EAL and Science: Exploring the Challenges

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ABSTRACT

Increasing numbers of international students are attending independent schools in the UK in pursuit of achieving qualifications to gain entry to an English language-based University. These students often achieve only limited success in science subjects in public examinations.

This qualitative study aims to explore in-depth 1) the nature of the challenges facing these students in the science classroom, 2) how the science and EAL teachers support their learning and 3) to identify any further support strategies that could be utilised to benefit this group of 'bilingual seeking' EAL (English as an Additional Language) students.

Eight science lessons were observed, including the three sciences of biology, chemistry and physics. Twelve interviews were carried out with five science teachers, one specialist EAL teacher and six international students, who had recently arrived in the UK. A narrative frame style, scaffolded writing exercise was also used to explore the students' science learning background.

Analysis revealed three themes of *language, inquiry* and *techniques* which emerged as the fundamental barriers to the students' learning.

The study reveals the nature of the linguistic and literacy challenges and highlights the need to nurture and develop the students' ability to inquire. The language skills needed to ask questions, negotiate meaning and critically evaluate need to be developed, as do the literacy skills of processing scientific texts. Classroom techniques which facilitate understanding and learning are revealed and a need for specialised, 'English for Science' (EfS) materials which are linked to the science curriculum, is highlighted. Close collaboration between science and language teachers is regarded as key to effectively achieving these aims.

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C O N T E N T S

APPENDICES *

** In the original, submitted version of this MA, the appendices also included:*

- *FREC forms (completed)*
- *participant information sheets and consent form proforma*
- *data collection schedule*
- *narrative frame stories (6)*
- *lesson observation forms and notes (8)*
- *interview transcripts for students and teachers (6+6)*
- *summary tables of lesson observation comments.*

For this publication, these have all been removed in order to maintain confidentiality.

CHAPTER 1

INTRODUCTION

1.1 Background

The establishment of English as the worldwide language for scientific publishing during the last century has resulted in many aspiring scientists and academics seeking the learning of science through English (Porzucki, 2014). Consequently, increasing numbers of international students attend UK independent boarding schools (Espinoza, 2015) and learn science as EAL (English as an Additional Language) students. The Independent Schools Council 2016 Annual Census (p. 17) shows that nearly 50% are from mainland China, Hong Kong and Russia. These students learn curriculum subjects in English, usually with the aim of achieving GCSE's, and then further qualifications, to enable the studying of Medicine, Engineering or Business in English.

An analysis of the England National Pupil Database (NPD) by Strand, Malmberg and Hall (2015, p. 27), identifies the achievement gap between EAL and FLE (First Language English) students in state schools to have an Odds Ratio (OR) rising from 0.67 at age 5, through 0.81 at age 11, to 0.9 at age 16 (where an OR of 1.0 means there is no difference between the two groups). This data stems mostly from students living with their parents in the UK from an early age. However, in independent schools, the EAL students typically arrive as late as age 14 or 15 years which, as Strand, Malmberg and Hall (2015) point out, is a key factor in limiting EAL achievement. Accelerated language learning is required in this case, particularly in terms of science.

This research study is focussed on an independent school with a strong history of educating EAL students from diverse nationalities. An International Study Centre (ISC) operates within the school, where specialist EAL teachers provide language tuition and curriculum support for these students, according to their needs.

On inspection of recent GCSE results obtained in the school, it is calculated that the EAL/FLE achievement gap across all three science subjects, averaged over the last three years, has an OR of 0.31 (0.54 in 2016), for a grade A*-B. This is in marked contrast to Mathematics which has an OR of 9.2, with a higher percentage of EAL students achieving A*-B than FLE students. This indicates the need for special attention to be given to the language and related academic skills which are needed for science learning.

1.2 EAL students

The diverse groups of EAL individuals in the UK that have been described in Government Education policies and strategy documents are identified by Conteh (2015, p. 15) as including: a) '*advanced bilingual learners'* - children born and educated in the UK as members of a settled ethnic minority, with a different home language; b) '*pupils new to English'* -recently arrived learners, new to English, with varying degrees of previous schooling; c) '*asylum seekers and refugees'* - those arriving with no English, whose education has been disrupted by war or trauma and d) '*sojourners'* - learners who are in England for only short periods of time with parents.

I suggest that a new category of '*bilingual seekers*' is needed for these EAL learners sent by their affluent parents to board in independent schools, with the aim of becoming sequentially bilingual in English. Students in this category have usually had a good education in their first language and most aspire to entering an English language-based University.

The UK Government policy concerning EAL learners and the Curriculum is 'to promote rapid language acquisition and include them (children learning EAL) in mainstream education as quickly as possible.' This policy was issued by the Department for Education and Skills (DfES) (Overington, 2012, p. 1) in response to rapidly increasing numbers in all categories but is related to maintained schools.

The context of maintained (Government funded) and independent schools (self-funded) is in many ways different, but they have the common goal of raising English linguistic competence to a level where success in public examinations is achievable. In this study, the focus is on the challenges facing 'bilingual seeking' EAL students studying science curriculum subjects in an independent boarding school.

1.3 Aims and scope

English language deficiency appears to limit the students' achievements, particularly in science subjects and this study seeks to investigate the factors involved, aiming to identify further ways in which teachers can support newly arrived EAL students.

Science teachers often find themselves teaching EAL students. Many teachers receive little, if any, training for this and may not be aware of the nature of the language difficulties and frustrations that these students experience.

In this investigation, there were three strands to my research, firstly, the challenges faced by newly arrived, Year 9 or 10 EAL students when studying science subjects, secondly, how these difficulties are addressed by their science and EAL teachers and finally, to identify any further support strategies to help them.

1.4 Personal reasons for the research

As an EAL teacher, I am interested in developing a deeper understanding of the nature of the difficulties EAL students encounter when learning science subjects. My personal aim is to help enhance the language support they are given, to facilitate their learning and achieve examination success.

I originally studied science subjects to degree level, but now, as a trained language teacher, I believe I am well-positioned to understand the difficulties and needs of students studying science in English as an additional language. I have supported EAL students in learning the language needed for science subjects for nearly ten years and have discovered that their difficulties are not necessarily those that science teachers perceive.

Furthermore, following an extensive literature search, no studies have been found relating to EAL students in independent boarding schools in the UK. I am interested in pioneering research in this field and to gain an initial insight into this context.

1.5 Overview

The study was qualitative and exploratory in nature, as explained by Croker (2009 p. 9), aiming to gain new insights and ideas by observing newly arrived EAL students in science lessons and interviewing both teachers and students to increase understanding of the different perspectives.

Following this Introduction, I shall provide a review of the literature and research relevant to the study, together with some theoretical background to the second language learning issues involved. Further details of the methodology, participants and procedure adopted, are given in Chapter 3. Following this, the main findings are presented in Chapter 4 and I discuss their significance in relation to the findings in the literature. Finally, in Chapter 5, I shall consider the conclusions from the study and their implications to the teaching of these EAL students.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

> In science classrooms students need to develop, not only scientific conceptual understandings, but also the ability to express the complex relationships among scientific phenomena through oral and written modes.
>
> Ardasheva, Norton-Meier and Hand (2015, p. 201)

This inter-relation between science and language learning in the classroom, which Ardasheva, Norton-Meier and Hand (2015) eloquently describe, has become a focus of attention in both the field of science education and English language learning. In the United Kingdom (UK), increased immigration from Europe and beyond has started to stimulate new literature and resources concerned with educating English as an Additional Language (EAL) students. However, very few EAL studies based in the UK were found, so the search was widened. In the United States (US), mass migration, particularly from Mexico, created a surge in ELL (English Language Learner) related research and literature. This literature is closely related to the context of EALs, as it involves teaching science to classes with both native-speaker and ELL students. Research relating to bilingual-based studies in French-speaking Canada are also relevant and included in this review. Literature relating to CLIL (Content and Language Integrated Learning), which has developed in several European countries (notably Spain), was initially included in the search, but it soon became apparent that the CLIL literature generally applies to classes of students with the same first language (L1) and who are learning science through English. The lessons are often mainly or equally focussed on the language learning, which is an inappropriate approach for the mixed native speaker/EAL classes in this research. This review, therefore, includes mainly ELL literature based in North America, in addition to the UK based research.

All the literature found, in both the UK and internationally, appears to relate solely to maintained schools rather than independent schools. Also, some of the studies, in the UK and North America, relate to primary rather than secondary schools. Literature from both maintained and primary schools are included here where the outcomes are broadly transferrable to this independent school context.

The EAL students in this study are generally well-educated in their own country and are from an affluent background, with the parents investing large sums of money in their child's education. The expectation is for a very intensive, rapid, (and often unrealistic) language development, with the aim of the student being able to sit public examinations within one or two years after their arrival.

In this review of literature, I seek to uncover the complexities involved in learning the sciences (biology, chemistry and physics) in English as an Additional Language and this is presented in three main sections. Firstly, I present a theoretical background to the acquisition or learning of additional languages in general and attempt to briefly summarise the evolution of relevant views and theories that have shaped current thinking and feed into current pedagogical practice. Secondly, I examine literature relating to the nature of scientific language and any documented difficulties and challenges likely to be experienced by EAL students learning science. Finally, there is an overview of research and literature that recommends teaching strategies and pedagogy for teaching science to EALs to achieve science and language learning integration.

2.2 Principles of language development for EAL learners

The first stage of this review is to summarise relevant key principles that have arisen from established Second Language Learning theories and consider how recent thinking may be relevant to the teachers and students in this study.

EAL learners and their stakeholders in this study aim to achieve communicative and sociolinguistic competence and performance, in all four skills of speaking, listening, reading and writing, as described by Canale and Swain (1980). One aspect of sociolinguistic competence is the ability to know and use the appropriate register or genre of language in specific contexts, including academic. This is required to achieve success in public examinations taken in English.

2.2.1 Second language learning theories

Innatist or Empiricist

The nativist view of a Universal Grammar, originally put forward by Noam Chomsky (1959), advocated that children are born with the ability to process the samples of language that they are exposed to and discover the underlying rules of a language system, developing in much the same way as any other biological function. Empiricists, such as Piaget (1963), argue that language is learned as the individual interacts with the world. This debate enters the EAL teaching world when considering whether English needs to be taught separately in language lessons or whether an immersion into curriculum subject classes suffices.

Acquisition or learning

Krashen (1982, cited in Lightbown and Spada 2013, p. 106) argues that far more language is acquired than learned. Krashen's Monitor Hypothesis proposes that second language users may use an internal editor, or monitor, which is based on rules and patterns that have been learned, enabling them to make minor adaptations and finely tune what has been produced by the acquired system.

Acquisition theory might argue for a total immersion approach to EAL language learning. However, the counter-argument for instruction put forward by Schmidt (1983), suggests that, without specific language instruction, fossilisation of linguistic competence (grammar) may occur leading to a termination of language development. This supports the idea that pre-mature withdrawal from language lessons may be detrimental to language development for EAL students.

Comprehensible input and output

The comprehensible input theory proposed by Krashen (1985) was countered by Swain (1985), who focussed on the need for comprehensible output. She concluded, when studying an immersion programme in Canadian bilinguals, that exposure based on comprehensible input alone is not sufficient to develop learners' productive abilities, particularly in writing. She argued that learning occurs by interacting with others and that pushing learners to produce output (speech and writing) is essential. This forces them to notice errors, to then modify the output which, in turn, makes them think about the input. This provides evidence against using a total immersion approach with EAL students and highlights the need for language lessons carefully tailored to the individual level.

Socio-cultural or Constructivist

Vygotsky (1978) proposed a socio-cultural view of learning. When studying children and adults in the Soviet Union, he concluded that social interaction is the key factor in language development. He observed the importance of conversations with adults and identified a *Zone of Proximal Development* (ZPD). Optimal language development occurs in an individual when the language of interaction is just slightly above the language level currently held. This suggests that EAL students must have opportunities to interact with peers and that for language to develop, the language used in lessons should not be of a level much higher than their own. In terms of teaching EAL students, the importance of one to one conversation with language teachers, must not be under-estimated, as special techniques, such as that of re-casting (Lyster and Ranta, 1997), facilitate learning.

A cognitive constructivist approach was proposed by Piaget (1951), in which interactions between the child and the world around him/her are viewed as being fundamental to learning with the child actively *constructing* knowledge. This was then developed further by Bruner, Olson and Anglin (1980) who viewed language as being a vital tool in cognitive growth.

2.2.2 Language development: the journey

General stages of language learning

The generally accepted stages in second language learning (Haynes, 2005) are as follows:

Stage I: Pre-production - the Silent Period (2-6 mths or much longer)
Stage II: The Early Production Period
Stage III: The Speech Emergence
Stage IV: The Intermediate Production Period
Stage V: The Advanced Production Period

Comprehension always precedes production. The production of each grammatical area such as negation, questions, possessive and reference to past have also been graded into accepted phases of development (Lightbown and Spada, 2013, pp. 45-57).

Pre-production – the 'Silent Period'

In the first stage of learning a language there is a well-documented, but much debated, 'Silent Period' that can last for 2-6 months, or longer (Ellis, 2008, p. 73), when some students opt not to speak in the target language. This is defined by Vygotsky (1986, p. 225) as an inner speech and Guerro (2004) identified four possible types of processes of this nature in teenagers. However, this idea seems to conflict with the interaction theory of language learning, as proposed by Long (1988), who maintains that learners need to interact and check their comprehension of meaning by asking questions and repeating. This is interesting for this study because there is a question as to what extent subject teachers should push the EAL students for verbal answers in class.

Interlanguage

When a student is learning an additional language, particularly in an immersion-style situation (as the EAL students in this study), Cummins (cited in Conteh, 2015, p. 63) recognised that languages are not kept separate and that multilinguals switch between their languages and there is a common underlying proficiency (CUP). Codeswitching, where students switch between their different languages when they don't know a word, is a widespread practice and forms an interlanguage between the two languages (Cheng, 2013).

Scaffolding

The cognitive constructivist, Bruner, Olson and Anglin (1980), introduced the important concept of scaffolded learning. This is where learning occurs by small steps of guided self-discovery which is learner centred and task based. Most modern teaching methods incorporate these principles. As Conteh (2015, p. 42) points out, the value of scaffolding learning is helping pupils to be independent. It is more than just providing 'support'. Moreover, as Cameron (2001, p. 9) explains, it is 'helping children attend to what is important', in other words helping them to 'notice'. The teacher keeps in mind the whole task and goals on behalf of the pupil, while the pupil focusses on one part of the task or language.

2.3 Challenges for EAL science learners

This study focusses on the difficulties experienced by EAL students that are specific to science learning. Some difficulties, such as that of culture shock, which is well-documented and a subject of recent research by Goldstein and Keller (2015) and Presbitero (2016), can have a significant effect. However, this generally affects all learning and is therefore beyond the scope of this research.

2.3.1 The language of science: linguistic difficulties

Social and academic language

Science education is delivered through the medium of academic language. Cummins (1980) introduced the terms **BICS** (Basic Interpersonal Communicative Skills) and **CALP** (Cognitive Academic Language Proficiency), highlighting the distinction between social language and academic language. Based on studies of Canadian bilingual teenagers, he proposed a Common Underlying Proficiency (CUP), maintaining that individuals with competence in both BICS and CALP in one language will have equal competence in an additional language. The theory is much debated and recently Cummins (2016) responded to criticisms that the theory is an over-simplification, by likening it to the simple term *European,* used to describe someone from a European country.

This CUP theory has implications to this study as it indicates that the previous education level of newly arrived EALs may determine how quickly the pupil will be able to achieve academic language proficiency in English.

Hakuta, Butler and Witt (2000) analysed empirical evidence from studies in the US education system and conclude that, in favourable conditions, it takes three to five years for ELLs to develop oral proficiency, but that it takes between four and ten years for academic English proficiency to develop, depending on their previous level of education. The achievement gap discussed in the Introduction may often be explained by this literacy gap in the social language (BICS) and academic language (CALP) proficiency. The implication to this study is that pupils may be judged as having a proficient level of English because they can hold a natural sounding conversation but performing well in academic language may need a surprising degree of support.

Linguistic characteristics of scientific language

The specific language patterns used in different contexts, for different purposes are referred to as language *registers* (Conteh, 2015, p. 196). The register used in academic texts in schools is gradually developed from the day a child first starts. Students learn to write scientific responses in this register without being given any explicit instruction as to how to structure it linguistically. This is likely to pose specific difficulties for EAL students who join the education part-way through. Schleppegrell (2001) analysed in detail the lexical features in a science text about sedimentary rocks and concluded that it is highly structured. Science texts typically use frequent nominalisations and fewer conjunctions, with logical connections often being made by embedding clauses. In doing this, scientists strive to produce text that minimises the number of words and is much more lexically dense. This means that there is more content to process and understand in a given word count, which can also create ambiguity.

Scientists have created their own linguistic tools and one example of this is the use of nominalisation, written about by Halliday (1993, cited in Atkinson, 1994), and discussed by Fang, Schleppegrell and Cox (2006). Nominalisation refers to when a concept that would normally be expressed as a verb or adjective, is re-modelled into a noun or noun phrase, such as 'reflect' to 'reflection', thus enabling a lengthy explanation to be condensed. Newton's seventeenth century work, *Treatise on Opticks,* was written in English (unusual for the time) and marked the birth of technical language by introducing this distinctive way of nominalising experimental processes and physical phenomena. The significance of the linguistic composition of this work is discussed extensively by Gerstberger (2008).

Scientific language comprises many terms that sound like every day conversational English but have different meanings in science. Carrier K. (2005) discusses the confusions arising from this, giving the examples of 'periodic *table' and '*animal *class'.*

The prevalence of the use of the passive tense in scientific language was noted by Lemke (1990, quoted in Short, 2006, p. 207) when he remarked that 'people tend to disappear from science as actors or agents'. Imperatives are also frequently used for giving instructions and writing up investigations.

Cross linguistic cognates (i.e. words that share form and meaning in different languages), particularly in science, have been shown to give students from some languages, for example Spanish, an advantage when learning English (Kelly and Kohnert, 2011). This is very pertinent to the mixed nationality intake in the school in this study and may help explain different rates of success by different nationalities.

Scientific language can be thought of as being made up of specialised 'vocabulary, including content-specific words, for example, 'mitosis', and general utility words, for example 'as a result' '. (Ardasheva, Norton-Meier and Hand, 2015, p. 216). The terms '*bricks*' and '*mortar*' applied to these two different word classes by Dutro and Morgan, (2001), is a powerfully graphic analogy for the main building blocks of scientific vocabulary ('bricks') and the words used to join them together ('mortar').

2.3.2 The language skills of science: literacy challenges

Scientific literacy uses specific strategies for effective reading, writing, listening and note-taking in the scientific genre. This involves students being able to:

> a) demonstrate basic skills common to all literacy, b) ask, find or determine answers to questions derived from curiosity about everyday experiences, c) describe, explain and predict natural phenomena and d) read with understanding, articles about science.
>
> Burkhardt et al (2003, quoted in Carrier K., 2005, p. 5)

Carrier K. (2005) goes on to point out that acquiring this literacy involves learning to use many academic functions concerned with handling information such as: seeking, reporting, describing, classifying and analysing. Other academic functions include: hypothesising outcomes, causes, effects; identifying patterns; and describing solutions to problems. This functional linguistics approach (FLA) to science language (Schleppegrell, 2004) can help in understanding how scientific meanings are constructed linguistically. Inadequacies in using these academic functions can contribute to a science literacy gap between ELLs and English speakers and requires science literacy objectives to be routinely incorporated into science teaching and taught explicitly. (Carrier K., 2005).

2.3.3 Inquiry-based learning

The ability to ask and answer questions form the basis of the discipline of science. There is a plethora of literature on the nature of science and the study of science inquiry, that is beyond the remit of this study.

Negotiation of meaning is an essential process in the construction of scientific knowledge, as emphasised by Ardasheva, Norton-Meier and Hand (2015), and students need to be able to ask questions and inquire in order to understand scientific concepts and develop into good scientists. They point out that scientists need to be able to formulate new ideas by inquiring and to debate and defend their ideas and highlight the importance of teachers fostering student inquiry and problem-solving skills.

Lemke, a physicist by origin, who carried out a comprehensive analysis of classroom discourse in high school classrooms, advocates that:

> It is when we have to put words together and make sense, when
> we have to formulate questions, argue, reason and generalise,
> that we learn the thematics of Science.
>
> Lemke (1990, p. 24)

Cazden (1992, p. 125) explains how Lemke maintains that when teaching science, teachers can improve comprehension by avoiding the use of 'colloquialisms, personal reference, figurative language and fantasy', but that this renders the lessons 'dull and alienating' for students. He advocates using colloquialisms but, concurrently, explaining them. He recommends finding alternatives to the traditional IRF (inquiry-response-feedback) discourse and explicitly teaching the writing genres of science.

2.3.4 Cultural factors

Differences in perceptions of the World by different cultural groups are described by Edmonds (2009), who compares the linear-progressive perceptions of the Western world (e.g. Darwin's theory of evolution), with the Chinese spiritually based view of cyclical patterns. These cyclical patterns (not always positive) are concerned with balance, Yin and Yen, rather than progression. The key point here being that many ELLs are from cultures and have educational backgrounds that, as Cuevas et al. (2005, p. 338) point out, can be 'discontinuous with those of Western modern science' and not based on inquiry.

These different perceptions of the world can be instrumental in the development of culture shock, experienced by new arrivals in a new country, the effects of which can be moderated by cultural intelligence (CQ) (Presbitero, 2016). Adapting to a new culture is a process that goes through five distinct stages (Pedersen, 1995) and can give rise to high stress levels (Saylag, 2014), resulting in a negative impact on learning.

Furthermore, some claim that differences in culture affect the very learning process itself and that characteristics such as Asian students being quiet and non-participating in the classroom can indicate a certain learning style that is one of reflective observation rather than active experimentation. Joy and Kolb (2009) investigated the existence of cultural influences on the learning process and concluded that culture has only a marginally significant effect on learning style, with gender, level of education and area of specialisation accounting for most of the variation. So, according to this, it is not valid to culturally stereotype learning style preferences.

Similarly, Atwater et al. (2013, p. 11) maintain that it is important for science educators to 'move beyond the myths and stereotypes' and make use of the strengths and cultural values of different ethnic groups. As part of a study looking at the patterns of science learning and educational needs of African, Latino and Asian American students, they concluded that social class is a significant factor in educational performance in Asian students. They also point out that due to the unrealistic parental expectations for academic success they can feel psychologically and socially isolated when they fail to meet demands, which is often based on language barriers beyond their control.

2.4 Teaching pedagogy and the classroom

There is a vast amount of literature and research relating to the simultaneous teaching pedagogy of science and language, much of which was carried out about a decade ago in North America or is CLIL related. Many of the research studies relate to primary or middle school years (age 6-13) but, in most cases, can be applied appropriately to the slightly older age-group in this study. I can only represent a very small selection here, but I give a brief overview of a few key issues that emerge from the literature relevant to the context in this study.

2.4.1 Integration: science-language teacher collaboration

The most important message to emerge from the literature, in my view, is the need for the integration of teaching science with the development of associated language. Creese (2005, pp. 106-131), after studying the various modes of possible support (in-class support and withdrawal for language lessons), concluded that the best outcome for the pupils' learning, is close collaboration between the subject and EAL teachers in teaching partnerships. She pointed out that subject teachers appear to feel little responsibility in making language-learning an important aim in their classrooms and that very little is included in any initial teacher training to help them achieve this. This is changing, however, and recently Feez and Quinn (2017) have reported an Australian initiative where science teacher training successfully incorporates the teaching of specialised science literacies. Creese (ibid) compared the discourse of a geography teacher and an EAL teacher, with the same year 10 pupils, in a UK secondary school. The subject teacher was much more directive and concentrated on the transmission of subject knowledge whereas the EAL teacher, whilst still focussing on the subject content, transmitted the knowledge through an interrogative approach.

The need for close collaboration between EAL and science teachers has been corroborated more recently by Conteh (2015, p. 111), in a case study carried out by Pete Rouse. Whilst the context of the study (i.e. a large class with some challenging behaviours) was rather different to the one in this study, it provides a clear illustration of how subject teachers can work collaboratively with EAL teachers, particularly highlighting the area of fair testing of knowledge.

How to structure integrated science and language objectives is clearly explained by Carrier, K. (2005), who gives the example of the need to teach the language function of describing shapes and patterns when teaching about cells in biology. Once written (maybe collaboratively), the objectives can be used by EAL teachers to help support the development of scientific literacy. She also gives practical examples of resources that can help meet these objectives. Alternatively, useful practical ideas to bring language activities into a content-driven subject class are provided by Deller and Price (2007).

The wide variety of research and teaching recommendations available for the science teaching of ELLs is commented on by Janzen (2008, p. 1010), whose extensive review of research also considered 'the linguistic, cognitive and sociocultural features of academic literacy'.

2.4.2 Strategies for teaching vocabulary

A good knowledge of science vocabulary is necessary to be able to communicate effectively as a scientist and hence a significant feature of science lessons is teaching vocabulary associated with new concepts. Richardson Bruna, Vann and Perales Escudero (2007) stress the importance of teaching both the 'bricks' vocabulary and also the 'mortar', the linguistic tools the students need to express the science processes and semantically connect the vocabulary (Dutro and Morgan, 2001). Moreover, in a case study on a teacher called 'Linda', Richardson Bruna, Vann and Perales Escudero (2007), discuss the tension existing between teaching the language of science against teaching the science concepts themselves and warn that if the vocabulary drives the science teaching and is taught too explicitly then this may compromise the conceptual development of the science content.

A common criticism in the language learning literature of science teaching, is that vocabulary is often presented in linguistic isolation (Robinson (2005), Richardson Bruna, Vann and Perales Escudero (2007), Carrier, S. (2011). A key UK study illustrating the problems was carried out by Robinson (2005), who, when studying teaching practice in science and geography, noticed a disparity between the vocabulary knowledge pupils were taught and what they needed to participate in lessons. She maintained that to be able to utilise unfamiliar words learners 'need to acquire not only semantic knowledge of the vocabulary … but also the syntactic and morphological word knowledge' (Robinson, 2005 p. 443). She discovered that because vocabulary was generally taught quite explicitly with only a very narrow focus of meaning and with no focus on form, the pupils were not able to express their understanding of the science concepts linguistically. For example, 'erosion' was taught, but the verb and adjectival forms 'erodes' or 'eroding' were not later recognised as belonging to the same concept. This highlights the difficulties concerned with nominalisations mentioned previously in this review (see 2.3.1).

Much research into vocabulary teaching strategy has been carried out in North America with many intervention studies being reported by CREATE (Center for Research on the Educational Achievement and Teaching of English Language Learners).

2.4.3 Teaching literacy skills

Literacy development involves a range of abilities more than being able to speak, listen, read and write. Lee and Buxton (2013a) describe how developing literacy involves not only learning to think, and reason, but also to communicate information visually using pictures or graphs. To be effective in the science classroom, teachers need to incorporate reading and writing strategies into their lessons and promote, not only science learning, but also the development of literacy. This can be done using well-planned comprehension questions about science texts, narrative vignettes and writing tasks in different scientific genres, such as lab reports or designing posters. Lee and Buxton (ibid) also recommend the use of graphic organisers such as concept maps, word walls, Venn diagrams to reinforce the learning of scientific concepts and literacy skills. They suggest that effective teachers give alternative explanations of concepts and try to communicate at a level just above the students' current level of communicative competence. An example is given of a lesson involving the words 'increase' and 'decrease', where the teacher gives the alternative terms 'go up' and 'go down', along with hand gestures or drawings. Brown and Spang (2008) introduce the term 'double talk' when discussing this useful approach.

Problems associated with the language of teacher instructions in science is identified by Seah, Clarke and Hart (2014) in their case study of a class on thermal expansion. By carrying out content and lexicogrammatical (LG) analyses they uncovered 'differences between oral and written language' and 'differences between the everyday language and the language of school science' (e.g. use of 'expand') and highlighted the likelihood that the language the students use is driven by the language that teachers use for giving instructions (Seah, Clarke and Hart, 2014, p. 970).

Reading

Reading skills, as taught in a second language learning environment such as the ISC, are invaluable to science reading. The skills of skimming and scanning and identifying key words are essential components for the scientific reader. In fact, it could be said that all students would benefit from these skills being explicitly taught in the science classroom. Herman and Wardrip (2012) discuss the reading techniques for science and underline the power of annotating texts, using double entry journals and explicit pre-teaching of vocabulary.

Writing

Technical writing is central to scientific learning and, as already mentioned, uses many distinctive linguistic functions and devices to convey meaning, in a very word efficient manner. There is general agreement in the literature that the ability to communicate effectively in writing using the scientific register is a necessary skill to acquire and that this is especially challenging for newly arrived EAL students. Weiss-Magasic (2012) discusses how to train students in writing up experiments (lab-reports) and how to stimulate their interest and develop language by using cartoons, celebrations, and science fiction. Nelson (2010) reports on using science notebooks with younger pupils to record vocabulary in pictorial form and/or L1, incorporating sentence frames to scaffold the writing. Sentence frames (or gap-fill exercises) are useful tools for supporting EAL students – especially for teaching the 'mortar' language. However, the challenge for the science teachers is finding the time needed to generate these support materials.

Several intervention methods have been tested including the Sheltered Instruction Observation Protocol (SIOP) Model. Echevarria et al. (2011) tested this intervention and found it to have a positive effect on achievement levels in science in US middle schools. The SIOP Model aims to provide teachers with the kind of teaching strategies and techniques that can be adopted to facilitate science content comprehension for ELLs and simultaneously develop their academic language.

2.4.4 Questions and dialogic interaction/inquiry strategies

EAL students need to be trained in asking high order questions (Alcón, 1993) by learning the language and being given opportunities to practise asking questions in the EAL classroom. The ability to ask questions influences students' reading comprehension ability and the importance of teaching students to question independently to enhance reading comprehension in science is emphasised by Taboada (2012).

Cuevas et al. (2005), proposed an inquiry framework to explicitly teach inquiry to address the differences in some students' cultural and educational backgrounds. Similarly, the Argument-Based Inquiry (ABI) teaching technique is promoted by Ardasheva, Norton-Meier and Hand (2015, p. 202), as it 'supports students' critical thinking, scientific reasoning and problem solving through guided dialogue, reading and writing as thinking tools.'

The use of dialogic-inquiry, as proposed by Haneda and Wells (2010), is found to be effective when teaching ELLs science. In this approach, interactive speaking and questioning in small groups is scaffolded by the teacher to integrate literacy with science instruction. Dialogic learning is explained well in a video on the website 'thescienceteacher.co.uk', together with excellent explanations and resources to help develop scientific oracy. The importance of saying new words, together with opportunities to 'negotiate the meaning and construct their own understanding of the words' was also stressed by Robinson (2005, p. 443).

Another area of interest to this study is that of teacher questions. The importance of the type and quality of teacher questions in the CLIL classroom was raised by Dalton-Puffer (2007). She stressed the importance of the I-R-F (Interaction-Response-Feedback) cycle to the development of scientific knowledge through classroom talk. Rice, Pappamihiel and Lake (2004, p. 121) criticise teachers for often ‘engaging in a “benevolent conspiracy” intended to save ELLs from embarrassment’ and explain that this ‘consequently deprives them of learning opportunities’. They rightly point out that the key to correctly supporting ELLs is to simplify the language used for questioning ELLs, without simplifying the concepts or cognitive challenge. This idea is supported by Fang and Schleppegrell (2008) who emphasised that scientific language tends to have a very high lexical density and so teachers need to use more words (not less) to ‘unpack’ the scientific language.

The results of a study by Dalton-Puffer (2007) into CLIL classroom language, showed that teacher questions mostly asked for facts using display questions, but rarely for reasons or explanations. This is indicative of interactions that are relatively cognitively undemanding, and which do not elicit extended responses. This can be argued to have the effect of improving linguistic confidence but will not help build scientific literacy. Science teachers need to take care particularly with referential questions (answer is unknown to the teacher), which, as Zohrabi, Yaghoubi-Notash and Yousefzadeh (2014) showed, tend to be used more as the language level increases. The language needs to be simplified without compromising the cognitive level.

2.4.5 Scaffolding learning

The value of scaffolding learning, as introduced by Bruner, Olsen and Anglin (1980), is highlighted by August, Artzi and Mazrum (2010), in their review of research relating to the efficacy of science teaching for ELLs. The two large intervention studies outlined, (one pre-teaching keywords with picture cards, another having an initial introduction activity when teaching diffusion and osmosis), both conclude that the most effective way of helping ELLs when learning science, is for good science teaching to be complemented by appropriate scaffolding, with a focus on language development.

Robinson (2005, p. 441) noticed that teachers naturally resort to using linguistic frameworks when trying to explain or define words. Small steps are used to develop the meaning, as in the example,

'*a buggy is a very, very simple vehicle*', then '*it's a very simple moving object*' and finally, '*so it's going to be a very, very simple moving four wheeled object.*'.

The use of sentence frames or sentence builders to provide 'ready-made chunks of language' which allow language learners to become more fluent and communicate concepts without the burden of grammar rules, is promoted as a way of scaffolding learning (Wood, 2002 cited in Carrier, K., 2005, p. 7).

A new way to facilitate the simultaneous learning of English and science subjects by EAL students has been recently introduced by Afitska (2016). The materials which scaffold the learning are the outcome of a collaborative EAL science project involving City Council and University. Whilst this approach, based on an intervention study in maintained primary schools in Sheffield, involved younger children, the principles might be usefully applied to the secondary school context in this study. Afitska (2016, p. 76) emphasises the distinction between 'language support' and 'language acquisition' and introduces some example science language support tasks for EAL students, where the cognitive challenge of learning is preserved, whilst making it linguistically more accessible.

2.4.6 Funds of knowledge

Every individual has a distinct cultural and personal fund of knowledge that they have gained throughout their life. As Fernandez (2011) points out, EAL students may have knowledge that is relevant to science, such as experiencing earthquakes or hurricanes, or of living in a different climate and knowing about different horticulture. Barton and Tan (2009) investigated actively encouraging the sharing of these 'funds of knowledge' during discussions, reading and writing activities and science tasks in the classroom. The teacher invited students to talk about their own 'funds' openly, which they then did willingly. The students felt more involved and they found the scientific knowledge to be more meaningful, as well as adding a 'rich source of data' to the classroom. This, in turn, then leads to increased engagement with contents and improved learning outcomes (Barton and Tan, 2009, p. 68). Lee and Buxton (2013b, p. 112), reinforce this by remarking that 'effective teachers of ELLs in science identify and then build upon students' funds of knowledge related to science topics'. They give the example of discussing the efficacy of herbal medicines used in non-Western cultures, where the 'community funds of knowledge' can be accessed usefully, by asking EAL students to share their knowledge.

2.4.7 Co-operative learning and peer-tutoring

Interaction with peers and co-operative learning have been identified by Ardasheva, Norton-Meier and Hand (2015) as being beneficial to ELL learning. It is suggested that teachers need to arrange seating plans, or classroom pairing, in a way that encourages students to discuss meanings and support each other, thus expanding their knowledge beyond their current position. These negotiations are argued to be a necessary process in science learning in which students help each other to understand new concepts and build language skills together. McDonnough and Cho (2009) advocate pairing less advanced ELLs with an advanced ELL, or possibly a FLE student. The advanced ELL can use simplified English, an interlanguage or the same language to explain task and homework directions. This suggestion, however, comes from a science teacher where the focus is firmly on development of the science content. Language teachers, on the other hand, may argue that speaking in their native language does not advance the students' English language.

Atwater et al. (2013) highlight the importance of peer-support based on academic goals, particularly for Asian students. They suggest that science teachers should encourage students to gain a deeper understanding of complex science concepts by organising hands-on activities and co-operative learning strategies which rely less on direct knowledge transmission and language proficiency.

2.5 Final comment

The main message coming out of the literature is a call for the integration of the teaching of science and language, with close collaboration between science and specialist language teachers. Effective communication skills and the ability and willingness to confidently ask and answer questions is fundamental to science learning and it is important that learning is scaffolded by the teacher to ensure that the language input is in the ZPD. Previous education, cultural factors and funds of knowledge are important indicators of potential success for these EAL students. The importance of developing scientific literacy alongside teaching science content is widely written about and techniques to support this are discussed.

It is also important to remember that, as expressed by Tong et al. (2014, p. 412), 'science provides ELLs with a context-enriched setting for the learning of language structure and functions and the expansion of students' vocabulary'. In other words, learning science benefits language development.

Finally, the inter-relation between science and literacy is discussed in depth by Norris and Phillips (2003, p. 226) who argue that 'reading and writing are constitutive parts of science' and that 'science cannot exist or be learned without text'. They maintain that the ability to interpret is needed to process science text. Perhaps, one question to ask is "Who teaches these skills: the scientists or the linguists?"

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Aim and research questions

This research aims to gain a greater understanding of the challenges and support for EAL students learning science in a UK secondary school.

To achieve this, the focus was on the following broad research questions:

1. What factors limit the learning of newly arrived Year 9 or 10 EAL students when studying science subjects in a UK independent secondary school?
2. How do their curriculum and English teachers address the difficulties?
3. What further support strategies can be identified which would help to extend their learning?

3.2 Research approach

3.2.1 Qualitative

This study adopted a qualitative approach which, as Dörnyei (2007) describes, explored and probed to gain an in-depth understanding. Rather than take the approach of individual or multiple case studies, as described by Hood (2009), I chose to seek an in-depth qualitative understanding across a broader range of teachers and students in the school, exploring their perceptions regarding EAL science learning in general. The 'emergent nature' of qualitative research (Dörnyei, 2007, p. 37), means that changes can occur if new discoveries are made as the study proceeds. The interview questioning was constantly refined throughout the study as it progressed through the 'research cycle', as described by Freeman (2009, p. 29), with the research process cycling through the stages of inquiry, data collection, data analysis and claims, several times.

3.2.2 Naturalistic

Naturalistic research refers to the situation where 'the researcher conducts observations in the natural environment in which people live and work' (Jasslo-Aguilar, 1999, p. 31). During the research, my role constantly shifted from teacher to observer to interviewer in a familiar setting which, according to Brewer (2000, p. 10), is a variation of 'participant observation'. As discussed by Eder and Fingerson (2002, p. 183), it is very important when interviewing adolescents, that the interview context is natural to them and it is recommended that the interview is conducted within a larger activity that the respondents are already familiar with.

Being an established teacher in the school allowed me to adopt an 'emic perspective', as described by Rossman & Rallis (2003, cited in Heigham & Croker, 2009, p. 8), with an 'insider' point of view. This enabled me to interact naturally with the research participants, establishing rapport and gaining the trust and confidence of the participants.

3.3 Research participants

Five science teachers, one EAL teacher and six students were observed and interviewed.

The Year 9 and 10 students selected were new international arrivals joining the school in September 2016, who were identified as needing extra language support in the ISC. All students live in the school boarding houses during term-time (with Houseparents, UK and other international students), but re-join their families (usually overseas) during the holidays. The students attend bespoke EAL lessons in the International Study Centre and selected curriculum subject lessons in the main school, depending on their English level and choices. EAL lessons are mainly for English Language but also give cross-curricular support. The students study science subjects, in addition to mathematics and one or two other subjects, such as DT (Design and Technology) or Art.

The teachers included in the study represented the three sciences of biology, chemistry and physics and were teaching the student participants. There was a mix of male and female teachers, with a range of age and experience of teaching EAL students.

The profiles of the six students included in the study are shown in Table 1 and that of the teachers in Table 2, using the codes adopted for the study.

Student	Male/Female	Nationality	Year Group	Science subjects
S1	M	Chinese	10	physics
S2	M	Chinese	10	chemistry, physics, biology
S3	M	Chinese	10	chemistry
S4	F	Russian	10	biology, chemistry
S5	M	Chinese	9	biology, chemistry, physics
S6	M	French	9	biology, chemistry, physics

Table 1

Teacher	Male/Female	Science subjects
T1	M	physics
T2	M	physics
T3	M	chemistry
T4	F	biology
T5	F	biology
T6	F	EAL

Table 2

3.4 Research design and instruments

The study comprised a series of science lesson observations, in-depth, qualitative interviews with students and teachers, together with a narrative frame written exercise with students.

3.4.1 Science lesson observations

Observations focussed on the areas of student engagement, student-teacher interactions, meta-language and lexis, instructions and signals. In accordance with the qualitative nature of this study, any interesting observations, including facial expressions and body language were made. An observation sheet (see Appendix 1B) was designed by making adaptations to formats and forms suggested by Wajnryb (1992) and all lessons were digitally sound recorded.

During the lesson observations, I adopted the role of 'complete observer', a term introduced by Gold (1958, cited in Cowie, 2009 p. 167), which allowed me to collect information about the participants' outward behaviour and to understand the experience of learning science from each individual's perspective. This put me in an informed position to follow up with questions designed to understand the reasons, during in-depth interviews with both teachers and students, as suggested by Croker (2009, p. 17).

The lesson observations provided a view of the difficulties, experienced from a more objective perspective, as described by Dornyei (2007, p. 185) and gave the opportunity for any other factors that were not talked about, to be identified. The classes were observed before carrying out the narrative frame exercise and interviews. This ensured that the lessons were not influenced by raised awareness of factors introduced during the interview.

3.4.2 Student narrative frame exercise

The first stage of questioning of individual students was the online completion of a narrative frame exercise. This technique was introduced by Barkhuizen (2008) and applied by Macalister (2012) when investigating the language learning needs of US Seafarers. The questions formed part of a narrative story that the students completed about themselves and aimed to establish their previous education and experience and began to explore what their science learning difficulties are.

The narrative frame exercise, titled 'My Science Story', was introduced as an additional exploratory tool, requiring students to give a written response. The resultant data provided the first round in the inquiry, data collection, data analysis, claims cycle (Freeman, 2009, p. 29) and gave information that could be followed up in the interview.

The narrative frame started as follows (and is included in Appendix 1A):

'When I was young I was interested in learning about............ '

Students were encouraged to change the words to make a continuous story and create more interest.

In accordance with the naturalistic approach adopted in this research, the initial narrative frame exercise was completed using the students' own laptops and delivered as an exercise within a normal EAL lesson.

3.4.3 Interviews

Qualitative, in-depth interviews were carried out with individual students and teachers. Interview guidelines were produced for student and teacher interviews. During each interview, a list of statements or possible factors were presented to the participant mid-way through the interview, asking them to tick a maximum of five factors which they consider to be the most important in limiting learning. These then helped to guide the respondent's thoughts and the interview to areas of interest. Interview guidelines and statements can be found in Appendix 1C.

The interview approach was of 'active interviewing', as defined by Holstein and Gubrium (1995), whereby the interview has a broad plan of topics to be covered but is held as a conversation. This approach is based on the idea that the respondents can be 'constructors of knowledge in collaboration with interviewers, rather than just repositories of knowledge' (Holstein and Gubrium,1995, p. 76). I felt that, since I am so well-known to the participants, this 'constructive conversation' approach was appropriate and would 'elicit richer data'. A flexible interview guide was also used to provide a list of some structure and consisted of sample questions on topics to be covered, as illustrated by Lindlof and Taylor (2011, p. 200).

As Gillham (2005, p. 24) points out, a semi-structure allows more depth to be obtained by further probing than a structured questionnaire but keeps the interview to the topic areas of interest to the study. The order and wording of these questions was not strictly adhered to and further questions were posed according to the responses. The in-depth interviews were carried out by the researcher, in accordance with the guidelines provided by Johnson (2002, p. 103), adopting an open, experimental attitude, at times allowing the interview to follow an individual path whilst subsequently returning it to the planned course.

The students and teachers were asked to describe challenges experienced whilst learning science in English and to identify those that are most limiting to their learning. They were also asked to give suggestions as to what other help/support would be useful.).

The EAL teacher was questioned about what difficulties they perceive the students to have in terms of language and what support the ISC does and could provide. The interview guide was adapted from the guide used for the science teachers.

3.4.4 Triangulation

The challenges experienced by students were investigated from three different perspectives: objective observation of lessons; narrative frame exercise; interviewing the students and their teachers. This provided methodological triangulation as defined by Denzin (1978) and Cohen, Manion and Morrison (2000), in which data collection is from three different sources (science teachers, English teachers, EAL students) and by three different methods (observation, narrative frame exercise and interview). This enables validation of the data by cross-verification from the various sources and methods. The sample was also triangulated by observations and interviews being carried out across the three science subjects.

The value of using several different sources and methods was highlighted by Jasso-Aguilar (1999) in the needs analysis case study for an English course for a group of Waikiki Hotel maids. This triangulated approach gave me the opportunity to compare the data from different methods, for example, to explore the extent to which practice in the classroom matches what was said in the interviews and this increased the reliability of the data, as explained by Dörnyei (2007, p. 165).

3.5 Conduct of research and data collection

3.5.1 Pilot studies

Each research instrument was piloted at the beginning of the study, as suggested by Dörnyei (2007, p. 75). Following the videoing of the pilot observation, I decided to use a sensitive dictation machine to audio-record subsequent observations and interviews. The video recording had clearly affected the behaviour of some students and achieved a very limited view and sound.

Obtaining quality, analytical information in the pilot student interview proved difficult, due to immaturity and limitations in their English language ability. I considered the possibility of using older students of the same nationality as interpreters or translators but, overall, decided that this would compromise the naturalness and that age was the bigger limiting factor.

3.5.2 Lesson observations, interviews and narrative frame

The main data collection phase of the study took place in the middle of the academic school year, so teachers and pupils were in a settled phase. The study comprised eight science lesson observations (three biology, three physics, two chemistry), six student narrative frame exercises with follow-up in-depth, qualitative interviews and six teacher interviews. Three year 9 and five year 10 science lessons were observed and twelve interviews were carried out in total. As the researcher, I carried out all lesson observations and interviews and a detailed schedule of observations and interviews, together with codes used, are included in Appendix 2 (*removed for publication)*.

Peer observations are a frequent practice in the school and so my presence in the class was not an unusual event. In a broad sense, my role was as a participant observer in that I am a colleague to the teachers and a teacher to the students, but as an observer in the classroom, my role was non-participant, in that I did not interact with the students or teachers.

The 'Science Story' framework was shared in a Google Pages document, so the students could independently complete open-ended prompts, using their Macbooks and the individual responses can be found in Appendix 2 (*removed for publication)*.

The student interviews were carried out as part of their EAL lesson in the ISC and the teacher interviews were held in the science laboratory/classroom during school time. Student interviews were generally about 20 minutes, whilst those with the teachers were about 45 minutes.

My interview technique was refined during the process. After the first interview (T3), I believe I developed a useful balance between active interviewing (Holstein and Gubrium, 1995, p. 76) and semi-structured interviewing (Richards, 2009, p. 185) where the interview developed naturally, but the conversation was kept more tightly to the intended interview guideline. This approach seemed to yield more useful data.

3.5.3 Data recording and storage

All lesson observations and interviews were audio-recorded using a sensitive dictation machine and the digital recordings were stored securely and confidentially. A digital file structure for storing the data was set up at the beginning of the study enabling the data to be systematically organised. Each observation and interview was given an individual code to enable easy, but anonymous, identification during analysis.

3.6 Data analysis

The completed observation forms gave detailed insight into the science classroom and are included in Appendix 2 (*removed for publication)*. The lessons are identified by codes, for example, P1, B3, where P1 is the first physics lesson observed. The field notes from the observations were analysed for commonalities relating to the research questions and the recordings of the lessons listened to for further insight into linguistic problems. A summary of some of the language phrases and words used by the teachers are in Table 3 (*removed for publication*). Some observed instances of help given and suggestions are found in Table 4 (*removed for publication*).

Typed transcripts of the audio-recordings of all interviews were produced and can be found in Appendix 2 (*removed for publication*). Transcripts were sensitively edited to comply with ethical considerations of confidentiality, such as names or identifying factors. A key of conventions used, based on an example in Dalton-Puffer (2007, p. XI), is in Appendix 2A. As recommended by Richards (2003, p. 199), the degree of detail in the transcription achieved a balance of discourse detail and readability and 'best served the research needs' by not 'distracting attention from the features that are important'. As the aim of this study is collecting views, as opposed to any transactional analysis, the transcription mainly reflects the words and omits some of the 'linguistic clutter' such as false starts, ums and errs, so that the content of what was said comes through clearly (Lindlof and Taylor, 2011, p. 215). Line numbers were applied to the transcripts and events in the observed lessons were identified by time e.g. 't20' refers to 20 minutes after commencement of the lesson.

All interview transcripts were read several times and analysed for important emerging themes and anecdotes. Analysis of the datasets was mainly intuitive via the typed transcript but some categorical analysis as described by Gillham (2005, p.134) was applied to the data. The use of a coding frame is discussed by Heigham and Sakui (2009, p. 102) and after considering the counter-arguments of being time-consuming and potentially superficial, I decided to proceed with this approach, whilst also maintaining a 'whole picture' view of the data.

A system of highlighting was applied using coloured highlighter pens to code the text according to comments relating to the three research questions of: challenges, support and future ideas.

Each comment was then summarised and, referenced with the interview code and line number. These were saved as lists in separate Word documents for each research question. These summarised comments were then read through several times and the categories of language, skills, cultural, socio-psychology began to emerge. These were then considered and chunks of text relating to each category were highlighted in colour. After further consideration, the themes were changed to language, inquiry and classroom techniques (see Findings and Discussion). An example of these codings are included in Appendix 2C. Each summarised chunk was coded with the participant's code and line number in the interview. These steps were all carried out separately for the student and teacher interviews.

3.7 Ethical considerations

The participants in this research included children under the age of 16 years and I am also their teacher, so, it was necessary to seek approval for the study from the Full Research Ethical Committee (FREC) of the Faculty of Arts and Humanities at the university, as discussed by Kimmel (1996, p. 275). An application form completed for this formality was completed and submitted (see Appendix 1 – *removed for publication)*. Notification of approval was received by email from the Chair of the Humanities Ethical Research Committee on 11th January 2017.

Initially, permission was obtained from both the Headteacher and Boarding House co-ordinator who act as school gatekeepers for the students. However, as Homan (2002, p. 36) argues, there is a risk that relying on this gatekeeper consent can lead to ethical compromises and so it was important to gain informed consent from the students themselves and the parents of the students. This proved challenging as the parents reside abroad and mostly cannot communicate in English. After consultation with the school gatekeepers and the University Research Ethical Committee, it was agreed that the normal school protocol for obtaining consent for school trips would achieve compliance. An email with the information sheet was sent to the student's appointed Guardian (who acts *in loco parentis* while the students are in the UK) to ask for their permission for the student's School Boarding House Parent to sign the consent form. In most cases, this was passed on to the parents in their language. One parent refused participation on behalf of their child (reason unknown), which illustrates and highlights the importance of this step. In another case, the parents visited the UK and could give direct consent, but I needed to obtain a full translation of the information sheet and form into Chinese (checked by a local Chinese interpreter).

As Homan (2002, p. 31) points out, many studies neglect obtaining informed consent from children and so it was important that Student Assent forms were also signed by the students themselves. This was only done after they had understood the 'Student Participant Information Sheet' explaining the aims of the study in detail, ensuring participants were aware of their right to refuse participation and reassurances of anonymity and confidentiality. Similarly, Teacher Consent forms were signed by the teachers who were observed and interviewed, after reading the Teacher Participant Information Sheet. All forms and information sheet pro formas can be found in Appendix 1 (*removed for publication*).

To comply with ethical and confidentiality considerations (Dörnyei, 2007, p. 65) and to retain anonymity, no names are revealed in this report, no video or sound recorded data or transcripts are included in the results, and the source of any anecdotal quotes included remain anonymous. Signed consent forms are not included to preserve anonymity but are available for inspection.

This study was carried out in such a way that fully complies with the British Sociological Association: Statement of Ethical Practice; British Psychological Society: Code of Conduct and British Educational Research Association: Ethical Guidelines (McNamee and Bridges, 2002, pp. 235-255).

CHAPTER 4

FINDINGS and DISCUSSION[1]

4.1 Overview

In this chapter, the main findings from the qualitative data are presented. The first findings discussed are from the narrative frame exercise, 'My Science Story', which provided background to the science learning for each student.

Initial processing of the data from the interviews and observations, identified four potential key coding categories, namely: *language, literacy, cultural* and *socio-psychological.* After further analysis, *literacy* was included with ***language*** due to a limited number of comments. Most comments relating to *cultural* and *socio-psychological* factors appeared to be concerned with the reluctance or inability of certain students to interact with the teacher or peers through asking and answering questions. Different possible reasons, relating to cultural, educational background, personality and confidence factors were offered to explain this, but careful consideration of the data revealed that the teachers agreed that a lack of inquiry is the key barrier to learning. As science is an inquiry-based discipline, the ability to ask questions, evaluate or be critical is essential to the successful development of scientists, so the decision was made to use the category of ***inquiry***, instead of the *cultural* and *socio-psychological* categories. There were many comments in the data relating to classroom pedagogy and so a category encompassing this emerged, which I refer to as ***classroom techniques***. These include classroom factors that can facilitate or inhibit learning, such as verbal communication and instructions. It was therefore decided to report the key findings based on the themes of: *language, inquiry and classroom techniques.* These are considered and discussed in relation to the research questions.

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[1] In the original, submitted version of this MA, all quotes from interviews were referenced with a line number (e.g. T4, ln20). These references have been deleted here because the transcripts have been removed from the appendices, in order to maintain confidentiality.

4.2 Narrative frame, 'My Science Story'

The narrative frame 'My Science Story', was a scaffolded writing exercise, given as part of a normal EAL lesson prior to the interviews, which initiated thinking about the students' previous science learning. The findings from 'My Science Story' provided an insight into the students' previous scientific education and attempted to give a measure of their interest and motivation for learning science subjects (see Appendix 2 -*removed)*.

The stories revealed a wide range of childhood interests including: 'dinosaurs'; 'space and chemical experiments' and 'ships and history'. The start of formal science lessons ranged from 6 to 14 years, which has significant implications to their level of knowledge. Only physics had been studied by all the students previously, some had never studied biology or chemistry. Five of the six students were enjoying practical work in the UK, despite having done little, if any, practical work previously. Difficulties learning science in English included the language (described by S4 as a 'wall' to speaking), doing tests on paper and replying to questions. A surprising comment made by one student (S5) was that he finds the "science work in the UK easier than in China", which gives him "time to think about it more". This is an interesting key point in that science education in the UK aims for understanding and knowledge application rather than just learning. It was also interesting to note that only a minority of the students (S3, S5) anticipate needing science qualifications for their future career, with others thinking of business, design or the Arts.

One of the teachers remarked that not much is known about the students' previous education and suggested that "to have a finding-out-about-them exercise would be helpful" (T4).

4.3 What factors limit the learning of EAL students?

The main difficulties inhibiting the EAL student's ability to thrive in science are related to:

a) language systems, such as vocabulary and grammar, and literacy, such as writing and extracting information from scientific texts; b) the ability to inquire, to clarify understanding by asking questions, to ask questions and interact in class, to think critically and evaluate their actions and

c) classroom techniques such as carrying out practical work, copying from the board, recording homework, pre-learning vocabulary. Other difficulties such as homesickness, culture shock, food, socialising, personality and educational background were identified as generally creating barriers to learning but, as these factors affect all learning and not specifically science, they are beyond the scope of this study.

4.3.1 Interview factors statements

The factors questionnaire, completed as part of the interviews, identified the five main factors limiting the learning and served to stimulate thinking. Analysis of the data represents an overview of the views expressed by the students and teachers. These are summarised in Appendix 2B.

Some commonalities were found but also some interesting discrepancies in the perceptions of the students and teachers as to the main barriers to science learning.

The factors with the highest level of agreement between students and teachers were about:
a) lexis (*'I don't know the scientific words/poor knowledge of scientific vocabulary*,)
b) lack of interaction or inquiry (*'I feel too shy or unconfident to speak in class discussions' / 'Inability or reluctance to ask questions or participate in class discussion)* and c) writing (*'I find it difficult to write down my ideas' / 'Inability to express ideas in writing*'). These factors were chosen by most students and teachers as being mainly responsible for limiting science learning. Conversely, few students or teachers ticked the following factors about: a) science knowledge (*'I haven't studied the science topics before in my own language'/'Weak scientific knowledge*); b) poor speech comprehension (*'I can't understand the way the teacher speaks'/'Inability to understand fast speech or regional accents*'); c) using practical equipment (*'poor practical skills or knowledge of equipment'/'I don't know how to use the equipment in practical sessions*') and d) English grammar (*'My grammar is not good enough*'/' *Weak command of English grammar')*. These are not generally regarded as main barriers to learning.

However, in some areas, the opinions of students and teachers differed. Nearly all the teachers thought that complex language used in lessons is a key factor in inhibiting learning (*'The language the teacher uses is not simple enough'/'Low understanding of colloquialisms, phrasal verbs and connected speech'*), whereas none of the students considered this to be a problem. Similarly, no students felt that the factor about understanding instructions or questions from the teacher (*'I don't understand when the teacher tells us what to do or asks questions'*) stops them learning, whereas half of the teachers ticked this (*'Poor understanding of instructions/questions'*) as a main factor. Another discrepancy was that a third of students identified teachers' handwriting as a problem, whereas no teachers regarded this to be an important problem. This is an interested finding that is discussed later (section 4.3.3).

4.3.2 Language

Language systems

The teachers showed awareness of the difficulties of acquiring scientific language whilst simultaneously learning English. This was neatly summed up by T5 who said

> Well, it's quite major, isn't it? .... The struggle of a native speaker year 9 is to be able to use the scientific language within a sentence, but EAL students have got the double problem of forming the sentence in the first place! (T5)

T2 also pointed out that "the language in science is very different to any English they have been exposed to in any other English experience...like watching movies". Conversely, the students had very little awareness of the nature of their language difficulties beyond "I need to study it" (S5), or "it's very difficult to understand some sentence" (S2).

Vocabulary is highlighted by all teachers as a challenge. T1 talks about the "jargon of science ... strange terms that you would only meet in science", referring to words like 'osmosis' and 'refraction' which can be regarded as 'bricks' in the 'bricks and mortar' analogy, as discussed by Dutro and Morgan (2001, cited in Ardasheva 2015, p. 16). T6 points out that the "wording around the scientific terms causes a problem, for example 'Where does a virus exist?' The word 'exist' is not something that they might know." This relates to the 'mortar' language (Dutro and Morgan, ibid) that binds the scientific words together.

In addition, 'refraction' is an example of the nominalisation problem reported by Halliday and Martin (1993, cited in Atkinson, 1994). 'Rate of change' is identified by T2 as also being a key word used in physics which causes confusion, along with everyday words that have a different and specific meaning in science. For example, 'yield', which in science means 'the quantity that has been generated (farming and chemical reactions)', when translated, the first definition may be 'to give way' and the students "look absolutely shocked and flummoxed" says T4.

Vocabulary normally introduced in primary school science is described by T4 as often creating difficulties. "So, things like 'a weed', an unwanted plant. You know, so they see it in an exam paper and suddenly they're lost."

Command terms used in instructions also often cause difficulties. When learning scientific procedure, T2 explains that "sometimes they're not exactly sure what we actually mean". During observation B3 and subsequent discussion it was observed that the words 'label', and 'place' were not understood, both of which have different meanings as nouns in everyday language, as described by Carrier K. (2005). The command words used in questions such as 'describe', 'explain' and 'evaluate' are stated as causing difficulties by T2. These are the academic functions referred to by Carrier K. (2005) in which inadequacies using them contributes to the 'scientific literacy gap'.

Many examples of colloquial expressions were heard in the observations, (see Table 3, Appendix 3 -*removed for publication)* such as "to give you a heads up" (C3), "topsy-turvy" (P2), "let's go through it"(P2). Difficulties in understanding colloquial expressions were thought by T4 to be "probably massive, you know it's the sort of thing that we're not always *clocking*." Case in point.

Phrasal verbs are described by the EAL teacher as being "especially tricky" (T6) and explains that there is little awareness by FLEs that these are so difficult to understand. This is illustrated by the example "hand this out to everybody".   Using the word 'distribute' or 'give' would be more helpful and overcome the translation difficulties presented by phrasal verbs. Another issue that T6 highlights is that students need to verbalise novel words in order to use them. For example, 'photosynthesis', a student needs to be able to write it, read it and say it, in accordance with Robinson (2005).

Grammar was not thought by the teachers to be a big issue in science learning. However, T2 astutely remarked that "grammar is not a problem, unless it is affecting their ability to understand the question." The collective opinion from the factors questionnaire was that English grammar is not important in science. However, the grammar often conveys the subtlety of meaning and thus, arguably, it is fundamentally important to science. For example, the difference between 'has little effect' and 'has a little effect' has been known to cause confusion in a biology examination question. The addition of the article changes the meaning from having 'no effect' to having 'some effect'. T4 gives the example that EAL students are not able to describe relationships like "As the light intensity increases, the colour changes." Subsequent remarks that "I don't worry about grammar" because poor grammar does not "impede massively conveying their knowledge in science", conflict with this view. Responses from the students about grammar were inconclusive: S6 remarked that his poor grammar was important in the examination; S2 gave science and grammar as the useful things he has learned in the ISC but S5 did not understand the word grammar. This lack of awareness of how a good command of grammar is related to communication of meaning is, arguably, something that needs to be addressed.

The effect of cross-linguistic cognates was mentioned by T6 and the French student (S6), who gave the example of being able to link 'sucrose' as a type of sugar through the connection to the French word 'sucre'. This resonates very well with the views put forward by Kelly and Kohnert (2011). Interestingly, S6 also gave a clear example of the codeswitching utilised by students as described by Cheng (2013), when he said "Maybe, but he just write word at the board, the *produit*, er it just chlorine ….".

Literacy skills

Literacy skills in the more expanded sense, as described by Carrier K. (2005), were identified as problems by the EAL teacher (and to a limited extent the students), but were not really mentioned by the science teachers. T6 remarks that "watching a video and taking notes is probably the hardest thing they have to do". Another academic skill mentioned by T6 is "summarising and using their own words". To a certain extent it could be argued that these skills can be deficiencies common to all students, however, learning these in an additional language carries specific difficulties. This is an area where it might be useful to raise awareness of these issues with science teachers, since these problems are well documented in the literature regarding EALs. For example, language functions such as describing shape, as discussed by Carrier, K., (2005), need to be considered as part of academic literacy development.

4.3.3 Inquiry and interaction

Science is an inquiry-based discipline. In the interviews, both teachers and students put a major emphasis on the willingness and ability (or not) of students to interact and ask critical questions (T1, T2, T4, T5, S2, S5). This necessitates them being able to ask and answer questions about new concepts to gain understanding and further their scientific knowledge.

The students showed general awareness of the problem and S2 explained that he does not ask the teacher for help very often because he "can't really explain the question" that he has in his mind and that it's difficult to ask because they were not able to ask questions in class in China. S4 is not shy by nature but confessed to not taking part in class discussion because she "says things wrong" and is scared to embarrass herself in front of people. S5 said that "it would be too often" to ask the teacher when he wants to. It is possible that these observations are examples of the contentious 'silent period' which may occur in language development (Vygotsky, 1986, p 225, and Ellis, 2008, p. 73)

The teachers view interaction and questioning as vital to the students' development in science, which is in accordance with findings in the literature. Learning science through dialogic inquiry is strongly advocated as being beneficial to EAL students (Haneda and Wells, 2010) but with the proviso that a balance is struck between hands-on and text-mediated investigations. T5 complains that "they're not communicating enough", T2 similarly says "they don't engage as much as they should" and that "students who don't engage have very little access to learning", T4 expresses frustration, "I know they need to be coming and asking for help and they are just not doing it." The reasons offered by the teachers for this range from lack of confidence, cultural differences in acceptability of questioning, differences in previous education, not wanting to embarrass themselves and personality type. However, no-one seems to consider the possibility that they may have difficulty forming the questions linguistically. Question forming in English is linguistically challenging. It involves word reversal, question tags, intonation and complex grammatical changes and, as Alcón (1993) points out, EAL students need training in asking higher order questions.

The ability to answer examination questions is obviously an important goal and this often presents challenges. Understanding questions in examinations is a problem, as T1 explains "they can know all the science but can't work out what the question is saying." As pointed out above, command words can cause problems and words, such as 'evaluate' and 'criticise', can be culturally, conceptually and linguistically difficult, particularly for Chinese students.

These problems were also observed in the classroom. In all eight observed lessons, students did not directly ask the teacher and any help given was offered by the teacher. One problem observed in the classroom was where S5 was paired with a native English speaker (B3). S5 was directed with gestures to do things by the native English speaker and there appeared to be very little two-way interaction or understanding by S5 of what was happening. There was no apparent 'negotiation of meaning' occurring, as discussed by Ardasheva, Norton-Meier and Hand (2015).

4.3.4 Classroom techniques

The physical skills required to carry out practical work were mentioned as often lacking or deficient in EAL students. T3 pointed out that "some people, even in year 12, have never lit a Bunsen burner". But this was not regarded as a barrier to learning, as strategies are in place to close this knowledge gap. However, it became apparent when observing the lessons and talking to the students, that the language relating to practical investigations does. During a biology observation (B3), it was very clear that neither of the EAL students could follow or really participate in practical work, despite having been given very clear written instructions. They did not have enough knowledge of the names of the equipment or the instruction language, as described previously, to access the lesson and had no idea how to use a microscope. T5 points out that "the students are taking note of where everything is, but not how, or what, they're doing with the apparatus." S6 talks about having to watch carefully and follow other students to find the equipment.

Speaking skills of the teacher, such as pace, regional accents and intonation were suggested as potentially causing difficulties, with two of the teachers mentioning their personal need to consciously limit their speed (T1 and T4). T6 comments that "intonation, pace, word separation and emphasis can all cause a problem if not done in an accessible manner" and continues that the other extreme when teachers stress every word without any fluency or intonations is equally unhelpful. Poor word separation was noted in one of the observations (P2), where the teacher frequently used the phrase "Does that make sense?" resulting in a single string sounding like /"dʌzæʔmeɪsents?"/ being heard. The phrasal verb 'make sense' also added to the complexity.

Reading the teacher's script handwriting on the board is found to be a problem experienced by several students. S4 complains "I can't understand the writing. I copy it down, but the K is like an N and the N is like, I dunno, an L". S5 finds writing very difficult and cannot write and listen at the same time, so often stops writing to focus on listening and understanding. Moreover, S5 explains that he has a lot of difficulty reading the scripted writing on the board. This is clearly more of a problem for students with a logographic (different symbol per word) first language such as Chinese or those used to a Cyrillic (e.g. Russian), Greek or Korean alphabet which doesn't use cursive script. Students with a Roman based first language such as French, German, Italian are less likely to have difficulties with this, as is the case here with S6. This finding is potentially significant. However, the problem could, in theory, largely be eliminated through the use of typed script presented through technology. This finding is not only relevant to science learning, hbut it was remarked on so strongly that it merits a mention here as a problem that teachers should perhaps be more aware of.

4.4 What help and support do teachers provide?

Many ways of supporting these EAL students in their science learning were observed and mentioned in interviews. Intensive language and academic skills support is given through individual and class lessons in the International Study Centre. Further academic and socio-psychological support is given after school in the boarding house, both by peers and boarding house parents. In the science classes themselves, individual help and support is limited due to curriculum pressures and time constraints. Subject clinics (open-door help sessions) are offered, but not often attended by year 9 and 10s. In lessons, the teachers were observed to check understanding individually as part of general monitoring, extended help was given in observation P2 and B3.

Science/Language teacher collaboration

There is a high degree of liaison and collaboration between individual science teachers and EAL specialist teachers in the school providing support to the students, described by T2 as being "critical" to the ability of the students to cope. Several science teachers mentioned a strong, positive liaison between science teachers and EAL teachers. For example, T1 commented that the communication is "great – it's certainly working" and T2 remarked that "I think you're (EAL teacher) probably more adept at noticing what key words they're misunderstanding" and T4 thinks that they "get great support outside the classroom". This integrated and collaborative approach is supported by Creese (2005) and Conteh (2015) who both strongly advocate close partnerships between EAL and science teachers.

4.4.1 Language

Vocabulary

There was generally good awareness among science teachers of difficulties experienced with the language in terms of vocabulary. Support is given in the form of extra glossaries, attempts to find words that they know when explaining new words, extra explanations, emphasis of key words (T3 gives an example when describing dissolving). Some attempts at supporting the comprehension of vocabulary is occurring in the classroom with varying levels of success. In P2 the teacher helpfully gave an alternative when he said, "the *combined* resistance, that is, the *total* resistance" and in a biology class B3 the teacher explained and displayed a definition of 'dilution' on the whiteboard. The same teacher also described an attempt at showing a picture of 'cotton wool' that was not successful and created more problems than it solved (T5). As T3 points out "you've got to watch the words you use" and T1 describes how he gives a demonstration of setting up practical apparatus, saying 'right, watch me, do it like this' and then he takes it all apart again and says 'now, it's your go".

One to one help was observed in the classroom P2, B3, C1 and T2 agrees that "it's the one to one that really helps them". This reinforces Vygotsky's view (1986) of the importance of conversations with adults and was backed up by the classroom observation where teachers helped the EAL student individually (P2). In effect, this allows the Vygotsky ZPD (1973) to operate, as the teacher is naturally tailoring the interaction to be just above the student's current language level.

Literacy

The skills of listening, speaking, reading and writing in English are generally addressed in separate EAL lessons in the ISC through individual and group work, with careful scaffolding. In terms of developing scientific literacy, some individual and small group bespoke lessons are given by EAL specialist teachers.

There was no mention by the science teachers of any strategy to develop these language skills, but several talked about the inability of students to understand the textbook and write longer answers (T2). There was some recognition that scientific language is like a whole new language and yet the science teachers do not regard it as an objective for them to teach.

Two teachers (T1, T4) talk about consciously modifying the speed of their speech (particularly at the beginning of the year) to aid comprehension. Self-help by the students includes taking a photo of the whiteboard to aid homework or writing up notes (C1). T2, T4 and T5 use Google Classroom to post instructions, so students can go back and read them again later.

Academic skills such as summarising in their own words, notetaking, evaluating, presenting an argument are mostly taught in the ISC as part of general English language lessons but were not discussed in the interviews. This is discordant with the general findings in the literature where there is a strong focus on the development of literacy skills in the context of science (Lee and Buxton, 2013a; Herman and Wardrin, 2012; Weiss-Magasic, 2012; Nelson, 2012; Echevarria, 2011).

4.4.2 Inquiry and interaction

Science teachers remark that some students (particularly from Asia) do not inquire and ask questions enough in class, however, very little specific support was observed being given to these students to encourage and develop this ability. The problem was generally accepted as being 'cultural'.

Most science teachers admitted allowing students of the same nationality to sit together, despite the school policy to mix them up (T1, T2). Teachers regard the opportunity to question and discuss content and new concepts in their own language as beneficial to science learning, as suggested by McDonnough and Cho (2009). The view is that sitting together enables them to participate in dialogic inquiry about the science, even if it is in their own language (T1) and this was seen to be the case in all observations where they had the opportunity. However, if students mainly talk in their own language, they never use the terms verbally (see 4.3.2). There is, perhaps, a balance to be made here. Some students (S4), did say, however, that they actively seek the opportunity to sit next to English speaking students. Interestingly, and perhaps pertinently, the student (S5) who has no same language peers in the class and proactively asks for help from the teachers was awarded the ISC prize for excellent progress at the end of the year. This student also had a lot of science specific support in the ISC. One or two instances of teachers nominating EAL students to answer class questions was observed (P2, C2), but mostly this was not seen to occur and seems to stem from a desire to keep the EAL students 'comfortable'. This backs up the views by Rice, Pappamihiel and Lake (2004), Fang and Schleppegrell (2008) and Dalton-Puffer (2007) about teacher questions being cognitively lowered, but in this case questions were not even asked.

Several teachers talked about inquiring into the students' background and utilising their different funds of knowledge in the class, as promoted by Barton and Tan (2009), Fernandez (2011), Lee and Buxton (2013b). For example, T1 talked about using China's policy on opening coal-fired power stations, T2 talks about 'Bremsstrahlung' in relation to x-rays and T4 gives the examples of organ donors, gender selection and blood types as areas where students from different cultures have different funds of knowledge. The teacher who is also a boarding house teacher discussed many areas where the students are supported in socialising with their peers and the positive effect this has on their general language development.

4.4.3 Classroom techniques

Practical work

Practical skills are often inadequate, but are filled in as the year progresses, with the teacher giving individual support where needed. Teachers don't view this as a barrier to learning, but the students themselves regard it as quite a problem. The teachers are not necessarily aware of just how little the students know and the students' ability to participate would benefit from increased scaffolding of the instructions.

Visual support

T3 emphasised that "it's very important to visualise." During the lesson observations, it was very clear that the student's attention was related to the degree of visual information available. Examples of this include: holding up a molecule model in C1S3; showing a video clip of how diseases spread in B2 (t10); demonstration of voltage sharing in P2 and an interactive demonstration of an electromagnet P1. Diagrams are used extensively by teachers, sometimes on the whiteboard or just an individual sketch (T2). T6 emphasised the importance of using gestures, diagrams, pictures and keywords on the wall, as visual aids to support the verbal explanations and this is in line with general TESOL pedagogy found in the literature.

Videos clips from the internet are being increasingly used as a quick way of visualising concepts (B2) and the use of English subtitles aids understanding.

Technology

Many teachers and students mentioned the value of using Google Translate and Google Classroom. These are powerful tools in the school as every student has permanent use of a laptop. T2 and T4, for example, are using it constantly and it is proving to be a very powerful tool as it enables increased teacher collaboration (as explained by T6). Google Classroom can be used to provide a written form that can be revisited.

Technology is very useful for translating. Google Translate now has a voice translator, so students can hear how to pronounce words, as well as discover meanings. Google images can be an easy way to quickly understand a new word (S2). There are many mobile phone Apps now available to aid translation and learning.

Interactive whiteboards are standard in all classrooms and can be a way of displaying notes and images, and a few examples were observed (B1, B2).

4.5 What further support might be given?

Many suggestions for improved support were put forward by both teachers and students. A selection of suggestions is presented here under the three themes.

The teachers in this study were very positive about a collaborative approach and integration of the science and language learning of EAL students. There is scope for a deepening in this relationship by further pooling and sharing between the teachers in the two disciplines and the possible development of jointly designed materials, as proposed by Afitska (2016) and Haneda and Wells (2010), would be very beneficial. The joint development of literacy objectives tightly linked to the science curriculum as advocated by K. Carrier (2005), combined with on-going development of teaching pedagogy advocated by, for example, Lee and Buxton (2013a), (2013b) would serve to enhance the already excellent support being given.

4.5.1 Language

Language systems

A big issue that was raised by several teachers was the language used in examination questions. One teacher suggested working more on the command words used in examinations (T2), using material from the examination boards. It was also suggested that linking words need teaching (T4,) and that basic scientific words such as ‘dissolve’ and ‘evaporate’ could be taught in small classes in the ISC (and initially may be better use of their time instead of attending science lessons (T3). Two teachers suggested that it would be good to have an extra lesson for students starting in year 10 who have missed year 9.

Student comments mostly made suggestions including: having lists of words with pictures rather than translations or definitions (S2); writing words on the board that might be difficult (especially abbreviations) (S5); teachers giving more vocabulary tests to encourage learning (S5) students writing down more words (S2); students learning the English words for topics covered early on in science before coming to UK (for example, force, pressure) (S2); more repetition of science words to help learn (S3); learn 10 words a day on an app (S5) and study BBC Bitesize videos at the beginning of new topics (S5).

These were all very specific and constructive ideas which can be given as useful feedback to the teachers and illustrates the importance of asking the students themselves rather than simply theorising about the difficulties. Many of these suggestions, however, are found in the literature, for example in Lee and Buxton (2013b)

Literacy skills

In terms of literacy development T4 remarked on the need to scaffold writing more. Using English subtitle on videos can help with listening skills (T5). T5 also suggested that more work needs to be done on the skill of extracting necessary information from examination questions.

It was clear from the observations that practical skills would be improved if there was familiarisation with the basic equipment used in practicals (words and use), together with language for data collecting, analysing and graphically representing (mentioned by T5).

4.5.2 Inquiry and interaction

One student suggested that they would like the teacher to ask them direct questions, he explains that sometimes students are too shy or afraid to speak but they want to and will, if the teacher asks them directly) (S3). Interestingly, there was a discussion about how students could ask questions in the lesson without speaking out and the idea of encouraging interactive written questions using Google classroom during or after the lesson was put forward.

There was recognition that the EAL students need more help working out what questions are asking (T1), T2), particularly with respect to examination questions.

T4 suggested having a questionnaire to find out what newly arrived EAL students have studied before and having a 'pre-lessons' session to explain to them what the expectation is in the UK in terms of asking questions. This is line with suggestions in the literature about dialogic inquiry by

Haneda and Wells (2010) but it needs to go further and involve some activities involving training and practise in active questioning.

4.5.3 Classroom techniques

From the lesson observations, there were many in-class techniques that were observed to be beneficial to the EAL students but that could be done more, or by more teachers. Factors like using visual representations (models, realia, diagrams, images, demonstrations, gestures) could be used to much greater effect, as could writing words on the board to show spellings and giving quick, alternative words when speaking (for example, say 'give out', but also say 'distribute'). In the observed lessons, a long explanation at the beginning of the lesson may have been 'unlocked' by a simple visual (image or object) to show the EAL student the topic of the lesson (for example in C1, a picture of perhaps an oil rig or tanker might have been useful at the beginning to explain the topic of hydrocarbons).

The students generally found the use of Google Classroom helpful. When instructions or content are posted, the students can see what has been said when they don't understand. Also, this aids science/language teacher collaboration and one student explained that he can see the words and check the spellings and that typed words are much easier to read than script written on the board (S5). Those teachers who are using Google Classroom had ideas of how to use it more, such as: creating wordlists; Quizlet sets; in-class communication; video/website links; shared planning documents between teachers. There is much scope for using technology to enhance and facilitate the integration of language learning into science (or vice versa), as explained by Walker and White (2013).

Other general suggestions from students included writing more on the board at the beginning of the lesson (S3), telling students what the next topic is so they can pre-learn (S5) and pausing to give students a chance to catch up (S6).

CHAPTER 5

CONCUSIONS and IMPLICATIONS

5.1 Conclusions

In this study of the interface between science and language learning for newly arrived EAL students, three themes that present challenges have been identified and strategies that are, or could be, used to ameliorate these are discussed. Overall, four areas of importance have emerged from the study, namely, language, literacy, inquiry and techniques.

First, in terms of language challenges, the linguistic characteristics of science language is well documented, such as: a) a high lexical density; b) many specialised words used only for scientific terms; c) a high degree of functional language terms and d) many everyday words with different meanings in science. The interviews and observation revealed a general awareness of some of these types of problems and much is being done to support the comprehension and learning of scientific words and other language related problems. However, when considering the 'bricks and mortar' word types (Dutro and Morgan, 2001), there is less awareness of, and focus on, the 'mortar' type words.

Secondly, regarding scientific literacy, there appears to be a large gap between the literature available and science teacher awareness of the need to develop the language and academic skills relating to reading and writing scientific texts. It is traditionally the domain of language teachers to teach the language skills of reading, writing, speaking and listening together with key academic skills such as summarising, note-taking. However, this is not necessarily carried out in the context of science texts. It is argued here that there is a need for these literacy skills to be addressed more explicitly in terms of science, with a more integrated science and language approach.

Thirdly, there was good triangulation achieved in the study regarding the issue of inquiry, with observation data, teacher interview data and students interview data all revealing deficiencies in the area of inquiry. There was very little inquiry on the part of teachers and students in the observed lessons. Science teachers agree that the inquiry-based nature of science means that students must be able to ask and answer questions to: a) clarify their own understanding, b) design and carry out sound investigations to further scientific understanding and c) be able to critically evaluate scientific data. Interviewing the teachers revealed that interaction and questioning in class by students is regarded as a necessity for learning, progress and development into effective scientists. A fundamental barrier to learning for many EAL students seems to be their lack of interaction and inquiry in class. This is most evident in students from East Asia, (such as China or Japan). Different possible reasons for this were offered by the teachers, including previous educational background, cultural attitudes to questioning, or personality differences. Interviewing the students also revealed concerns about inquiry but suggested that the problems may stem from language difficulties in not being able to grammatically form the questions, and not being 'expected' or 'nominated' to answer. In any case, the reason for this effect is immaterial, the critical point is for teachers to address the difficulty and stimulate a questioning approach.

Finally, less anticipated difficulties that were regarded as key factors, particularly by the students, were found, including: the inability to read cursive script handwriting; the inability to form questions; problems with translating and the carrying out of practical work. Whilst there was some agreement between teachers and students as to what the difficulties are, there were also major differences. There is a lot of research and literature documenting the theoretical difficulties at the science / EAL interface, but this perhaps overlooks some of the simple classroom techniques that can facilitate, or inhibit, learning.

5.2 Implications for teaching

The main implication from this research is that close collaboration between science and language teaching is essential to address the needs of the students in their learning of both science and English. This is supported by extensive literature and by qualitative data generated by the teachers and students in this study. The close teacher partnerships between EAL teachers and science teachers that have developed in this school are effective and highly valued by teachers and students alike. However, there is potential for these links to be widened and deepened, allowing the development of more collaboration and teaching with joint objectives. Much of the literature relevant to this study concerning ELL and EAL school students learning science was found in professional journals for science teachers, and this perhaps highlights a need for TESOL professionals to embrace this area of specialist science teaching in young EAL learners and teenagers.

One major implication of this study is that the language needs to be carefully scaffolded for learning to occur. Careful scaffolding of tasks designed to improve scientific literacy (reading and writing) needs to be delivered. Such scaffolding may be in the form of giving sentence starters or phrases when having to produce writing, in the way suggested by Afitska (2016). A way of scaffolding the learning of 'bricks' and 'mortar' language using sentence frames has recently been suggested by Tretter, Ardasheva and Bookstrom (2014) who experimented with focussing on language structures within the science lesson. In terms of vocabulary more attention needs to be given to supporting the comprehension and use of functional language, phrasal verbs and words with double meanings, together with the associated translation difficulties. Also, an appreciation of the need to give wider meanings and form when introducing new lexis would be beneficial, as would the links between grammar and communication of meaning.

There is strong agreement in the literature that science language and literacy objectives need to be integrated and delivered collaboratively by science and language teachers. A need for resources specific to EAL science learners has recently been highlighted by Afitska (2016) who has produced example materials as an outcome to a rare UK study on KS2 (Keystage 2) science learning. However, as she rightly points out the development of materials which integrate the language and literacy with science content requirements 'takes a considerable amount of time, effort and expertise' and needs specialist attention. The use of technology may be helpful in the possible development of materials accessible by individuals online, as students in this study endorse.

The ability to inquire is of paramount importance in the development of effective scientists. There are many factors that can constrain this ability and for some students this needs to be developed explicitly. It was apparent in the research, through observations and interviews, that there is an awareness and frustration in the science teachers, but that little is being done to directly address it, in neither the science classes or EAL lessons. Perhaps innovative ways of eliciting inquiry and interaction can be explored and developed.

It became clear in the study that students would benefit from more explicit teaching of the issues around 'inquiry'. The term 'inquiry' encompasses asking questions in class, carrying out good scientific investigations, answering long written examination questions and carrying out academic functions such as evaluating and criticising.

If teachers can develop a higher expectation of dialogic interaction, with careful scaffolding and possibly in small groups, as suggested by Haneda and Wells (2010), this will help students to gain the ability and confidence they need to ask and answer scientific questions. Also, the Argument-Based Inquiry teaching technique (Ardasheva, Norton-Meier and Hand, 2015) or the SIOP Model (Echevarria et al,, 2011) could be explored to develop scientific literacy and inquiry. As Taboada (2012) has shown, the teaching of self-generated student questioning helps improve comprehension in scientific reading. These approaches could be introduced either within the science lesson or in small groups with a specialist EAL teacher.

This study highlights a need for ongoing teacher development and sharing of pedagogical practices (across and within the sciences and EAL). Developing the small ways that can make big differences to EAL students' ability to access the learning is of paramount importance and informal training needs to be given early on in an induction for science teachers who are new to supporting EAL students.

Recommended techniques arising from this research to use in the classroom include:
To support new lexis:

- Maximise use of visual material (especially at the beginning of the lesson): use images, gestures, word spellings on board, step by step pictures WITH words, demonstrations of practicals and using equipment.
- Use video clips where possible and display English subtitles.
- Give simple, alternative words of terms/words (but not long, wordy explanations).
- Increased awareness of colloquialisms or idioms. Use them but explain, or give simple alternatives, where possible (e.g. 'hand-in' that means 'give it to me').
- Relate sound to spellings (unlock abbreviations).

To facilitate comprehension:

- Speak with clear pronunciation, good intonation and at a reasonable pace.
- Type or print writing rather than handwriting.
- Use Google Classroom (or similar) to post materials and resources.
- Don't start a new topic while they are copying from the board.
- Allow pre-teaching of vocabulary for internal tests.
- Inform students of the next topic before the lessons to allow pre-preparation.

To encourage inquiry:

- Nominate EAL students to give simple answers.
- Encourage small groups and pair work with mixed nationalities.
- Use the students' individual funds of knowledge to enrich the classroom for all (good for interactions and integration).

Regarding the students, however, this study has highlighted differences between teacher and student perspectives and uncovered some interesting ideas and views from the students that could be incorporated into teaching pedagogy. This study highlights the value of consulting the students. In addition, the 'narrative frame' technique could be explored further as a way of probing previous education, motivation and attitude towards science learning and could potentially be used as a needs assessment tool.

I hope that this study may provide a foundation for the development of an 'Induction to English for Science (EfS)' programme in the school which may incorporate banks of language and lexis to be used together with science literacy learning materials closely linked to the science curriculums.

5.3 Limitations and further research

This research only represents the situation in this one school and provides an initial insight in qualitative understanding. Further studies would need to be carried out to establish whether my findings are replicated in other schools or settings.

One possible limitation of this study is that the researcher is also an EAL/science specialist teacher of the student participants. The responses given by the students could be affected by a potential power differential between teacher and young adult (Eder and Fingerson, 2002). Although, the benefits of having an emic (insider) researcher who is 'not a stranger' to the students, gives balance to this possible limitation (Heigham and Sakui, 2009, p. 97).

A wider limitation of the study is possible subjectivity in the analysis of qualitative data. Also, that the questions were designed, delivered and the data generated was analysed by the same researcher, which could introduce bias. This study was limited to only three different nationalities, due to the sample available, and it would need to be extended to a much wider range of nationalities before any general conclusions about differences in nationalities could be made.

Also, this research focussed on newly arrived EAL students, but the sample could be widened within this school setting. Interviewing students who have been in the school for longer may reveal interesting insights into the difficulties experienced when they first started and may generate possible suggestions for facilitating a quicker integration. A quantitative approach could now be used involving a wider student base (within this school and in other schools) to see if the main factors identified in this study are representative of other students, teachers and other schools.

The study generated a wealth of data which could be subjected to further analyses. In particular, the sound recordings of the observations could be studied to investigate, for example, teacher questions, instructions, intonation. Furthermore, discourse analysis could be carried on the teacher-student interactions.

5.4 Concluding comments

The demands of learning science through an additional language in school are complex and need careful consideration when delivering an educational programme to meet the simultaneous development of scientific knowledge and scientific communicative competence. Resources and materials tightly linked to the science curriculum which teachers can use to help scaffold the language for these students would be welcomed. These may be of equal use to FLE students, especially those with specific additional learning needs, as suggested by Afitska (2016, p. 87).

Overall, this research can be considered to have achieved a deep understanding of the challenges facing both the students and their teachers. The literature and research are in accordance in terms of the language and inquiry difficulties but more needs to be understood about the difficulties arising from poor literacy skills. Science teachers and language teachers can do much to support the students in these areas. It is important that teacher development is a continuing process and close collaboration between science and EAL teachers is essential in the provision of effective support.

When considering strategies that can be generally adopted it is important to look carefully at how maximum use of visual material and an increase in scaffolding can be incorporated into the teaching. Also, it is important to consider how the increasing technology in the classroom can be effectively utilised to support and provide customised resources to EAL students in science.

In conclusion, given adequate support and scaffolding, learning science in an additional language can not only lead to scientific learning, but can also enhance and facilitate the acquisition of a vast array of linguistic competences.

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APPENDIX 1 - RESEARCH INSTRUMENTS

A SCIENCE STORY NARRATIVE FRAME

(administered and completed digitally, with additional verbal instructions)

MY SCIENCE STORY

Complete with details of your science learning experiences to make your own history of your science learning. Change the words if you like.
Add text at each place where there is a *.
Delete the bold words that are not correct for you.

When I was young I was interested in learning about * . I started having science lessons when I was * years old. I ***was/was not*** interested in science then because *. The first thing I remember learning in science was *. I have studied ***Chemistry/Physics/Biology*** in my country and I am most interested in *. We **did/did not** do lots of practical work (experiments). I **like/don't like** doing practical work and I find it **easy/difficult** because *. I **do/do not** like learning science subjects in England because *. What I find difficult about learning science in England is *. The most difficult time in science lessons is *. I prefer to sit next to someone who speaks **my language/English** because *. I think that I ***will/will not*** need science qualifications for my future career. I think that after GCSE's I would like to study * and maybe I would like to work as a *. The most interesting thing I have learned in science is *. Finally, I would like to tell you about *.

APPENDIX 1

B SCIENCE LESSON OBSERVATION FORM

SUBJECT	EAL STUDENTS	TEACHER	DATE	Duration
Topic/aim				

Seating Plan	
General	Practical work

Lesson Stages

Activity

Time |____|____|____|____|____|____|____|
0 10 20 30 40 50 60 70

EAL Student Engagement (observed)

Active Participation

Passive Participation _|____|____|____|____|____|____|____|
0 10 20 30 40 50 60 70
Time (mins

Distracted

Lesson Opening and Closure			
	Teacher Language	Non-Verbal Signals	Visual/Written Aids
Opening			
Closure			

Interactions (T⇔S, S⇔S)							
Purpose	Frequency S⇔S T=>SS T=>S S=>T EAL Eng					Verbal/ Non-Verbal	Discourse/Notes
Help (T gives-**g**, S seeks-**s**)							
Comprehension (T checks- c, S seeks-s)							
Other (e.g. praise, reprimand)							
Unknown							

Teacher Meta-Language (Idioms, colloquialisms, science confusions)		
Language	**Communicative Purpose**	**Context**

Handling of 'difficult words'	
Words/phrases	**Action** (explanation, list on board, refer to glossary)

Lesson Phase Transitions – signals			
Teacher Language	**Teacher Action**	**Student Reaction**	**When/Phase**

Instructions (**V**-verbal, **D**-digital, **B**-board, **P**-paper)						
Purpose	**Format**				**Comprehension Check** (Yes,No)	**Language**
	V	**D**	**B**	**P**		

Other Information Given		
Medium (**V**, **D**, **B**, **P, Video**)	**Purpose**	**Language**

Extra Notes

e.g. use of visual aids – videos/pictures/objects etc. ; comments about teacher accent, intonation, speech speed; use of L1; specific difficulties/misunderstandings; disruptive behaviour; quality of output; use of translators - electronic dictionary/laptop, phone; recording of lexis;

APPENDIX 1

C INTERVIEW GUIDELINES

<u>Student Interview Guide</u>

1. **What do your teachers (science and ISC) do to help you in and out of Science lessons? (**probe re. observed lesson)

2. **What do other students do to help you in Science lessons?** (probe: EAL, English)

3. **What do you think you are better at doing than UK students? What skills do you need to get/improve?**
   Open and then prompt.
   (use as prompts e.g. *using practical equipment*, *summarising information (note-taking), writing concisely, writing in simple language, identifying keywords, interpreting graphs, presenting data, analysing data***)**

4. **In science, in your opinion, do you have more difficulties with *understanding* (i.e. the teacher/textbook/questions) or with *speaking/writing* (i.e. note-taking, homework tasks, tests etc)?**

5. **In what ways do you help yourself?**

6. **Does it (or would it) help having other EAL students in the class? (**probe: in what ways).

7. **What do you think was the main problem that stopped you learning when you first arrived? (*open-ended with probing)*** *(sep sheet after)*

   Input- *technical and subject specific lexis OR everyday language – colloquialisms, idioms, phrasal verbs, connectivity etc*

   Output – *participation in discussion, use of scientific terms, writing, grammar*

   Can you give me some illustrative examples?

8. **Are some lessons easier to understand than others? What is it about the way the teachers speak or things they do that makes it easy or difficult to understand?** (too soft, too fast, accent, extra expressions/phrases. Intonation etc)

9. **Can you always read/understand what is written on the board? What could be improved?**

10. **What kind of help has been most useful to you in ISC lessons?** (prompt – help with homework, vocabulary for subjects, speaking practise, grammar learning?)

11. **Do you find it easy to know what your homework is and when you have to give it in?** (probe re. Google Classroom)

12. **What other help do you think could be useful to you (or your teachers) ?**

FACTORS – STUDENT INTERVIEW

In your experience/opinion, which of the following are the <u>main</u> difficulties that you have when learning science subjects in English? *(please **tick** (✓) a **maximum of five** boxes)*

- ☐ I haven't learned the science topics before in my own language
- ☐ I don't know the scientific words in English
- ☐ The language the teacher uses is not simple enough (e.g. saying things like 'look through it', 'pipe down')
- ☐ I don't know the basic scientific language (e.g. rate, sample etc)
- ☐ I can't understand the way the teacher speaks (too fast or has a regional accent)
- ☐ I feel too shy/unconfident to speak in class discussions
- ☐ I don't know how to use the equipment in practical sessions
- ☐ I find it difficult to write down my ideas
- ☐ I can't explain my ideas very well when speaking
- ☐ My grammar is not very good (e.g word order, tense etc)
- ☐ I don't understand when the teacher tells us what to do (e.g. homework tasks) or asks questions
- ☐ I can't read the teacher's writing on the board

- ☐ Other (please specify ______________________________

- ☐ Other (please specify ______________________________

Science Teacher Interview Guide

1. What do you think are the main challenges or barriers to learning experienced by newly arrived EAL students learning Science, in Year 9 or 10? *(open-ended with probing)*

2. What specific language difficulties have you noticed? Give illustrative examples?
   a. *Prompt: Input- technical and subject specific lexis OR everyday language – colloquialisms, idioms, phrasal verbs, connectivity etc*
   b. *Output – participation in discussion, use of scientific terms, writing, grammar*

3. In general, what skills do EAL students most need to acquire, compared to UK students? What skills do they have that UK students do not? *Open and then prompt.*
   (use as prompts e.g. *using practical equipment, summarising information (note-taking), writing concisely, writing in simple language, identifying keywords, presenting data, analysing data, interpreting graphs*)

4. In your experience, do EAL pupils tend to have more difficulties with Science language input or output (i.e. *receptive* aspects such as teacher/textbook/test comprehension or *productive* aspects such as notetaking, homework tasks or tests)?

5. T completes 'Factors' questionnaire.

6. What do you do to help/support EAL students <u>in lessons</u>? (probe re. observed lesson) (*check use of glossaries, gestures, visuals, subtitles, modify language, dictionaries, translation….)*

7. Do you consciously modify your language/behaviour for the EAL students and, if so, in what ways?

8. What <u>other</u> help/support do you give to EAL students (when and what)?

9. In what ways do they help themselves?

10. In what ways does the support they receive in the ISC help them? What else would be useful?

11. What problems/frustrations do you experience as a Science teacher with several EAL students in the class?

12. What do you think the students themselves perceive to be their main difficulties?

13. To what extent do you think language learning and science learning should/can be integrated and how is this best achieved?

14. Are there any noticeable differences in how different nationalities or different year groups cope?

15. Do you perceive any benefits of having International EAL students in the class/school?

What else?

FACTORS - TEACHER INTERVIEW

In your experience/opinion, which of the following are the main difficulties that inhibit learning in Science subjects for EAL students generally?
*(please **tick** a **maximum** of **five** boxes)*

- ☐ Weak scientific knowledge
- ☐ Poor knowledge of specific scientific vocabulary in English
- ☐ Lack of understanding of everyday language, colloquial expressions, phrases, connected speech (e.g. look through it, pipe down)
- ☐ Poor knowledge of basic language used in science (e.g. rate, sample etc)
- ☐ Inability to understand fast speech/regional accents
- ☐ Inability/reluctance to ask questions or participate in class discussions
- ☐ Poor practical skills or knowledge of equipment
- ☐ Inability to express ideas clearly in writing
- ☐ Inability to express ideas orally
- ☐ Weak command of English grammar (e.g word order, tense etc)
- ☐ Poor understanding of instructions/questions (e.g. homework)
- ☐ Inability to read handwritten notes/instructions on the board

- ☐ Other (please specify ______________________________

- ☐ Other (please specify ______________________________

APPENDIX 2 A - Transcription Key

Transcription Key

Adapted from Dalton-Puffer (2007)

I:	Interviewer (researcher) speaking
T1:	Teacher being interviewed speaking
S1:	Student being interviewed speaking
=	latching utterances – no gap
-	An abrupt end
I: [	simultaneous,
T1: [	or overlapping talk
[.]	Short pause
[..]	Medium pause
[…]	Long pause
?	rising intonation
!	strong emphasis with falling intonation
{ }	comment about actions – non-verbal
::	lengthening of previous sound e.g. goo::d
{*inaudible*}	indicates a stretch of talk unintelligible to the analyst
[*student name*]	name of student or teacher not included in the study
S1, T1	name of student or teacher included in the study (coded)
What do	bold font shows topic questions
xx minutes	number of minutes (xx) since beginning of interview
Highlighted text	text that is quoted or referred to in the report (Findings and Discussion

APPENDIX 2 B - Factor Statements Analysis

TOP FIVE FACTORS - STUDENT and TEACHER INTERVIEWS

KEY: Students (blue) | Teachers (green)

Total	Number of ticks	Statements
2		I haven't studied the Science topics before in my own language
1		Weak scientific knowledge
5		I don't know the scientific words in English
4		Poor knowledge of specific scientific vocabulary in English
0		The language the teacher uses is not simple enough
5		Low understanding of colloquialisms, phrasal verbs, connected speech (eg hand in)
1		I don't know the basic scientific language (eg rate, sample etc)
4		Poor knowledge of basic language used in Science (eg rate, sample)
2		I can't understand the way the teacher speaks (too fast or has a regional accent)
2		Inability to understand fast speech/regional accents
3		I feel too shy/unconfident to speak in class discussions
4		Inability/reluctance to ask questions or participate in class discussions
2		I don't know how to use the equipment in practical sessions
1		Poor practical skills or knowldege of equipment
3		I find it difficult to write down my ideas
4		Inability to express ideas clearly in writing
4		I can't explain my ideas very well when speaking
1		Inability to express ideas verbally
1		My grammar is not very good
0		Weak command of English grammar (e.g. word order, tense etc)
0		I don't understand when the teacher tells us what to do (prep) or asks questions
3		Poor understanding of instructions/questions (e.g. homework)
2		I can't read the teacher's writing on the board
0		Inability to read handwritten notes/instructions on the board
2		- Difficult to study after class - Baby BBC (BBC Bitesize for KS2 for vocabulary) - Know what will study first (which topics studying next) - I don't know where is the equipment in Science

APPENDIX 2 C - (i) Transcript analysis – example of coding (stage 1)

RQ1 - challenges
RQ2 - teacher support
" - self-help
RQ 3 - Future support

S3 Interview 23/03/17

I: {*Intro chat*} […] So, thinking about Science lessons [.] you're only doing Chemistry now [.] you started Physics but not anymore?
S3: Yes, Chemistry.
I: **So, thinking about Chemistry then, what do the teachers do to help you in the Science lessons, to help you with the language?**
S3: If I don't know I will ask the teacher and teacher will tell me about some Science word and some sentence and what is the meaning of the word and maybe try to explain to me [..] and sometimes if I don't know I will ask my classmate or someone.
I: Ok and do you do that in the lesson or after the lesson?
S3: While I was in the lesson I will ask teacher and while I was do my prep I was ask my friends.
I: So in the lesson, do you put your hand up and or do you just wait for the teacher to come?
S3: Just wait for teacher.
I: Just wait and he does, he comes and checks that you are ok?
S3: yes.
I: And also in the lesson, the other students are they helpful? Are they friendly?
S3: Yes, my classmate is very friendly and they always help me […] help me to explain some Science questions.
I: Ok, and is that in Chinese or English?
S3: No, English.
I: **Is there anyone in your class who speaks Chinese?**
S3: Yes, there is [redacted] but he not the very good friend. I just talk with Baron in English.
I: So, you talk in English, which is good for your English.
S3: Yes.
I: And what about afterwards when you are doing homework in the boarding house – do you have other Chinese people you talk to?
S3: Yeah, I ask [redacted] because [redacted] is good at Chemistry. […] and [redacted] maybe.
I: And you'll talk to them in Chinese then, will you?
S3: Yeah, and they will explain to me how to do the questions and what the prep mean.
I: Good, so that works well then. So thinking now about what you've found difficult, especially when you were starting. Let's have a look at what you said in your story. […] **Did you do Chemistry when you were in China?**
S3: Yes, but just […] not a lot [.] we just learn a little bit.
I: A little bit, ok. And did you do much practical work -you know, experiments? {*S3 agrees*} Did you do experiments in China where you were doing things, or was it all just listening?
5 minutes
S3: We just learn elements - I can remember some elements of Chinese.
I: Ok, but did you do mixing chemicals in China?
S3: No, I think not.
I: Not really. But do you do much here?
S3: Yes.
I: Yes. So was that difficult when you first came [.] because you hadn't done it before?
S3: I will ask my friend what to do and what shall we do next.
I: Ok, and does the teacher help you with that?
S3: Yeah.
I: Do they give you something in writing or just speaking?
S3: Just speaking.

1 S3 23/03/2017 SKS

I: **And other things like drawing graphs, writing about what you've found, maybe, making notes? Do you think you are better at anything than English people?** […] {*S3 looks puzzled*} **Is there something you've done more in China [.] you do less practical [.] did you do more with data, with numbers or anything - or not?**
S3: I'm not sure.
I: Do you understand what I mean?
S3: Yeah, why in the China I learn about something is more than in England?
I: Yes.
S3: – I think not, not really.
I: So, the practical, - when I say practical I mean doing the experiments, doing them - you had to learn that here?
S3: Yeah.
I: **So, do you think you have had more problems understanding speaking, or understanding writing, like in your textbook – which is more difficult for you?**
S3: I think is the reading and writing.
I: And have you had much help with that?
S3: Yeh, I told my guardian "help me find a teacher while after the class I can ask the teacher to learn some more Chemistry" so, question and now my guardian help me find a teacher.
I: Where? Near where your guardian lives?
S3: Canterbury.
I: ok and will that be in the holidays?
S3: yeah, Saturday and Sunday.
I: Good. Would that be better if that was done here? Would that be useful to have a teacher helping you more?
S3: Yes. It would be good to have more here.
I: If it was here, would it be more important now or would it be better to have that at the beginning when you first start?
S3: I think it's now.
I: So, the writing in the textbook is difficult to understand?
S3: Yes.
I: Would it be better to have a book with easier English?
S3: Mmmm maybe.
I: The textbook is […] difficult?
S3: Yeah I need, while I do my prep, I need to translate some questions.
I: **Ok, so you're translating. Do you translate in the lesson, or not really?**
S3: Not really.
I: Why is that?
S3: Because I can ask.
I: Oh, because you can ask – ok, so that's easier and you prefer to ask?
S3: Right. Yes.
I: When you use translate – do you always think "oh yes" or is it sometimes not helpful?
S3: I think is helpful.
I: **So, is there anything else that you do to help yourself? You're using your translator, you're asking friends, and you've asked your Guardian for help -is there anything else?**
10 minutes
S3: Search in the internet and BBC Bitesize. I will to [inaudible] learn in the internet.
{*too feint and both T and S interact and laugh*}
I: You find that useful?
S3: Yes, it's very good.

2 S3 23/03/2017 SKS

APPENDIX 2 C (ii) Transcript analysis – example of coding (stage 2)

Problems/difficulties Student interviews

Language · Literacy · cultural · Social

S1	9	don't understand
S1	55	never studied Chemistry or Biology before. Younger than other Chinese students in class – they have done it in China
S1	83 +	teacher assumes knowledge e.g. elements, periodic table etc.
S1	92	Biology has too much homework
S1	129	Never used email before (doesn't know how) – couldn't email teacher
S1	157	Difficulty drawing – doesn't like drawing graphs
S1	178	Can't remember all the words in tests
S1	`85	Didn't understand anything when he arrived
S2	49	very difficult to write his own work or show his ideas
S2	60	Having a teaching assistant prevents him talking to someone else in Chinese to get explanations (-ve)
S2	72	Easier in Physics because done before in China but still need some help with language
S2	95	Big problem is the language – understanding people when they are talking
S2	98	Very difficult to understand some sentences – especially with the paragraph of key info.
S2	114	Doesn't seek help from teacher because can't really explain the question he has
S2	121	Not used to asking questions in China – not expected to ask during class – only afterwards maybe - so it's not easy to here
S2	130	Finds it very difficult to interact with other students or teachers
S3	34	Didn't do any practical work in Chemistry in China – just learned the elements
S3	57	Biggest problems are with reading and writing (gets a lot of help speaking from friends in Chinese)
S3	115	Couldn't understand much at the beginning but understands much better now.
S3	171	When first came didn't know what 'pardon?' meant, but found out from a friend that it means 'can you repeat that please?' Survival lang.
S3	176	S3 thinks test results are much lower than would get in China.
S3	178	Can't understand question or know how to write the answer.
S4	14	Science is boring
S4	53	There are things S3 has never done before e.g. drawing a graph – never done that in my life.
S4	89	S4 doesn't take part in class discussions because she says things wrong and is scared to cause herself embarrassment - worried about what people will think of her (not shy by nature and not like this in her own country.)
S4	108	S4 can't understand her Chemistry teacher's writing – copies it down but k is like an n or an l. Confusing.
S4	141	Gets very nervous in tests – forgets all English – panics. Needs a lot of time (like 2 hours more!)
S4	149	Doesn't do well in tests.
S4	162	Forget everything even if know it before.