. An example of a summarised implementation cycle can be seen in Figure 5.2.

Figure 5.2

Example of a Guided IBL Implementation Cycle, Informed by this Study



If schools or faculties wish to pursue guided IBL implementation the summarised implementation cycle in Figure 5.2 is a possible guide of what an implementation cycle could look like. Each step would need to be elaborated upon to suit the individual school or faculty requirements. For example schools may designate professional development funds to allow science faculties programming time to firmly embed guided IBL practices into teaching and learning programs. This would then create the necessary instructional time needed and the cycle continues.

5.6 Limitations of the Study

Limitations to the study include a small sample participant response rate, possible participant confusion with closed questions, limitations of participants self reporting, the assumption that participants have a common understanding of guided IBL and a possible bias from the researcher. Whilst responses allowed for a less than ideal amount of data to be collected, the data was reported as participant responses and no generalisation was made in terms of findings representing all NSW science teachers. As stated by Creswell and Creswell (2018), sample size is a trade-off between accuracy versus time and cost. A larger sample size could generate more accuracy for inferences made from the study but this must be balanced by the time allowed for the study and the cost of advertising or recruiting participants as well as other researchers to help with data analysis. As this research had no additional funding time and cost are significant limiting factors.

This study utilised a survey as a single source of data. Future studies should employ more than one data source to increase the reliability of findings such as surveys, interviews and focus groups. As this research had no additional funding the time and cost of these additional data sources were a significant limiting factor.

This study investigated participant perceptions of self in regards to practice as well as assuming participants had a common understanding of guided IBL. As has been mentioned in this study before, the definition and understanding of IBL and guided IBL is in itself a possible factor that affects the implementation of guided IBL. A difference of opinion and understanding amongst participants of guided IBL could also be a limiting factor of this study. It is possible that further questions in the survey could have gauged a common participant understanding of guided IBL, thus increasing the validity of conclusions from this study. There is also the potential bias of teachers' self reporting of their frequency of use of guided IBL. Further research into this area could include document analysis (Bowen, 2009) of teaching programs and units of work, to further investigate the use of guided IBL.

As mentioned earlier in the research findings and discussion chapter, there may have been participant confusion with some of the closed questions (see section 4.6.5 for more information). Whilst pilot testing did not expose this issue, in the future more extensive pilot testing of closed questions will minimise varied participant understanding.

With descriptive analysis, bias of the researcher is an issue. Descriptions always depend on the perceptions, inclinations, sensitivities, and sensibilities of the describer (Sandelowski, 2000, p.2) and therefore the descriptive analysis presented could have been coloured by the views of the researcher.

5.7 Further Research

Additional research is warranted to better understand how and why various factors affect the implementation of guided IBL. Four recommendations arise from this study.

Further research could seek to verify or support the claims of this study. A triangulation of data could occur in larger scale studies that utilise a similar survey with follow up interviews or case studies. This study focussed on guided IBL and most of the results reported, verified or supported those results of studies that look into factors that affect IBL more broadly. However, as previously mentioned in section 5.4, some of the results in this study do not align with previously reported results. This could be due to a difference between guided IBL and a broader definition of IBL or it could be because this study specifically asked participants to focus on guided IBL. A larger multiple method study could delve into survey responses and seek greater clarification and understanding from participants.

Researchers could delve deeper into the nature and frequency of guided IBL use in contemporary science education. Results of this study indicate that 55% of participants utilise guided IBL at least once per topic or module *per class*. This appears to be a larger number than what is currently reported (Cheung, 2011; Deters, 2005). Teachers may be utilising guided IBL at a greater rate than perceptions indicate and therefore even more studies may open up in regards to why there is an increased use of guided IBL. Continuing with this thought, further research could also investigate or quantify the implementation of other forms of IBL, such as confirmation, structured and open. Having a clearer indication, or quantified number, of IBL implementation could help determine if syllabus changes and broader efforts in NSW, Australia and the wider world are working to increase the utilisation of IBL.

Further research could also investigate the factors that affect guided IBL within different primary and secondary science courses. Data could be collected and categorised against different science courses as well as different student stages (year groups). How is the enactment of guided IBL similar or different in stage 3 (years 5 and 6) as stage 6 (years eleven and twelve) or stage 2 (years three and four). Some open ended responses in this study indicated that it may be easier for teachers to implement guided IBL in stage 4 and 5 classes (years seven to ten) than in stage 6 classes (years eleven and twelve). The indicated reason for this result was greater content demand and external exam expectations in stage 6 than in stage 4 and 5, but only further research could verify this. Furthermore, is it more common to use guided IBL in Physics, Chemistry, Earth and Environmental Science, Investigating science or Biology? Investigating a potential difference between the different science disciplines and then determining why there is a difference could be a valuable area of study. If there is a difference, is it due to resources or teacher belief or exam expectations?

Table 5.2 in section 5.5 introduced some prompts that school leaders could utilise if they wish to implement guided IBL in their science faculty. Further research could include action research into the use of these prompts in assisting with guided IBL implementation. Are the prompts useful in judging readiness? How can we add more details or measurements to these prompts? Do these prompts positively affect guided IBL implementation? Furthermore, to what extent are these prompts the transferable? Are these prompts transferable to other pedagogical implementations outside the realm of IBL? For example, is it possible to alter these prompts to suit problem-based learning implementation? Creating a universal system of prompts for teachers and educational leaders would be an incredibly useful tool to help assist with everything from resource allocation in planning phases through to the detailed professional development programs educators may create and utilise.

5.8 Conclusion

Debates about the most effective ways to teach have been held for thousands of years, since Plato, Aristotle and Socrates. Recent research suggests that guided IBL is an effective way to teach some scientific skills, knowledge, values and attitudes. If readers believe guided IBL is an effective, useful or worthwhile pedagogy in science education and they wish to implement it, hopefully this study has shed some light on the factors that will enable their successful implementation. If readers do not believe guided IBL is an effective, useful or worthwhile pedagogy in science education then they probably do not want to implement it, but there is still a possibility that this study has made readers curious about guided IBL or at least the factors that may assist with pedagogical implementation.

Many of the factors influencing IBL implementation stem from a core duality in science education, the duality between content-based and inquiry-based science education. The pressures on resources (teacher time, instructional time, professional development, curriculum resources, physical lab resources) and pressures from expectations (external examinations, syllabus, teacher beliefs) stem from this core duality. These opposing 'forces', content-based and inquiry-based, are exacerbated by the multiple definitions of IBL. Furthermore this perceived duality or conflict between 'content-based' external expectations and the use of guided IBL is a misjudgement. In reality, guided IBL can be utilised to help achieve student success in external examinations and to meet syllabus requirements.

The factors that will enable guided IBL implementation start with a clear definition or model of guided IBL associated with carefully planned ongoing professional development. Resources need to be allocated to ensure teachers have planning and programming time which will allow guided IBL to be explicitly embedded into faculty programs, teacher planning time and thereby creating sufficient instructional time. Guided IBL cannot be additional to current programs and the emphasis cannot be placed on teachers to find the time to implement it. Professional development should include discussion around the utilisation of guided IBL to meet NESA syllabus requirements and external HSC exam expectations. Furthermore, a positive attitude and beliefs of teachers are very important and are a key ingredient to the success of guided IBL implementation. If teachers feel that guided IBL is a positive tool in their teaching tool kit they will be more likely to engage and succeed in implementation. Teachers' beliefs also need to be supported with sufficient laboratory resources and equipment as well as scaffolding for student knowledge, motivation and skill development. With all of these factors in place, guided IBL implementation is more likely to be a positive experience that teachers will be more willing to engage with in the future, therefore increasing the frequency of guided IBL use. With an increased frequency of guided IBL use, we may also see student motivation and attitude toward science improve and subsequent benefits such as student engagement with senior secondary science, tertiary university science courses and careers in science.

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Appendix: Survey used in this study

Investigating Inquiry Based Learning in Schools: Perceptions of science teachers about Guided Inquiry

Introduction

Hello

Thank you for taking part in this survey. The aim of this survey is to learn more about the nature of Inquiry Based Learning (IBL) practices in the education system and gauge the barriers and enablers of IBL instruction.

The first 3 questions are about your science teaching experience. Please keep in mind that these broad questions are the only identifying questions in the survey and therefore this survey is confidential.

1. How many years have you been teaching Science.

- ◯ Less than 5 years
- ◯ 6-15 years
- ◯ More than 15 years
- ◯ teacher practicum experience only

2. What type and level of science have you taught in the last 5 years?

- ☐ Stage 1 - Stage 3 Science and Technology
- ☐ Stage 4 Science
- ☐ Stage 5 Science
- ☐ Stage 6 Biology
- ☐ Stage 6 Chemistry
- ☐ Stage 6 Physics
- ☐ Stage 6 Earth and Environmental Science
- ☐ Stage 6 Senior Science

3. What position do you currently hold in your school?

- ◯ Teacher
- ◯ Head Teacher/ Department Head
- ◯ Deputy Principal
- ◯ Principal
- ◯ I am not teaching in a school eg. Corporate, NESA, retired etc.

1

Guided Inquiry

Please read the following.

There are many definitions and models for Inquiry Based Learning. For the purpose of this survey please use the following model of IBL and more specifically Guided IBL. I am not proposing that this is "the" model for Science inquiry, just "a" model.

Guided Inquiry Definition: Guided Inquiry Based Learning is a level of science inquiry in which students investigate scientific questions given to them, using a **procedure of their own design** to collect data that **they analyse** to create their **own answers** to the question.

4. On average how often do you use this type of guided inquiry, intentionally or unintentionally, with each of your classes?

- ◯ More than once a week per class
- ◯ More than once per topic/module per class
- ◯ Once per topic/module per class
- ◯ Once a term per class
- ◯ Once a semester per class
- ◯ Once a year per class
- ◯ Once every 2 years per class
- ◯ Never
- ◯ Im not sure what guided inquiry is (try looking at the definition again)
- ◯ I do not understand the question
- ◯ other

Factors that affect guided inquiry implementation in Science classes

The literature in the field of scientific inquiry and Inquiry Based Learning in the science classroom mentions many possible factors that can possibly effect the implementation of Inquiry Based Learning in Science.

These factors are presented as an enabler of IBL (help implementation) or a barrier to IBL (hinder implementation) or as both an enabler and barrier. Whether the factor is an enabler or barrier is usually determined by what is happening with that factor.

This survey will ask you to identify factors that you find are enablers, barriers or both. Please briefly describe how you perceive these factors in relation to the implementation of guided science inquiry in your classroom or school experience. Please keep in mind that factors can include personal, student, faculty, school or system wide factors.

Enablers of Guided Inquiry Based Learning

5. In this section, please indicate the extent to which you agree or disagree with each statement, in relation to the implementation of guided inquiry based learning (IBL) in science classrooms.

Guided inquiry based learning is enabled by....

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a teacher's positive personal beliefs toward guided IBL.	○	○	○	○	○
professional development in guided IBL.	○	○	○	○	○
clear models, definitions and examples of guided IBL.	○	○	○	○	○
a teacher's knowledge of guided IBL.	○	○	○	○	○
the confidence of a teacher toward using guided IBL.	○	○	○	○	○
student motivation and behaviour.	○	○	○	○	○
a student's prior knowledge and skills.	○	○	○	○	○
textbooks and teaching resources.	○	○	○	○	○
NESA syllabi and requirements.	○	○	○	○	○
the school curriculum, whole school programs and school expectations.	○	○	○	○	○
available laboratories and equipment.	○	○	○	○	○
available instructional and classroom time.	○	○	○	○	○
available programming and planning times.	○	○	○	○	○
internal school assessments.	○	○	○	○	○

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
external state wide assessments (HSC, NAPLAN)	◯	◯	◯	◯	◯
student and parent expectations.	◯	◯	◯	◯	◯
science teaching colleagues.	◯	◯	◯	◯	◯
supervisors or school senior executive.	◯	◯	◯	◯	◯
school senior executive.	◯	◯	◯	◯	◯
past experiences in using guided IBL.	◯	◯	◯	◯	◯
industry or science research experiences.	◯	◯	◯	◯	◯
tertiary initial teacher education degree programs.	◯	◯	◯	◯	◯

6. In regard to the items in question 5, please use the text box below if you wish to expand on one or more of your answers.

7. In regard to the items in question 5, please use the text box below if you wish to add other factors that you believe are enablers of guided IBL.

Barriers to Guided Inquiry Based Learning

8. In this section, please indicate the extent to which you agree or disagree with each statement, again, in relation to the implementation of guided inquiry based learning (IBL) in science classrooms.

In my experience barriers to guided inquiry based learning include ...

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a teacher's negative personal beliefs toward guided IBL.	○	○	○	○	○
lack of professional development in guided IBL.	○	○	○	○	○
unclear models, definitions and examples of guided IBL.	○	○	○	○	○
a teacher's knowledge of guided IBL.	○	○	○	○	○
A lack of confidence in a teacher toward using guided IBL.	○	○	○	○	○
student motivation and behaviour.	○	○	○	○	○
a deficit in student prior knowledge and skills.	○	○	○	○	○
available textbooks and teaching resources.	○	○	○	○	○
NESA syllabi and requirements.	○	○	○	○	○
the school curriculum, whole school programs and school expectations.	○	○	○	○	○
available laboratories and equipment.	○	○	○	○	○
available instructional and classroom time.	○	○	○	○	○
available programming and planning time.	○	○	○	○	○
internal school assessments.	○	○	○	○	○

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
external state wide assessments (HSC, NAPLAN).	○	○	○	○	○
student and parent expectations.	○	○	○	○	○
science teaching colleagues.	○	○	○	○	○
supervisors or school executive.	○	○	○	○	○
school senior executive.	○	○	○	○	○
negative past experiences in using guided IBL.	○	○	○	○	○
industry or science research experiences.	○	○	○	○	○
tertiary initial teacher education degree programs.	○	○	○	○	○

9. In regard to the items in question 8, please use the text box below if you wish to expand on one or more of your answers.

10. In regard to the items in question 8, please use the text box below if you wish to add other factors that you believe are barriers to guided IBL.

11. Please state what you believe is the most important factor for the implementation of guided IBL in science classrooms.

Conclusion

Thank you very much for completing this survey. Please press done to finish.