UNIVERSITY OF SOUTHAMPTON

FACULTY OF NATURAL AND ENVIRONMENTAL SCIENCES

Chemical Education

Volume 1 of 1

The Measurement of KS3 and KS4 Students' Attitudes Towards Chemistry and Science Lessons and the Identification of Influencing Factors

by

Rachel Koramoah

Thesis for the degree of Master of Philosophy

February 2016

UNIVERSITY OF SOUTHAMPTON

ABSTRACT

FACULTY OF NATURAL AND ENVIRONMENTAL SCIENCES

Chemical Education

Thesis for the degree of Master of Philosophy

THE MEASUREMENT OF KS3 AND KS4 STUDENTS' ATTITUDES TOWARDS CHEMISTRY AND SCIENCE LESSONS AND THE IDENTIFICATION OF INFLUENCING FACTORS

Rachel Koramoah

Researchers in a number of countries have observed a trend of declining student interest and enthusiasm for science and chemistry lessons as they progress through education. The research sought to investigate the attitudes of students in Key Stages 3 and 4 (ages 11-16) towards science and chemistry lessons, and to identify the factors that contribute towards negative attitudes through both qualitative and quantitative exploration.

A preliminary qualitative research phase involved the participation of 69 students from Years 7-11 in focus groups, in which they identified 11 key factors that correlated with a negative attitude towards science and chemistry lessons. An existing attitudinal scale (Attitudes towards Chemistry Lessons scale, (Cheung, 2009)) was modified by the addition of qualitative questions designed to prompt respondents into identifying and qualitatively describing the reasons behind their answers, and utilised as an online survey.

The modified survey (ATCSLS) was taken by a total of 1654 students from a mixture of fee paying and non-fee paying schools in the UK, and confirmatory factor analysis validated the existence of a good fit between the scale and the quantitative data. The quantitative results of the modified ATLSCL showed that students in Year 7 held the most favourable attitudes towards science and chemistry lessons, and that there were no statistically significant differences between the attitudes of male and female students. However, as the age of the students increased, the attitudes of female students towards both science and chemistry lessons dropped significantly compared with their male counterparts along with a general decrease in attitudes. Younger students also had a more positive attitude towards chemistry theory lessons than older students, whilst older students held more positive attitudes towards chemistry practical work. Female chemistry students indicated that they would be more engaged with chemistry lessons if the explanations of key topics were clearer, whereas male students preferred a more interactive learning style. The findings should be employed by practitioners and researchers to develop effective teaching styles to ensure the development of positive attitudes towards science and chemistry lessons in schools.

Table of Contents

List of Tables

List of Figures

DECLARATION OF AUTHORSHIP

I, Rachel Koramoah

declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

The Measurement of KS3 and KS4 Students' Attitudes towards Chemistry and Science Lessons and the Identification of Influencing Factors

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
5. I have acknowledged all main sources of help;
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. None of this work has been published before submission;

Signed: ....

Date: ....

Acknowledgements

I would like to give thanks to what a dear friend has affectionately termed “universe juice”, as I strongly believe that it has guided me towards and along the path that I find myself on now.

My family, for providing an immeasurable amount of encouragement during the times when I felt challenged and excited by my work, and during those time when I did not, thank you all so much. I know I would not have been able to grow into the person I currently am without your constant support.

Matthew, thank you. I am so lucky and so grateful for all your love and support throughout all of my endeavours.

To my closest friends, I am so grateful for all of you. Thank you all for encouraging me when I needed to be encouraged, listened to when I needed your ears and for providing me with the joy that accompanies friendship.

Lastly, I would like to give thanks to Paul and David who have guided me through this project and kept me (mostly) sane.

Ethics Information

Ethics Approval

The preliminary research and deployment of survey received ethical approval from the University of Southampton's in-house Ethics and Research Governance Online (ERGO) system due to participants being under the age of 18. Ethics approval was granted before the commencement of interviews, which served the purpose of ensuring that informed consent was given by all participants before the interview and that frameworks for maintaining participant and data anonymity were in place. All documents pertaining to the ERGO application can be found in Appendix A.

Sample and setting

Participants were approached by their teachers, who opted to participate in this study. Participants of the preliminary focus group/interview phase were verbally informed that all questions were optional, that they would remain anonymous, and that they could opt out of the focus group/group interview at any time. Participants of the modified online survey were presented with a statement which informed them of their anonymity before they could answer any of the questions. Participants were required to tick a checkbox which signified that they had read the statement and consented to the terms of the research project.

Anonymity

All audio recordings were conducted on a password protected University maintained laptop which was only accessible to the main researcher. Participants were informed that their linked anonymity would be maintained as all resulting data will be coded so that personal identifiers were not linked to their responses.

Protection of data

Raw data produced by the project was not disclosed to any parties unless explicit consent was given by the participant(s). Any personal data were stored on university managed hardware and was accessible to only the main researcher by password.

Risk assessment

Each school that participated in the preliminary research phase had their own safeguarding precautions in place, which meant that no additional action was required from the researcher.

Definitions and Abbreviations

ATCLS – Attitude towards Chemistry Lessons Scale, developed by Derek Cheung.

ATCSLS – Attitude towards Chemistry and Science Lessons Scale. This scale measures both students' attitudes towards science and chemistry lessons, and was developed by modifying the original ATCLS

Modified ATCLS – Attitude towards Chemistry Lessons Scale section of the ATCSLS

ATSLS – Attitude towards Science Lessons Scale section of the ATCSLS

Chapter 1: Introduction

"Scientists, mathematicians and engineers contribute greatly to the economic health and wealth of a nation. The UK has a long tradition of producing brilliant people in these areas, from Isaac Newton and Isambard Kingdom Brunel, to Dorothy Hodgkin and Neville Mott last century, and most recently to Andrew Wiles who proved Fermat's Last Theorem. The challenge we face is to continue to attract the brightest and most creative minds to become scientists and engineers."

Letter to the Chancellor, Sir Gareth Roberts' Review, April (2002)

1.1 The importance of fostering positive attitudes towards science subjects

The investigation of students' attitudes towards the sciences has remained one of the major areas of science education research for the past 40 years, partly due to the mounting evidence of declining student interest in scientific careers (Osborne, Simon et al. 2003). Science educators and researchers have continued to research the attitudes of secondary school students, as many believe that it is imperative that schools are able to generate positive attitudes towards science amongst students, and that the curriculum should by geared towards doing so (Koballa 1988).

By fostering a positive attitude towards the sciences, schools can fulfil their potential of inspiring a new generation of scientific minds, capable of contributing significantly towards finding solutions for societal issues such as global warming (Skamp, Boyes et al. 2013). The importance of fostering positive attitudes towards science subjects in schools cannot be underestimated, especially as existing research noted that students' attitudes towards science declined as they progressed through secondary education (Kind, Jones et al. 2007, White and Harrison 2012, Archer, Osborne et al. 2013). Although it is inevitable that a large percentage of science students will not go on to pursue a career in science, being science literate is an extremely important life skill that will help students to better understand the world they interact with on a daily basis, from managing their health and wellbeing, to understanding the effects their choices have on the environment.

It is important to develop students' positive attitudes to science lessons in school due to two main reasons;

- Attitudes have been successfully linked with academic achievement. For example, Weinburgh's (1995) meta-analysis of the existing literature from 1970 to 1991 concluded that the correlation between attitude toward science and achievement could account for 25–30% of the variance in achievement. Similar results were found by (Freedman 1997, Bennett 2001, Salta and Tzougraki 2004) who all discovered that undergraduate students who had a less positive attitude to chemistry almost invariably obtained lower examination marks.

- Attitudes have been shown to predict behaviours (Glasman and Albarracín 2006). For example, Kelly (1988) found that British students' liking for a particular science subject was a good predictor of their actual choice of physics, chemistry, or biology later on in their academic life.

Table 1-1 illustrates that the percentage of UK student applicants for STEM courses at university through UCAS increased from 32.4% to 35.8% between 2011 and 2015. However, the grouping of biological, mathematical, physical and computer sciences with engineering masked the fact that the percentage of students applying for physical sciences decreased between 2013 and 2015.

Table 1-1 Table displaying the percentages of UK students applying for STEM courses at university from 2011 to 2015 (UCAS 2015)

Subject	2011	2012	2013	2014	2015
Biological sciences	13.1%	13.1%	13.4%	13.7%	14.4%
Physical sciences	5.7%	6.0%	6.1%	6.0%	5.9%
Mathematical sciences	2.4%	2.4%	2.5%	2.3%	2.3%
Engineering	6.1%	6.3%	6.4%	6.8%	7.1%
Computer sciences	5.1%	5.1%	5.4%	5.7%	6.0%
Total percentage of STEM applications	32.4%	32.8%	33.8%	34.6%	35.8%

This sentiment was echoed by Sir Gareth Roberts in his 2002 review of the Government's strategy for improving the UK's productivity and innovation performance, where it was noted that the number of entrants to chemistry degrees dropped by 16% between 1995 and 2005 (Roberts 2002). This highlights that positive changes have been made in recruiting students into STEM subjects, however it also accentuates the importance of ensuring that the positive changes, especially in the physical sciences are not reversed in the coming years.

Archer et al. (2013) investigated the science and career aspirations of UK students aged 10 – 14 (Years 5 to 9) and found that the 'science capital' of the students' families play a large role in whether they aspired towards careers in science. According to their research, science capital refers to the "science-related qualifications, understanding, knowledge (about science and 'how it works'), interest and social contacts (e.g. knowing someone who works in a science-related job)" a family possesses. The idea of science capital indicates that it is important for members of the general public to be science literate in order to be able to provide support and encouragement to the younger generation. Earlier research suggested that the general public in the UK were largely scientifically ignorant (Durant, Evans et al. 1992, Miller, Pardo et al. 1997, Bauer 2008), which spearheaded a movement towards inspiring positive attitudes towards the sciences in students and the general public (SCORE 2008). More recently, the Royal Society of Chemistry commissioned an in-depth study into public attitudes towards chemistry in order to better understand public perceptions and craft more effective outreach projects (BMRB 2015). More recent research evidence indicates that the public are becoming more aware of the importance of science to society (Castell, Charlton et al. 2014), which suggests that interventions are working.

The prevalence of such research and their outcomes highlight the importance of attitude, and the effect it can have on how receptive a person is to a certain stimulus. Researchers in a variety of countries have observed a trend of students' losing interest and enthusiasm for science and chemistry lessons as they progress through education (Pell and Jarvis 2001, Salta, Gekos et al. 2012, Archer, Osborne et al. 2013). In order to tackle the decrease in the number of students studying chemistry and other physical sciences, increased effort should be made to ensure that students at school level feel positively towards chemistry and science lessons.

1.2 What is an attitude?

In order to fully understand the findings of any attitudinal research, it is important to first understand what is being measured by an 'attitude'. Some early philosophers and sociologists defined the whole field of social psychology as the scientific study of attitudes (Thomas and Znaniecki 1918), which illustrates the importance of attitudes for understanding the behaviours of others. In general, an attitude can be described as a 'predisposition to respond in a favourable or unfavourable manor to a particular object or class of objects' (Oskamp and Schultz 2005).

Concerning attitudes towards science, Gardner (1975) defined them "as a learned predisposition to evaluate in certain ways objects, people, actions, situations, or propositions involved in learning science." Attitudes toward science involve an attitude object such as "science" or "science lessons," "laboratory work" and so on (Schibeci and McGaw 1981).

It is critically important that attitude scales are developed with aid of a theoretical framework, as it is widely accepted in the field of psychology and beyond that an attitude is an internal state and not directly observable (Cheung 2009). This means that an attitude can be referred to as a latent construct, as the existence of an attitude can only be inferred from observable attitudinal responses such as the response to certain question items. The more informed the researcher is about the theoretical underpinnings of a construct, the more likely they are to develop reliable, valid, and useful scales (DeVellis 2012). One of the highlights of the ATCLS survey was that it was designed with the consideration of a theoretical framework; the latent processes viewpoint.

As attitudes have been considered as a ‘central concept of social psychology’ for many decades, there has been a vast amount of specialised research into the field which has seen the definitions change and develop over time (Tesser and Schwarz 2001). However, over the years, three main theoretical viewpoints on the nature of attitudes have prevailed: the tri-component viewpoint, the separate entities viewpoint, and the latent processes viewpoint (Oskamp and Schultz 2005). The tri-component viewpoint suggests that an attitude is a single entity with three components, the affective, the behavioural and cognition (often abbreviated to the ABCs of attitude). This concept will be illustrated using question items from the ATCLS.

A. Affective component:

   This component refers to the feelings and emotions one has towards the attitude object. For example,

   I like chemistry more than any other school subjects.
   Chemistry lessons are interesting.
   Chemistry is one of my favourite subjects.

B. Behavioural component:

   The behavioural component refers to the overt actions and tendencies to the attitude object. For example,

   I am willing to spend more time reading chemistry books.
   I like trying to solve new problems in chemistry.
   If I had a chance, I would do a project in chemistry.

C. Cognitive component:

   The cognitive component encompasses the ideas and beliefs that are held about the attitude object. For instance,

   Chemistry is useful for solving everyday problems.
   People must understand chemistry because it affects their lives.
   Chemistry is one of the most important subjects for people to study.

The history of the tri-componential concept is one that can be traced back to long-established philosophical ideas. It was Plato who first distinguished three separate parts of the mind; the conative, affective and cognitive, which are more commonly referred to as the relationship between behaviour, emotions and thoughts (see Figure 1-1). The term attitude, based on the tri-component viewpoint, was first used by British philosopher and sociologist Herbert Spencer in 1862, and has been a well-employed theoretical viewpoint ever since (Oskamp and Schultz 2005).

However, the very nature of looking at attitudes as a sum of three different components raises questions about its empirical validity and usefulness, as it assumes that all three components have a 'relatively high degree of consistency'. This condition is necessary because if there was little consistency between the components, there would be no reason to consider them as aspects of the same construct, as they would be entirely independent of each other. However, if there was an extremely high consistency between the components, it would mean that they could not be distinguished as separate components, as they would "merely be different names for the same thing" (Oskamp and Schultz 2005). After surveying the literature, McGuire (1969) p. 157 concluded that the three components were extremely correlated and were not worth distinguishing between. However, further research has shown that there are moderately strong correlations between the three components (Eagly, Mladinic et al. 1994, Huskinson and Haddock 2004).

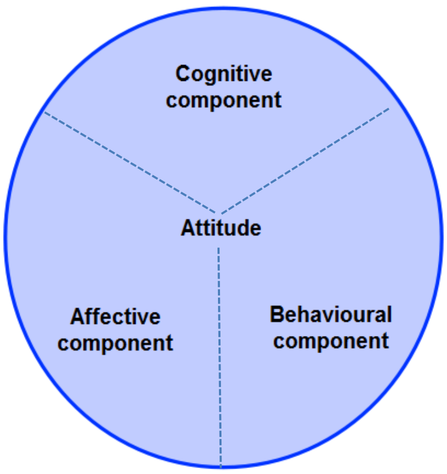


Figure 1-1 Figure illustrating the relationship of the ABCs in the tri-componential view of attitudes.

Huskinson & Haddock, (2004) identified another major weakness with the tri-component viewpoint when their research indicated that some individuals base their attitude predominantly on one of the components, such as the cognitive (their beliefs) or the affective (their feelings). Another point of contention with the tri-component viewpoint of attitudes is an argument that not all attitudes must have three components. It is easy to demonstrate the three separate components for the attitude object at the centre of this research project, however doubts are cast over the accuracy of a theoretical viewpoint that can only be used for specific attitudes. For example, Zajonc (1980) noted that an emotional response towards an attitude object such as spiders may not have a cognitive knowledge base.

The second major theoretical viewpoint is the separate entities viewpoint, and is illustrated by Figure 1-2. It is based on the assumption that the three aforementioned components of attitudes are distinct, separate entities, which "may or may not be related, depending on the situation" and has been advocated by Fishbein & Ajzen (1977). According to their theory, the term attitude should be reserved solely for the affective domain, which indicates a persons' favourability toward an object. The cognitive component was referred to as beliefs, and was defined as indicating a person's subjective probability that an object has a particular characteristic. An example of this would be how sure a student feels that "People must understand chemistry because it affects their lives", or "Chemistry is useful for solving everyday problems". The behavioural component was referred to as the behavioural intentions, and was defined as indicating a person's subjective probability that the will perform a particular behaviour towards a certain object, such as "I am willing to send more time reading chemistry books" or "If I had a chance, I would do a project in chemistry".

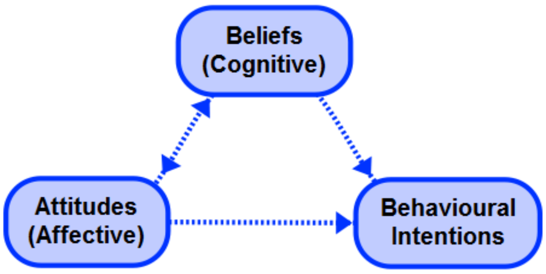


Figure 1-2 Figure demonstrating the relationship of the ABCs in separate entities viewpoint of attitudes.

A person may hold many beliefs about the same object, but that does not necessarily mean that the beliefs are related. For example, if a student believes that "People must understand chemistry because it affects their lives", they may or may not also believe that "Chemistry is useful for solving everyday problems" or that "Chemistry is one of the most important subjects for people to study". This is also true for behavioural intentions, as "I am willing to spend more time reading chemistry books" does not imply "If I had a chance, I would do a project in chemistry". However, Fishbein and Ajzen (1977) suggested that all measures of a person's affect toward a particular object should be highly related: "Chemistry lessons are interesting" does imply "Chemistry is one of my favourite subjects", and such responses should be quite consistent with the same person's answers to an attitude scale evaluating chemistry lessons.

An important detail about the separate entities viewpoint is that it does not require the three components (beliefs, attitudes and behavioural intentions) to have similarities to each other, compared to the tri-component viewpoint which would attribute the three aspects as part of the same attitude. For example, “Chemistry is one of my favourite subjects” (attitude) does not necessarily imply “Chemistry is one of the most important subjects for people to study” (belief), or “If I had a chance, I would do a project in chemistry”. The distinction between the three provides a justification for treating them as separate entities, which demonstrates the theoretical and empirical advantages over the tri-component view of attitude components. However, an attitude scale can only be expected to correlate highly with other standard attitude measures when it has been constructed from several well-chosen belief or behavioural items, as there are many beliefs and intentions that are not suitable for a scale. This includes beliefs that are widely agreed on, e.g. “Chemistry lessons are a type of science lesson” or vague statements that are difficult to evaluate such as “I think chemistry lessons are an average amount of fun”. An example of a scale constructed using the separate entities viewpoint is Francis & Greer’s (1999) scale measuring students’ attitudes towards science in secondary schools, however some of the question items such as “Science is relevant to everyday life” could be argued as being a cognitive property instead of an affective property.

The third main theoretical viewpoint is known as the latent processes viewpoint and suggests that an “attitude” represents a hidden, unobservable process occurring in an individual which can be used to explain the relationship between stimulus events (science or chemistry lessons) and the individual’s responses (DeFleur and Westie 1963). This is illustrated by Figure 1-3. The viewpoint acknowledges that stimuli can arouse any combination of a person’s ABCs, many of which are unobservable processes. These processes, either combined or separately, can create an attitude towards the stimuli, which is also an unobservable, latent process. However, affective, behavioural and or cognitive responses will be present due to the possession of an attitude, which can be observed and measured by the use of targeted questions (Cheung 2009).

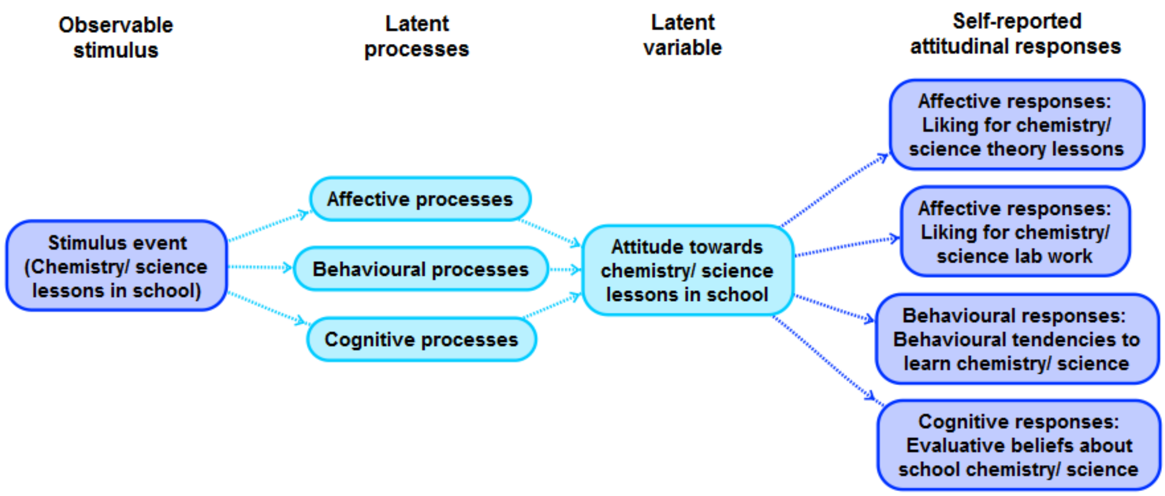


Figure 1-3 Figure displaying the latent processes viewpoint of attitudes, illustrated using chemistry/science lessons as the observable attitude stimulus.

The findings of contemporary attitude research concurs that attitudes can be formed from cognitive, affective, and/or behavioural information about the attitude objects, and expressed through cognitive, affective, and/or behavioural responses (Eagly and Chaiken 1998, Oskamp and Schultz 2005, Cheung 2009). For those reasons, the latent processes viewpoint of attitudes was deemed to be the most appropriate for the aims of this research and care was taken to ensure that the research was conducted under that theoretical framework.

1.3 Measuring Attitudes and Aims of the research project

Many survey instruments have been developed with the aim of accurately measuring the attitudes of students towards science and chemistry lessons, and will be assessed for suitability in the following chapter – The Development and Validation of Existing Attitudinal Surveys. As described previously, attitudes are formed and expressed in complex ways which can make it difficult to assess exactly what an attitudinal scale has been designed to measure, not to mention the constructs it actually measures. Much research has focused on measuring students' attitudes towards science or chemistry either qualitatively or quantitatively, however it has been suggested that the combination of the two research methods can be employed to enhance the validity of the collected data, as well as helping to ensure that the pre-existing presumptions held by the researcher are less likely to interfere with the findings (Johnson and Onwuegbuzie 2004). In order to investigate the attitudes of students towards science and chemistry lessons and address the existing issues of attitude measurement, four main aims were set for this research project:

1. To assess the suitability of existing attitudinal scales in order to determine whether a scale suitable for the purpose of quantitatively measuring the attitudes of secondary school students towards science and chemistry lessons in the UK across KS3 and KS4 (Year 7 – 11) already exists
2. To identify a range of factors that affect students' attitudes towards science and chemistry lessons by interviewing students in focus groups
3. To modify the survey by the addition of qualitative questions created from the factors revealed by the focus groups and preliminary research, with the purpose of allowing students to explain the reasoning behind their attitudes
4. To deploy the survey online, and identify whether any trends persist between the attitudes of students of different genders, year groups or types of schools (state funded or fee paying)

The following chapters will discuss each of the aims in detail, along with the methods that were employed to fulfil them.

Chapter 2: The Development and Validation of Existing Attitudinal Surveys

A variety of instruments have been developed by science educators for the purpose of measuring student attitudes towards chemistry and science (Pell & Jarvis, 2001), (Bennett, 2001), (Salta & Tzougraki, 2004), which have also been employed as useful tools for the evaluation the effectiveness of science curricula. Mayer and Richmond (Mayer & Richmond, 1982) noted that an 'extensive duplication of effort' had occurred in the development of attitude instruments in science education, and thus recommended that all further efforts should be directed toward the revision or refinement of existing instruments.

The Attitudes toward Chemistry Lessons Survey (ATCLS) was developed by Derek Cheung (2009) as a refinement of the Test of Science-Related Attitudes (TORSA) survey created by Fraser (1981), in response to the many survey instruments that had been developed without addressing some of the common problems that often arise during the development of an attitudinal scale (Tapia, 2004). This chapter will describe the problems that researchers have encountered whilst designing attitudinal scales, assess the suitability of the various scales that were investigated, and explain why the ATCLS was chosen for modification in this research project.

2.1 Assessment and Verification of Attitudinal Scales

Fraser (1977) stated that three important criteria should be considered when selecting attitude scales for curriculum evaluation: the multidimensionality of the scale, its educational importance, and economy of administration time. This sentiment was reiterated by Tapia and Marsh (2004) during their development of a scale to measure mathematical attitudes: 'attitude scales must withstand factor analysis, tap important dimensions of attitudes, and require a minimum time for administration'.

It is important for an attitudinal scale to display multidimensionality by possessing questions that focus on different aspects of an attitude, as it is widely accepted that an attitude is a multidimensional construct formed as a result of the interaction between three main unobservable components: the affective, the behavioural and the cognitive. As discussed in the introducing chapter, there are multiple psychological theories that discuss the precise nature in which the three components interact to form an attitude. As a result of this, it has been recommended that an attitudinal scale must contain a range of question items that successfully measure the different components of attitude by testing a respondent's affective response, behavioural response and cognitive response (Cheung 2009). Arguably, the most important methodological concern to stress about scales designed to measure a latent construct is that the question design and validation process cannot be informed by just the researcher themselves. Instead, scales should be composed of items that have been subjected to tests of validity to show that they can serve as reasonable proxies for the underlying construct they represent (Lovelace and Brickman 2013).

2.1.1 Construct Validity and Multidimensionality

The assessment of the multidimensionality of a scale is linked closely to its construct validity, which is a measure of the relationship between the question items and the unobservable constructs they aim to measure (Harrington 2008). Construct validity is an extremely important property of any scale that attempts to measure an attitude, as it measures the extent to which the question item measures the constructs they claim to. If a scale has bad construct validity, the resulting data can be extremely hard to draw conclusions from due to the uncertainty and possible disagreement about what constructs the items are measuring.

2.1.1.1 Confirmatory Factor Analysis and Exploratory Factor Analysis

Confirmatory factor analysis (CFA) and exploratory factor analysis (EFA) are both statistical techniques that can be used to investigate the distinct factors and constructs that are represented by a set of question items. As factors and constructs are revealed from the answers of the respondents, it can be said that factor analyses are dependent on the demographics of the dataset.

However, EFA is typically used to ‘isolate patterns and features of the data and reveal these forcefully to the analyst’ (Hoaglin, Mosteller et al. 1983), whilst CFA is used to confirm whether a pre-specified relationship between the observed variables and their underlying latent construct(s) exists. In order to successfully use CFA, the researcher ‘uses knowledge of the theory, empirical research, or both, postulates the relationship pattern *a priori* and then tests the hypothesis statistically’ (Suhr and Shay 2009). Ideally, a combination of both analyses should be utilised at different stages of the research (EFA near the beginning to establish the latent constructs, and CFA near the end to confirm the relationship between the factors/question items and the latent constructs) in order to develop a robust and reliable scale (Hoaglin, Mosteller et al. 1983).

Researchers Krosnick (2005) and Munby (1997) have emphasised that the nature of confirmatory factor analysis allows for the reliable testing of the construct validity of data, which makes it an invaluable tool for the evaluation of attitudinal scales. There are many programs that can perform such statistical analysis, including the program AMOS which is part of the SPSS statistical package. If respondents from multiple demographics complete a scale (e.g. science students in Year 7 and 9), CFA can help to determine whether a scale is more suited to one demographic than another if it is applied to the two distinct datasets. Factor loadings are a measure of how much a question item contributes to the overall construct, which signifies that items with high factor loadings are more representative of the construct (Yong and Pearce 2013). Factor loadings reflect the degree to which each item is linked to a factor, or underlying construct. This means that an item's factor loading 'reflects the degree to which differences among participants' responses to an item arise from differences among their levels of the underlying psychological construct being assessed by that item' (Furr 2016).

2.1.1.2 Cronbach's Alpha

A common measure of the reliability of a set question is the calculation of Cronbach's alpha (α - Equation 2-1), which measures the interrelatedness of a set of items (Field 2013).

Equation 2-1 Cronbach's alpha, (α), where N is the number of items in the scale, Mean(Cov) is the mean inter-item covariance, and Sum(Var/Cov) is the sum of all the elements in the variance-covariance matrix.

$$\alpha = N^2 \left(\frac{Mean(Cov)}{Sum\left(\frac{Var}{Cov}\right)} \right)$$

A set of question items with a low α value would suggest that the items do not measure a single construct, whilst a high α value suggests that the items are unidimensional (they all measure the same latent construct). Therefore, a set of items designed to measure a specific construct within a scale, e.g. items on attitudes towards theory lessons in a scale measuring attitudes towards chemistry lessons should have a relatively high α value overall, whereas the α value for all of the items should be lower as they are measuring slightly different constructs. Although an α value of between 0.70 to 0.95 has been reported to indicate an 'acceptable' level of reliability, in reality the interpretation depends on the specific context of the items resulting in additional complications (Tavakol and Dennick 2011). For instance, it has been shown that a high α is possible to achieve even though the items may be multidimensional, and Cortina (1993) demonstrated that the value of α varied with the number of items being tested, with the value of α decreasing as the number of measured constructs decreased. A low value of α could be due to a low number of questions, poor inter-relatedness between items or heterogeneous constructs (Tavakol and Dennick 2011).

2.1.1.3 Item-total correlations

The item-total correlation is the correlation between each question item within a scale and the total score from the scale. In a reliable scale, all items should correlate with the overall score. Values of > 0.3 have been reported to be acceptable for item-total correlations (De Vaus 2004, Field 2013).

2.2 Existing attitudinal scales and their development

A variety of different attitudinal scales have been created over the years by science educators, however a great amount of variation exists between them due to differences in opinion over the constructs that have been considered to be a property of an attitude towards science or chemistry (Salta and Tzougraki 2004).

Klopfer (1971) defined six conceptually different categories that a scale purporting to measure attitudes towards science should contain, in an attempt to minimise the lack of agreement researchers faced when attempting to quantify the multiple meanings associated with an 'attitude towards science' (Table 2-1).

Table 2-1 showing a comparison between Klopfer's (1971) categories of attitude for science attitudinal scales and those of Fraser's (1981) TORSA attitudinal scale.

Klopfer (1971) Classification of scales		TOSRA subscales	
H.1:	Manifestation of favourable attitudes towards science and scientists	S N	Social Implications of Science Normality of Scientists
H.2:	Acceptance of scientific enquiry as a way of thought	I	Attitude to Scientific Inquiry
H.3:	Adoption of 'scientific attitudes'	A	Adoption of Scientific Attitudes
H.4:	Enjoyment of science learning experiences	E	Enjoyment of Science Lessons
H.5:	Development of interest in science and science-related activities	L	Leisure Interest in Science
H.6:	Development of interest in pursuing a career in science	C	Career Interest in Science

Some attitudinal scales encompass all of the subscales defined by Klopfer (1971), whilst others focus on a few or a single construct and its corresponding scale. The Test of Science-Related Attitudes (TOSRA) scale (Fraser 1981) was created to assist in the measurement and encouragement of positive attitudes towards science in Australia and beyond. The scale was designed to measure seven distinct subscales of attitude, based on those that had been specified by Klopfer in 1971 with the distinction of splitting the 'H.1: Manifestation of favourable attitudes towards science and scientists' into two separate categories: 'S – Social Implications of Science' and 'N – Normality of scientists' (Klopfer 1971). This was due to Fraser assigning importance to the distinction between the manifestation of positive attitudes towards science and the manifestation of positive attitudes towards scientists. However, 'H.5 Development of interest in science and science-related activities' was not split into two subscales by Fraser due to an assumption that an interest in science related activities was a precursor to an interest in the discipline of science itself (Fraser 1977). The TOSRA was initially designed to measure the attitudes towards science held by Australian students in Years 7 to 10 (ages 12-16), consisted of 70 question items (10 per subscale), and came with a recommendation for administration time of between 30-45 minutes for students in Year 7 to 25-30 minutes for students in Year 10. Fraser tested the scale with a sample size of 1337 students and evaluated the reliability of the scale by calculating α for each scale. The mean α for each year group were judged by Fraser to indicate that the scale had good internal consistency and reliability (Fraser 1981).

In addition to this, the inter-correlations between the subscales were calculated in order to ascertain the extent to which a given scale measured a unique component of attitude compared to the other scales, and they were deemed to be quite low, implying that the subscales measured seven distinct constructs of attitude. However, the literature suggests that the item-total correlation between scales correlation should be > 0.3 (De Vaus 2004).

The multidimensionality of the TOSRA scale was assessed using both confirmatory factor analysis (Schibeci and McGaw 1981) and exploratory factor analysis (Pintrich, Smith et al. 1993) and both investigations failed to find seven distinct factors within the 70 question items. This indicated that it was likely that some of the question items were measuring the same construct instead of distinct ones. Table 2-2 demonstrates that question items from Enjoyment of Science Lessons subscale of the TORSA had the highest calculated reliability coefficients, which indicate that the question items are measuring the same construct. As only one of the seven subscales of the TOSRA measured the construct that matched the interests of the research project (Enjoyment of Science Lessons), adopting the entirety of the TOSRA scale would have been unsuitable for the purposes of this research project. The recommended time for administration was deemed to be excessive for this research project, as one of the specifications for the chosen survey was to ensure it was suitable for easy and time-efficient online administration.

Table 2-2 showing reliability coefficients calculated for Fraser's (1981) test of the TOSRA scale on 1337 students. The 'Enjoyment of Science Lessons' subscale has been highlighted for ease of comparison. α values > 0.8 are acceptable (Tavakol and Dennick 2011)

TOSRA Subscale	Reliability coefficient (α) range (Data from students in Years 7-10)	Mean correlation with other scales
Social Implications of Science	0.75 – 0.82	0.39
Normality of Scientists	0.70 – 0.78	0.27
Attitude to Scientific Inquiry	0.81 – 0.86	0.13
Adoption of Scientific Attitudes	0.64 – 0.69	0.33
Enjoyment of Science Lessons	0.92 – 0.93	0.39
Leisure Interest in Science	0.85 – 0.89	0.39
Career Interest in Science	0.88 – 0.91	0.40

Following from the work of Fraser, researchers developed new scales for measuring student attitudes towards science and chemistry. Some researchers focused on the measurement of students' attitudes towards science in primary schools (Pell and Jarvis 2001, Trumper 2006) or the attitudes of university students studying scientific disciplines (Bennett 2001). However, the majority of researchers focused on secondary school students' attitudes towards general science lessons and the separate disciplines (Hofstein, Ben-Zvi et al. 1977, Menis 1989, Parkinson, Hendley et al. 1998, Salta and Tzougraki 2004, Barmby, Kind et al. 2008).

An important aim of this research was to evaluate student attitudes towards both chemistry and science lessons, which required survey items to be suitably modifiable without compromising comparability. As the target survey respondents were UK students in Years 7, 9 and 11, the understanding of chemistry by students in each year group were considered carefully. In the UK, academic years are also grouped into Key Stages, in which certain academic targets must be achieved for the purpose of standardising education across the UK for the ease of examining pupils. Years 7-9 are referred to as Key Stage 3 (KS3), in which the majority of the science curriculum is taught in general science lessons where distinctions are not made between the sciences in Years 7-8. Schools generally begin to separate the sciences in Year 9 to prepare students for KS4, however there is no national requirement for general science lessons which allows for some schools to deliver lessons based on the separate disciplines earlier. The lack of uniformity in how schools deliver the science curriculum suggested that younger science students were unlikely to answer survey questions based solely on chemistry lessons reliably.

Students in Years 10-11 are grouped into KS4, during which they study for their General Certificate of Secondary Education (GCSE). From this time, the science curriculum is split into its three constituent subjects; biology, chemistry and physics, meaning that students in these years would be suitable for answering a survey based on their attitudes towards chemistry lessons. A complication however, was that a students' ability to recognise chemistry as a discrete science subject could vary depending on which GCSE science qualification they are studying for due to how the courses are delivered. The most common science qualifications for GCSE students are known as Core Science, Additional Science and Triple Science, and are often referred to as Single Science, Double Science and Separate Science. This results in differing amounts of exposure to chemistry as a distinct science subject.

Many of the available scales were designed to measure attitudes by measuring a broad range of subscales similar to those defined by Klopfer (1971) and the TOSRA (Fraser, 1981), meaning that they would have been unsuitable for measuring attitudes towards science or chemistry lessons explicitly. Efforts were made to investigate scales that purported to measure students' attitudes towards science lessons or chemistry lessons.

The target age group of a large number of existing surveys were students in their first year of university study in institutions based in the US and UK due to researchers' having easy access to large sample sizes suitable for in depth analysis. For example, Bennett's (2001) scale to measure students' attitudes towards the study of chemistry was designed for first year university students and foundation year students, and contained question items that focused on categories such as 'lectures' and 'tutorials' which would have been irrelevant to the target respondents, therefore making it unsuitable for this research project. The scale was based on the methodology of the Views on Science-Technology-Society (VOSTS) study conducted by Aikenhead & Ryan (1992) in Canada, which adopted the two-step process of attitude inventory design recommended by Oppenheim (2000) where:

1. *Interviews are used to establish the nature and origins of the attitudes in question, and*
2. *Question items should be developed from statements produced by the target respondents themselves.*

However, the survey items did not employ the use of a Likert scale, instead opting for a choice of fixed responses for each question item. This resulted in the identification of the factors that had the most impact on the respondents' attitudes, instead of explicitly measuring an attitude in a quantifiable manor. Both the VOSTS and Bennett's scales were powerful quantitative tools due to their strength as a provider of an 'in-depth' picture of students' attitudes' (Aikenhead and Ryan 1992).

Pell and Jarvis's (2001) scale measuring students' attitudes to science in primary schools highlighted the issues of adopting a scale that had been designed for younger students (Year 1 to Year 6, aged 5-11 years old). The scale featured three subscales:

1. ‘Being in school’, which had question items that focused on the respondents liking for school by measuring how much they enjoyed reading, writing, spelling, doing sums etc.
2. ‘Science experiments’, which focused on respondents liking for science experiments, and
3. ‘What I really think of science’ which was concerned with students’ evaluative opinions on scientists, school-based science and external views of science

The three subscales covered the many elements that constituted an attitude towards science lessons however in total, the scale consisted of 42 Likert scale question items which made it unlikely to have an efficient time for administration. The attitude instrument used a five point ‘smiley face’ Likert scale as recommended by West et al. (1997) which would have been suitable for Primary school students (Years 1-6), but not particularly relevant for Secondary school students. The scale was analysed using confirmatory factor analysis, and it was found that many of the subscales were most reliable when measuring the attitudes of the youngest pupils (Year 1), which confined the scale firmly for use with Primary aged students. Based on these findings, it was assumed to be very likely that the adoption of the scale for Secondary school students would have led to reduction of the accuracy of the data generated by the scale.

One of the few surveys that focused specifically on Secondary school students’ attitudes towards chemistry was created by Salta and Tzougraki (2004) with a focus on 11^{th} grade students (16-17 year olds) in Greece. The scale had a sample size of 576 students and consisted of four main subscales:

1. Difficulty of chemistry course
2. Interest of chemistry course
3. Usefulness of chemistry for students’ career
4. Importance of chemistry for students’ life

The scale placed little focus on practical elements of chemistry, which made it incompatible for adaptation for UK based student respondents. The National Curriculum states ‘Experimental skills and investigations’ as one of four aims that students should be taught across all science disciplines during Key Stage 3 and 4, which highlights the importance of practical work for an attitudinal scale (Education 2013). Some of the 30 question items were also deemed to be too complex, such as ‘I am incapable of interpreting the world around me using chemistry knowledge’, ‘Chemistry is a very sophisticated subject for our compulsory education’, and ‘The progress of chemistry worsens the conditions for living’ (Salta and Tzougraki 2004). Confirmatory factor analysis was not used to verify the fit of the data as the sample size was too small, instead the construct validity was investigated by calculating the split-half reliability and the reliability of internal consistency. The four subscales (Difficulty, Interest, Usefulness and Importance) had Cronbach's Alpha (α) scores of between 0.67- 0.89, which suggested that the majority of the scales had high internal consistency.

Many of the scales (Francis and Greer 1999, Bennett 2001, Pell and Jarvis 2001, Salta and Tzougraki 2004) made use of both positively worded question items alongside negatively worded question items, which were written as a reversal of positive items. Exploratory factor analysis of scales that include oppositely worded items designed to measure the same construct has established the items to be somewhat independent of each other (Spector, van Katwyk et al. 1997). This causes what is known as a measurement artefact (error) (Pilotte and Gable 1990), and care was taken to avoid this by ensuring that the survey chosen for development did not include negatively worded items.

2.3 Development of Cheung's Attitudes towards Chemistry Lessons Scale (ATCLS)

After a thorough investigation of the literature, the attitude survey that best suited the purposes of the project was Derek Cheung's Attitude Towards Chemistry Lessons Survey (ATCLS) (2009). The survey consisted of 12 short, positively worded question items which were suitable for the target age range, allowed for a short administration time, and was developed with the influence of a theoretical framework based in psychological research on attitudes. Cheung developed his scale by modifying the 'Enjoyment of Science Lessons' subscale of Fraser's (1981) TOSRA scale.

Cheung chose to keep the Likert scale that had been adopted by Fraser instead of using a semantic differential scale (SD), which 'measures people's reactions to stimulus words and concepts in terms of ratings on bipolar scales defined with contrasting adjectives at each end' (Heise 1970). An example of a sematic differential question can be seen in Figure 2-1. They differ from Likert scale items in that Likert scales require respondents to state the amount to which they agree or disagree with a statement (Likert 1932). SD scales have been recommended as a suitable technique for measuring secondary school students' overall attitude towards chemistry (Schibeci 1982), however Likert scales have been suggested as being a more appropriate style of questioning if more specific attitudes such as those held towards science or chemistry lessons are being investigated, as Likert-type question items produced data with the highest reliability when several formats were tested (Simpson 1990).

Please rate your chemistry lessons on the following traits:

Interesting	[ ]	[ ]	[ ]	[ ]	[ ]	Boring
Useful	[ ]	[ ]	[ ]	[ ]	[ ]	Useless
Relevant	[ ]	[ ]	[ ]	[ ]	[ ]	Irrelevant
Interactive	[ ]	[ ]	[ ]	[ ]	[ ]	Passive
Easy	[ ]	[ ]	[ ]	[ ]	[ ]	Challenging

Figure 2-1 An example of a chemistry lesson based semantic differential question, in which respondents' level of agreement towards stimulus words and concepts are measured.

Similar to Pell & Jarvis (2001) and Salta & Tzougraki (2004) the development of the ATCLS followed a two-step methodology as recommended by Oppenheim (2000) where:

1. Interviews are used to establish the nature and origins of the attitudes in question.
2. Question items should be developed from statements produced by the target respondents themselves.

Cheung conducted semi-structured interviews with 10 Secondary 4-7 students randomly selected from two secondary schools in Hong Kong in which the following free-response questions were asked:

1. When compared with other subjects that you have studied in this school, do you like chemistry lessons? Why?
2. Do you believe that chemistry is an important subject in the school curriculum? Why?
3. Do you intend to learn more chemistry? Why?

The interviews were recorded and transcribed which allowed for content analysis of the qualitative data to be conducted. The data revealed the following four attitudinal dimensions:

1. Liking for chemistry theory lessons
2. Liking for chemistry laboratory work
3. Evaluative beliefs about school chemistry
4. Behavioural tendencies to learn chemistry

The content validity of 20 question items were verified by two external science educators who assigned each item to one of the four attitudinal dimensions. This formed the pilot version of the ATCLS, which saw 777 students in Secondary 4-7 respond to the seven-point Likert items (strongly agree, moderately agree, slightly agree, not sure, slightly disagree, moderately agree, strongly agree). Cheung decided to include seven choices for the Likert items as recommended by Alwin and Krosnick's (1991) study which found that fully labelled seven-point attitude scales can generate the most reliable data. However, more recent research has suggested that the more options a scale has, the less reliable the resulting data is (Revilla, Saris et al. 2014). This could be due to the increase in central tendency bias that has been observed to occur when the number of response options increases (Bardo, Yeager et al. 1982). Central tendency bias occurs when respondents avoid using extreme response categories, such as strongly agree or strongly disagree.

The reliabilities of student responses to individual items and to the four subscales were examined on the basis of item–total correlations and Cronbach alpha values respectively, and the readability of the items was verified verbally with the help of five additional students. The three question items with the largest item-total correlations per scale were kept for the final version of the ATCLS as recommended by Bollen (1989), who stated that at least three indicators are needed to define a factor adequately using confirmatory factor analysis. The item-total correlation is the correlation between the question score and the overall score for the scale/or subscale, and is a useful measure of reliability (Gliem and Gliem 2003).

The remaining question items formed the final 12-item ATCLS scale. The construct validity of the final version of the ATCLS scale was verified using 954 Secondary 4-7 chemistry students, none of which were involved in the pilot study. The reliability of student data collected by the 12-item ATCLS was examined on the basis of item–total correlation and Cronbach's alpha. The 12 items were subjected to confirmatory factor analysis using the LISREL program in order to test the construct validity of the data, where each item was allowed to load on only one factor (i.e., the dimension of the attitudinal responses that the item had been constructed to measure) and the results can be found in Table 2-3 (Hooper, Coughlan et al. 2008).

Table 2-3 Reliability estimates and item-total correlations for final version of ATCLS (n = 954) (Cheung, 2009).

Subscale and item		Item-total correlation
Liking for chemistry theory lessons (estimated α = 0.86)		
	I like chemistry more than any other school subject.	0.76
	Chemistry lessons are interesting.	0.68
	Chemistry is one of my favourite subjects.	0.79
Liking for chemistry laboratory work (estimated α = 0.84)		
	I like to do chemistry experiments.	0.75
	When I am working in the chemistry lab, I feel as if I am doing something important.	0.60
	Doing chemistry experiments in school is fun.	0.75
Evaluative beliefs about school chemistry (estimated α = 0.76)		
	Chemistry is useful for solving everyday problems.	0.55
	People must understand chemistry because it affects their lives.	0.63
	Chemistry is one of the most important subjects for people to study.	0.61
Behavioural tendencies to learn chemistry (estimated α = 0.76)		
	I am willing to spend more time reading chemistry books.	0.57
	I like trying to solve new problems in chemistry.	0.65
	If I had a chance, I would do a project in chemistry.	0.57

The item-total correlations for each of the items were recorded as being ‘moderately positive’ by Cheung, which gave support for the reliability of the student data.

Table 2-4 Confirmatory factor analysis of student data from ATCLS (Cheung, 2009) Effective sample size = 930.

Standardised factor loadings of items under each dimension				
Question	Liking for chemistry theory lessons	Liking for chemistry lab work	Evaluative beliefs about school chemistry	Behavioural tendencies to learn chemistry
1	0.83			
2	0.74			
4	0.91			
6		0.84		
7		0.68		
10		0.88		
3			0.67	
8			0.75	
11			0.77	
5				0.71
9				0.82
12				0.64

The standardised factor loadings resulting from the confirmatory factor analysis were deemed to be 'most reasonable and statistically significant' (Cheung, 2009), and the fit indices generated by the LISREL program showed that the model fitted the data well, (goodness of fit index = 0.95, adjusted goodness of fit index = 0.92, normed fit index = 0.95, comparative fit index = 0.96) as a goodness of fit value close to 0.95 has been reported to demonstrate a good fit to a model (Hooper, Coughlan et al. 2008). The statistical analysis supported the notion that the final version of the ATCLS produced reliable data about students' attitudes towards chemistry lessons and confirmed the multidimensionality of the data produced.

2.3.1 Theoretical Framework – ATCLS Survey

As discussed in Chapter 1, the ATCLS was constructed under the influence of the latent processes viewpoint of attitudes, due to its advantages over the tri-componential and separate entities viewpoints.

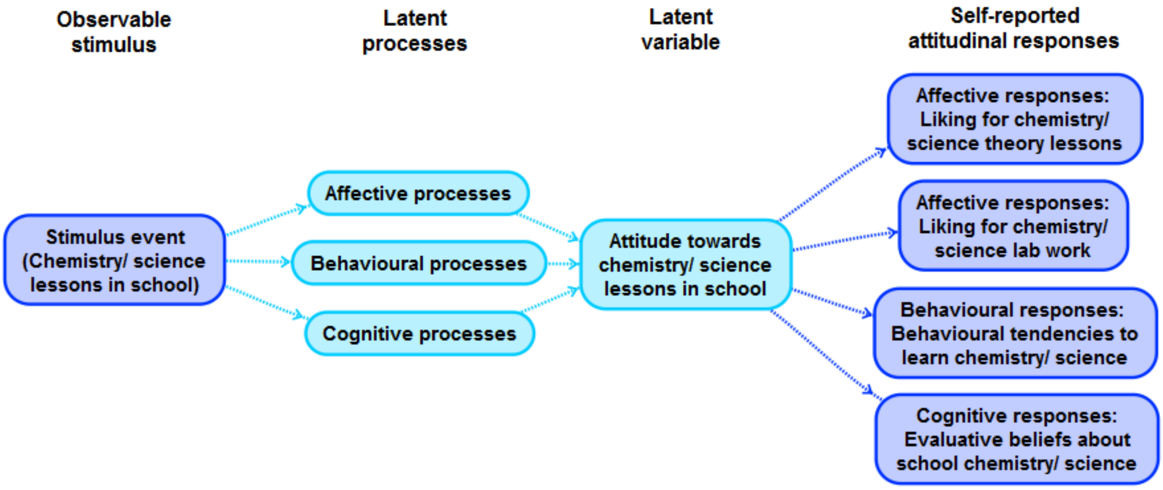


Figure 2-2 Latent processes viewpoint as applied to the stimulus of chemistry lessons by Cheung (Cheung 2009), and science lessons for the purpose of this research project

Figure 2-2 illustrates how Cheung's ATCLS demonstrates the idea that stimulus events can arouse a person's cognitive, affective and/or behavioural processes, many of which are unobservable. Individual or combinations of processes can give rise to an attitude, which as mentioned previously, is an unobservable latent construct. However, the presence of an attitude can give rise to observable responses, which may present themselves as cognitive, affective and/or behavioural responses to the attitude object, e.g. chemistry lessons.

The ATCLS scale items consisted of statements that covered four dimensions of attitude, with the first two, 'Liking for chemistry theory lessons' and 'Liking for chemistry lab work' covering the potential affective response of a student. Cheung was inspired to include this dimension by psychologists and science educators, who have generally agreed that people hold attitudes when they 'love or hate things, and when they approve or disapprove of them' (Cheung 2009). D. J. Bem (1973), a psychologist, simply defined attitudes as a persons' likes or dislikes.

Other science researchers interested in attitudes have included such a construct in their attitudinal scales, such as the 'Enjoyment of Science Lessons' subscale in the TOSRA (Fraser 1981) and the 'Interest of Chemistry Course' subscale in Salta and Tzougraki's (2004) attitude instrument. Behavioural responses are represented in the 'Behavioural tendencies to learn chemistry' subscale of the ATCLS. An example of another behavioural item in an attitudinal scale is 'I would like to have fewer chemistry lessons'. Evaluative beliefs have been described as a 'basic building block of attitudes' (Eagly and Chaiken 1998, Cheung 2009), which supports the notion that a student's attitude towards chemistry lessons can be inferred from their evaluative beliefs towards the importance or usefulness of chemistry lessons. Evaluative responses are covered in by the 'Evaluative beliefs about school chemistry' subscale in the ATCLS, and examples of other evaluative items in attitude scales include ‘Chemistry knowledge is useful to interpret many aspects of our everyday life’ (Salta and Tzougraki 2004), ‘Every high school graduate needs some knowledge of chemistry’, and ‘Chemistry is an essential prerequisite to the study of other natural sciences’ (Hofstein, Ben-Zvi et al. 1977).

The latent processes viewpoint of attitudes is seen as being advantageous over the two previous viewpoints as it avoids the possible over-simplification of the separate entities viewpoint which ignores cognitions or behaviours as being part of the attitude object, by focusing solely on the affective component. It also avoids the simplification that the three attitude components are equally responsible for an attitude (tri-component viewpoint), and clarifies that any given attitude may arise from one, or a combination of processes depending on the particular stimulus (Zanna and Rempel 1988). Similarly, the latent processes viewpoint also states that the attitude may be displayed in one, or a combination of the corresponding types of observable responses, which agrees with the findings of contemporary attitudinal research, making it the most appropriate theoretical viewpoint for a comprehensive attitudinal scale (Breckler 1984, Oskamp and Schultz 2005).

The research project was split into three distinct sections, with each informing the last as displayed in Figure 2-3. As the survey was based on the pre-existing ATCLS developed by Cheung (2009), the existing theoretical framework was examined in close detail. It was determined that the changes that were made in order to transform the survey into the Attitudes towards Chemistry and Science Lessons Survey (ATCSLS) followed the same framework.

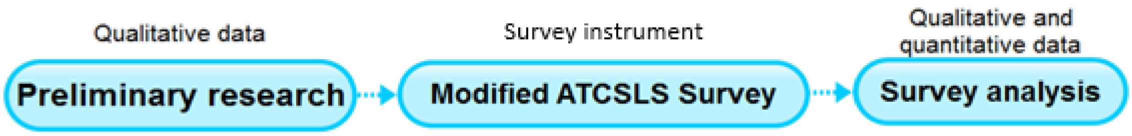


Figure 2-3 Diagram displaying the different stages of the research project and the different types of data produced.

2.4 Planned modifications

2.4.1 Rewording of questions

Overall, the ATCLS scale itself fulfilled the requirements described previously, which meant that the question items were evaluated in depth before modification into two separate surveys; one that measured attitudes towards chemistry lessons, and another that measured attitudes towards science lessons. As the original target respondents for the ATCLS were Chinese students aged 16-19, the scale items were conceived in the Chinese language and were translated to English later for publication purposes by Cheung. The following statements are the original items from the ATCLS, grouped with the subscales that they measure:

Liking for chemistry theory lessons

> I like chemistry more than any other school subjects.
> **Chemistry lessons are interesting.**
> Chemistry is one of my favourite subjects.

Liking for chemistry lab work

> I like to do chemistry experiments.
> **When I am working in the chemistry lab, I feel I am doing something important.**
> Doing chemistry experiments in school is fun.

Evaluative beliefs about school chemistry

> Chemistry is useful for solving everyday problems.
> People must understand chemistry because it affects their lives.
> Chemistry is one of the most important subjects for people to study.

Behavioural tendencies to learn chemistry

> I am willing to spend more time reading chemistry books.
> I like trying to solve new problems in chemistry.
> If I had a chance, I would do a project in chemistry.

The items in bold were not deemed to be worded in a way that would be clear and understandable to the target respondent (students in years 9 and 10), and were therefore changed slightly to:

I find chemistry lessons interesting.
and
When I do practical work in chemistry lessons, I feel I am doing something important.

The first statement was reworded to include an 'I' to shift the perspective of the statement to that of the respondent. It was felt that the original statement could be perceived to be asking the respondent to answer the question based on what they thought they should think, instead of answering according to their own personal opinion (Heise 1970).

In the second statement, the term 'chemistry lab' was changed to 'practical work in chemistry lessons' due to the term being more familiar to UK secondary school students.

The scale items of the ATCLS were developed with the influence of recorded semi-structured interviews in Chinese with 10 chemistry students randomly selected from two secondary schools, in order to ensure that the question item pool was generated 'on the basis of views expressed by chemistry students' (Cheung 2009). Researchers that gather qualitative data (such as that resulting from the semi-structured interviews conducted by Cheung) in a language that is different from that which the research is published in face potential problems when it comes to ensuring that meaning is not lost during the process. This is due to the belief that qualitative research is considered valid when the distance between the meanings as experienced by the participants and the meanings as interpreted in the findings are as close as possible (Polkinghorne 2007). In order to prevent such distances from growing, researchers have suggested that analysis of qualitative data should be conducted in the original language for as long as possible, and that a translator should be engaged if required (van Nes, Abma et al. 2010).

It is not stated whether Derek Cheung made use of a translator for the purposes of translating the scale items to English, however 46 papers (as of November 2015) have been published by Cheung in the English language, which gives weight to the assumption that his level of proficiency in English is more than sufficient for research (Professor CHEUNG Sin-pui 2015).

2.4.2 Addition of extra questions

Students' attitudes toward science lessons have been well-documented over the last 20 years, with the use of a wide variety of scales. However, the reasoning behind students' attitudes has not been explored in depth by many researchers.

Salta et al. (2012) attempted to investigate the reasoning via secondary school teachers' descriptions of secondary school chemistry however the focus was on why former students had chosen not to pursue a career in the further study of chemistry. One of the early research questions for this research project focused on whether it would be possible to identify the reasons behind students' attitudes toward chemistry and science lessons, and perhaps suggest solutions in order to increase positive attitudes amongst students. An attitude scale employing exclusively Likert questions would not be suitable for collecting such specific data, as the identification of factors required the pooling of potential factors, in the form of statements, by students themselves in order to properly identify the factors that affected them the most (Koballa 2007).

As the ATCLS survey was designed with the aim of having a short administration time, it was decided that the survey could be modified to include a selection of additional questions that would prompt students into identifying the reasons behind their attitudes without excessively increasing the time required for administration. This spurred an additional preliminary research phase, which was designed to gather students' opinions and input towards the design of question items. Full details of the process can be found in the next chapter, Development and Findings of the Preliminary Research and the Modification of the ATCLS.

Chapter 3: Development and Findings of the Preliminary Research and the Modification of the ATCLS

In order to prepare the Attitudes towards Chemistry Lessons Scale (ATCLS) for the measurement of students' attitudes qualitatively as well as quantitatively, modifications were required to the survey. It was decided that the best method of survey modification was the addition of question items that would allow student participants to identify the influencing factors themselves, which would be achieved by employing the use of multiple choice and free response questions. The main aim of the Preliminary Research was to source a pool of potential question items developed by students.

One of the main aims of the research project was to measure students' attitudes towards the science and chemistry lessons they received during their secondary education, as a means of creating a snapshot of attitudes of the current secondary school students.

The existing literature showed that students' attitudes towards science decline as they progressed through secondary education (Kind, Jones et al. 2007, White and Harrison 2012, Archer, Osborne et al. 2013), however no existing cross sectional research comparing the attitudes of students in different year groups was found during a review of the literature. By selecting to survey students in Years 7, 9 and 11, the research project aimed to capture the attitudes of students at distinct and pivotal moments during their secondary education and investigate the factors behind their attitudes. Due to the unforeseen circumstances of some school holidays and other extra extra-curricular activities, it was not possible for all schools taking part in the research to provide students from those specific year groups. Four Year 10 students participated in the preliminary research stage which was not deemed to be a problem since they were in the same Key Stage as Year 11 students (KS4). This meant that their chemistry-based science lessons will have been structurally the same as their future Year 11 lessons, due to the way in which the GCSE syllabus is delivered. More detail on this can be found in Chapter 3.3.

As the ages of the target students ranged from age 11 to 17, it was important to ensure that the chosen interview methodology would encourage all students to feel comfortable enough to share their opinions in a group setting. Group interviewing can be defined as the 'systematic questioning of several individuals simultaneously in formal or informal settings' (Fontana and Frey 1994); a process that places importance solely on the questions and responses between the researcher and the participants (Gibbs 1997). However, as the aim of the interviews was to identify the different issues that affected students, verbal interactions between students were deemed as having the potential to provide an important insight into issues they may not have felt comfortable discussing with a researcher alone. With this being considered, focus groups were employed as the main research methodology of the preliminary phase.

Focus groups are a type of group interview, but differ by the usage of organised discussions with a group of participants in order to gain information about their views and experiences of a topic (Gibbs 1997). This property makes focus groups well-suited for obtaining several perspectives around the same topic. The discussion element has been reported to increase the difficulty of the identification of individual views from the group view, however this problem was overcome by trialling a novel approach of data collection which will be detailed later in the chapter. It was decided early on that individual interviews would not be a time efficient method of gathering information from a large number of students, due to the minimal amount of time each student could spare from a school lesson. Additionally, the analysis of individual interviews requires the transcription of interviews; a time consuming process that would have been unsuitable for a project with a large number of participants.

3.1 Sample selection

Focus groups were conducted with a total of 69 students ranging from Years 7 to 11, chosen from a convenience sample consisting of four different secondary schools in the UK. An email detailing the research process was sent to a group of teachers that had expressed an interest in science and chemistry educational research in order to solicit participation. Four teachers responded, which resulted in the four participating schools. Although the results of the interviews and focus groups are exhaustive and comprehensive with regards to viewpoints of the students who participated, it is acknowledged that the results from this particular stage are gathered from a relatively small selection of students and may not be fully representative of the secondary population of the UK. However, the aim of the preliminary research was to identify a diverse range of popular factors that could affect students across the country in the same year groups. The cross-comparison of factors across different schools and year groups, along with the identification of trends, confirmed that those aims were achieved. Full ethics approval for the project was granted before the commencement of interviews, which served the purpose of ensuring that informed consent was given by all participants before the interview and that frameworks for maintaining participant and data anonymity were in place. Full details can be found in Appendix A.

3.2 Interview Protocol

To ensure the collection of reliable qualitative data from interviews, it has been recommended that they are conducted under the influence of a sound interview protocol (Turner III 2010). There are three main approaches to interviewing which fall between a structured approach and an unstructured approach.

An unstructured approach is encompassed by the informal conversational interview method in which the interviewer relies 'on the interaction with participants' to guide the generation of questions. The lack of formal structure has been considered to be useful to some researchers, as it allows for flexibility in the interview process. However, this approach would have been unsuitable for the research interviews due to the required ease of repeatability with different students, which would have been hampered by the inconsistency of the interview questions. For this reason, many researchers consider the informal conversational interview to be unreliable due to the difficulty of coding and analysing the resulting data (Creswell and Clark 2007).

The general interview guide approach is more structured in that it relies on the researcher to ensure that 'the same general areas of information are collected from each interviewee' (McNamara 2006). This provides more focus than the informal conversational approach whilst allowing the interviewer the flexibility to follow perceived prompts from the participants, but still results in the same analysis problems of non-standardised questioning, although to a lesser degree.

The most suitable interview protocol for the collection of specific data from a large number of students was the standardized open-ended interview, in which participants are 'always asked identical questions… (which) are worded so that the responses are open-ended' (Gall 2003). The standardised questioning reduces research bias within the interview, and the use of open-ended questions allows the interviewees to fully express their opinions whilst allowing for follow-up questions to be employed by the researcher. However, the resulting data can be extremely rich and detailed due to the nature of the open-ended questions, which can make the process of ensuring the fair representation of all perspectives in the analysis more time-consuming for the researcher.

3.3 Development of Framework Questions

The principle aim of the interviews was to identify the factors that students believed were negatively impacting their classroom science and chemistry experience. Due to differences in the science curriculum between the year groups, the specifics of the aim were adjusted accordingly for each year, with regard to whether the questions had a focus on chemistry lessons, science lessons or both. Framework questions for each year group of students were developed before the commencement of the focus groups in order to ensure the reliability of the interview process. The general questions were inspired by one of the questions Cheung used in the interview stage of the development of the ATCLS:

'When compared with other subjects that you have studied in this school, do you like chemistry lessons? Why?' (Cheung 2009) This question was chosen for further development as it provided students with an easy route into a discussion of their thoughts and attitudes towards chemistry and science lessons.

3.3.1 Year 7

Framework questions for Year 7 students were developed first as they were the first group of students to be scheduled for focus groups. One of the aims of the focus groups for Year 7 students was to gauge their general attitudes towards science, which led to the first question being designed as a probing exercise:

1. *'What words/thoughts/feelings come to your mind when I say the word science?'*

The students responded to the question by writing down all of their responses on a single Post-It note each. Each student then read out their responses, and there was a short discussion to cement universal definitions of the response item. The second area of interest were the students' attitudes towards their science lessons, which led to the question:

2. *a) 'Do you enjoy science lessons?'*

This question was presented as a precursor discussion to Question 2. b) by allowing the students to discuss their responses with each other before presenting individual responses back to the interviewer. This was permitted to encourage students to discuss the reasons behind their answers with each other. After the short discussion, the students were then asked:

2. *b) 'What changes would make your science lessons better for you?'*

This question was asked to encourage students into identifying the factors that they felt negatively affected their science lessons, so that a student-based item pool could be created for the final survey (Koballa 2007).

The word ‘better’ was used instead of more ‘enjoyable’ or ‘fun’, as the latent processes viewpoint of attitudes that the ATCLS is based upon acknowledges that attitude is not defined by behaviour alone (Cheung 2009). The latent processes viewpoint conceptualizes attitude as a latent variable that can be used as an explanation of the relationship between a stimulus and a person’s behaviours. Instead, science and chemistry lessons can arouse a student’s cognitive, behavioural and/or affective process, and the processes that occur within the student are not observable. Using a word such as ‘enjoyable’ or ‘fun’ could unintentionally stimulate a specific response in a student whose attitude towards science/chemistry lessons is based more on affective or behavioural components. By using the word ‘better’, the question was left open for the interpretation of the individual students. The students then responded to this question according to the Post-It Note method see Chapter 3.4). It is important to note that students that believed that there were no improvements that could be made to their science lessons were instead asked to record the top reasons why they believed their lessons were so good. Such responses were noted and accounted for during analysis.

If there was additional time at the end of the focus group or a particular teacher allowed the students to participant for longer, a third area of interest was probed by fourth question:

3. *‘What words/thoughts/feelings come to your mind when I say the word chemistry?’*

This question was asked in order to gauge the Year 7 students’ knowledge and pre-existing attitudes towards chemistry. The responses to this question demonstrated that Year 7 students did not yet have sufficient experience of the distinct subjects to distinguish chemistry as a separate discipline. This finding was expected due to the content prescribed by the National Curriculum for students within KS3. A total of 12 Year 7 students participated in the preliminary focus groups.

3.3.2 Year 9

Students in Year 9 are in the last year of Key Stage 3 (KS3) study. Depending on the type of General Certificate of Science Education (GCSE) they are entered for, Year 9 could be students’ last year of receiving combined science lessons before undertaking distinct chemistry, biology and physics lessons in Year 10. (Education 2013). However, by the time students have reached Year 9, they will have received more exposure on the topics and modules that relate to the three scientific disciplines through their progression from Year 7. This means that although in theory they may not sit separate science lessons until Year 10, older students are more likely to be able to identify 'chemistry' as a separate concept. This is further complicated by the fact that some schools start preparations for GCSE study in Year 9, making it highly unlikely that all students in Year 9 have a similar level of understanding of what 'chemistry' is.

For this reason, the framework questions for Year 9 were based on two separate areas of investigation:

- Attitudes towards science lessons, which used the same three questions 1, 2a) and 2b) as the Year 7 framework questions, and
- Attitudes towards chemistry lessons, with the aim of identifying and unifying definitions of 'chemistry lessons', and identifying factors of concern. This was achieved by asking question 3 along with modified versions of questions 2a) and 2b) in which the word 'science' was replaced by 'chemistry':

3. 'What words/thoughts/feelings come to your mind when I say the word chemistry?'
4. A) 'Do you enjoy chemistry lessons?'
4. B) 'What changes would make your chemistry lessons better for you?'

Students responded to question 4b) using the Post-It note method, which meant a short discussion was held in order to cement universal definitions of the response items, (chemistry). During these discussions there was often some confusion about the meaning of chemistry, which appeared to be dependent on the academic ability of the students present in the particular group. However, it was still quite notable across all of the schools, which highlighted the importance of ensuring that all of the students recognised chemistry lessons as distinguishable from science lessons before ordering their responses. A total of 22 Year 9 students participated in the preliminary focus groups.

3.3.3 Years 10 and 11

Students in Years 10 - 11 are grouped into KS4, during which they study for their GCSE's and either receive combined science lessons or separate physics, chemistry, and biology lessons depending on the level of qualification they have been entered for. It was determined from the earlier focus groups with students in Year 11 that they were familiar with 'chemistry' and could identify the lessons in which they learnt the subject even if they did not always receive separate lessons. As a result of this, Year 11 students were asked about their opinions and views on chemistry lessons only, using questions 3, 4a) and 4b).

Some of the schools involved in the preliminary phase could not provide students from Year 11 due to scheduling issues and offered Year 10 students instead. A total of 4 Year 10 students took part in a separate focus group, and it was found that they had similar responses to Year 11 students. A total of 41 Year 11 students participated in the preliminary focus groups, resulting in 45 KS4 student participants.

3.4 Post-It Note data collection method

The Post-It Note method of data collection was a novel approach specifically developed for the research project to counter the large amount of narrative data that results from the employment of standardised open-ended interviews. Due to the time constraints on the project and the difficulty of organising interviews outside of school hours, interviews were strictly restricted to school hours only.

The focus groups made use of short, semi-structured questions so that the minimal amount of time (roughly ten minutes) students could spare from their lessons was used efficiently. A novel approach of data collection was also successfully trialled during this time, which involved students writing down their responses to the structured questions on post-it notes. Benefits of the method included the subtle encouragement of students to write considered, succinct responses, simply due to the lack of writing space available, as well as addressing the collection of large amounts of qualitative data that usually results from the use of interviews. The method provided the researcher with an efficient and easy way of collecting data as the post-it notes could be collected very quickly and stored for analysis at a later point, and fresh post-it notes could be distributed very quickly for the use of following questions or by a new set of students. The combination of these methods meant that the total time of application for one group of up to 6 students could be kept between 10-15 minutes.

The Post-It note method was employed as follows:

1. A group of 3 to 6 students were seated at table and a number of blank Post-It notes were placed in front of each of them by the researcher conducting the interview.
2. The researcher would ask a question (see framework questions) and ask the students to write down as many responses as they could think of, with each response or idea on a separate Post-It note.

3. The students were then asked to arrange their Post-It notes vertically on the table, with their most important response/idea at the top and their least important response/idea at the bottom. This was completed without conferring to avoid the influence of other students.
4. Short discussions were held in order to clearly define the problems raised by students. Data collection was achieved by the researcher taking photographs of each student's ordered Post-It notes for analysis (see Figure 3-1).
5. The students were then asked to discuss the most important factors as a group and arrange the Post-It notes as a group vertically on the table, with their most important response/idea at the top and their least important response/idea at the bottom. Photographs of the completed list were taken for analysis and the used Post-It notes were recycled.

The process was repeated for each new question and new set of students.

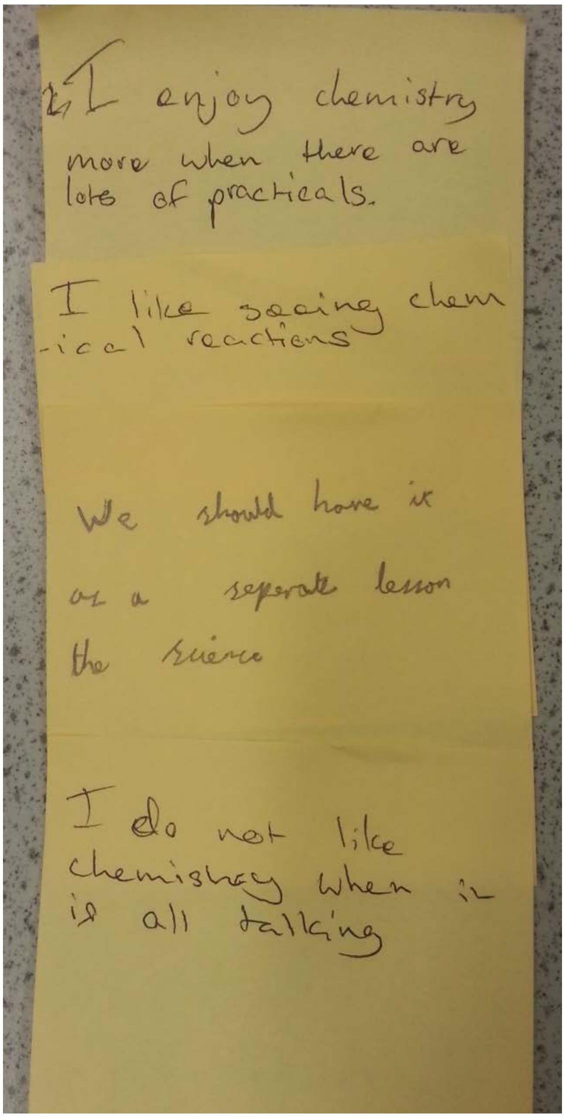


Figure 3-1 An example of Step 5 of the Post-It note method, as employed by a group of Year 9 students.

3.5 Analysis of Preliminary Data – Coding

Once data had been gathered from students in all four participating schools, the responses were analysed for recurring themes, which were coded to form the range of factors students' could identify with in the survey. Coding is an analytical process that helps the researcher to categorise the qualitative data they have collected and develop theories, where a theory is 'a description of a pattern… (found) in the data' (Auerbach and Silverstein 2003). A code is most often, a 'word or a short phrase that symbolically assigns a summative, salient, essence-capturing and/or evocative attribute for a portion of language-based or visual data' (Saldaña 2012). The Post-It note qualitative data were subjected to three cycles of manual coding to ensure the accuracy and consistency of codes across the dataset.

3.5.1 First Cycle of Coding

The first cycle of coding was conducted on the same day focus groups were completed at each school. The images displaying students' arranged Post-It notes were uploaded to the University-managed laptop and each point was analysed to reveal the underlying factors, which were represented as codes. The codes and the responses from which they were derived were entered into an Excel spreadsheet so that they could be compared to other codes and responses to ensure consistency.

Using paper-based methods of data collection has many merits when conducting focus groups with multiple groups of students in a short amount of time, as it allows for efficient data collection. However, during the focus groups, there were many discussions between the students themselves and the researcher which yielded interesting, valuable information. The discussions were not recorded due to the time constraints additional transcription would have placed on data analysis.

However, 2 groups of Year 7 focus groups were recorded, as they were able to express themselves better through speech over writing. Although transcription was time-intensive, the recordings yielded much richer data than would have been possible using text alone. This method was employed in order to preserve and record the contextual information that would otherwise have been lost; as when combined with the written data provided with students, it provided a very clear insight into the true thoughts and feelings of the students on the response items. Notes were made about the reoccurring themes, which were revisited and revised as more focus groups were conducted.

3.5.2 Second Cycle of Coding

After the data from all of the focus groups had been transferred to the Excel spreadsheet, the second cycle of coding was conducted as all of the responses could now be analysed as one set in the same place. 22 separate factors emerged from the data, which on further inspection could be classified into six main themes: Curriculum Issues, Chemistry/Science Theory Issues, Practical Issues, Student Self-Efficacy, Classroom Dynamics and Lesson Structure Issues. The corresponding factors can be reviewed in Table 3-1, and Figure 3-2 displays the relationship between the factors and the themes.

3.5.3 Explanation of Codes

The factors elicited from the data consisted of specific constructs that students had brought up in their responses, which were represented by a short code consisting of just a few letters for ease of analysis. A total of 22 codes were grouped under 6 broad themes (Table 3-1).

Table 3-1 Second coding cycle - Factors and corresponding themes. Each theme has a distinct colour, which can be used to identify the base theme of each factor.

Curriculum issues	**Chemistry/ Science theory issues**	**Practical issues**	**Student self-efficacy**	**Classroom dynamics**	**Lesson structure issues**
RT More relevant topics	CO Cognitive overload	BP Better practical work	AS Assessment pressure	OS Problems with other students	CI Clear introduction to chemistry topics
LC Coherent structure of syllabus	MI Maths problems	MP More practical work	SS Self-efficacy	TD Teacher Discipline	DS Different lesson structure
ML More links to other subjects	TI Triplet issues	SP Shift from practical work compared to previous years		HE Teacher not fostering environment for questions and participation	CE Clear explanation of concepts
CR Career relevancy - more links to other subjects	CT Problematic chemistry terminology			GTS General teacher specific issues	LD Lesson delivery
	ST Problematic science terminology				

These codes were applied to responses in which students indicated that the following issues were a problem for them:

Curriculum issues

- *RT – More relevant topics:* A need for more relevant topics, as they did not believe that the ones they studied in their science/chemistry lessons had any relevance to their lives.
- *LC – Coherent structure of syllabus:* A preference for the topics on the syllabus to be taught in a 'coherent' structure. This was mentioned by students that felt that they would benefit from the curriculum being organised in a way that took advantage of the links between topics of the difference science disciplines. For example, a KS3 student noted that in one science lesson, they had studied a physics topic and the in following lesson they studied a biology topic that appeared to have no link to the lesson before.
- *ML – More links to other subjects:* Science/chemistry lessons would be improved if the topics and lessons could have more tangible links between other subjects, including non-science subjects.
- *CR – Career relevancy:* The lack of enjoyment and engagement with their science/chemistry lessons was due to the student determining that the subjects, along with the accompanying topics were not relevant to their future career plans.

Chemistry/Science theory issues

- *CO – Cognitive overload:* The amounts of information that they were expected to take in every lesson was problematic.
- *MI – Maths issues:* The maths or numerical problems were a major issue during science/chemistry lessons.
- *TI – Triplet issues:* Difficulty switching between the macroscopic, symbolic and the sub-microscopic concepts in chemistry and science. This was discovered through some students writing about how much they valued practical work because they helped them to visualise the links between what they 'learnt about in the lesson' and how it actually worked in practise.
- *CT – Problematic chemistry terminology:* Chemistry terminology as a concept that hindered the experience of the students' chemistry lessons.
- *ST – Problematic science terminology:* Science terminology as a concept that hindered the experience of the students' science lessons.

Practical issues

- *BP – Better practical work:* The desire to receive practical sessions of a higher quality.
- *MP – More practical work:* Science/chemistry lessons would be improved if the frequency of practical sessions increased.

- *SP – Shift from practical work compared to previous years:* The belief that students were doing less practical work as they progressed through school, leading to a decrease in engagement with their science/chemistry lessons because of decrease in elements they enjoyed.

Student Self-Efficacy

- *AS – Assessment pressure:* The hindrance of the lesson experience by the excessive pressure of exams. Some students stated that assessment pressure led to the removal of 'fun' from topics, and made them dread the lessons.
- *SS – Self-efficacy:* The prevention of students fully engaging and enjoying their science/chemistry lessons because of their lack of self-belief in their abilities. Some students went as far to write that if they 'tried harder' and 'paid more attention' in their lessons, they would probably get more out of them.

Classroom dynamics

- *OS – Problems with other students:* The disruption of learning by other students present in their science/chemistry lessons.
- *TD – Teacher discipline:* When the teacher's method of disciplining the class negatively affected the learning of the student. This code covered responses such as a student not feeling that their teacher trusted their set enough to partake in the 'fun' experiments, and another student not feeling like they had enough time go through all the material because the teacher had to spend too much time on discipline.
- *HE – Teacher not fostering a welcoming environment for questions and participation:* The lack of a welcoming environment for questions and participation. This code was used when students specifically mentioned that they felt uncomfortable or 'too scared to participate' fully in the lesson, due to the perceived 'strictness' of their teacher.
- *GTS – General teacher-specific issues:* A discord with the teaching style of the teacher and other teacher-specific issues. During the grouped interviews, students who focused on their teachers as being a problem were asked to clarify what exactly they felt were the problems with their teaching, which gave rise to factors such as CI, DS and CE.

Lesson structure issues

- *CI – Clear introductions:* The prevention of student engagement with their lessons due to the absence of a clear introduction to the topics being covered. Some students reported that they did not feel they understood what was going on in their lessons, and linked having better explanations with gaining greater understanding.

- *DS – Different lesson structure:* The structure of lesson delivery could be improved, which was used when students mentioned 'less lecture style teaching', 'splitting stuff up more' and 'less copying off the board' as possible areas of improvement.
- *CE – Clear explanation of topics:* Clearer explanations of topics could make a positive impact on their science/chemistry lessons. Responses which were coded with CE often used words such as 'difficult' in response to why they felt that more explanation would be helpful. The factor also throws up interesting experiences, as one student mentioned that their teacher spent more time explaining the topics that they were fond of. Some students also mentioned that they felt that more links across different subjects would help to explain concepts.
- *LS – Lesson delivery:* Science/chemistry lessons could be improved by an increase in the level of general student involvement in the lessons. Some students reported that they did not feel that they had 'a chance to get involved in the lesson', which is when this code was used.

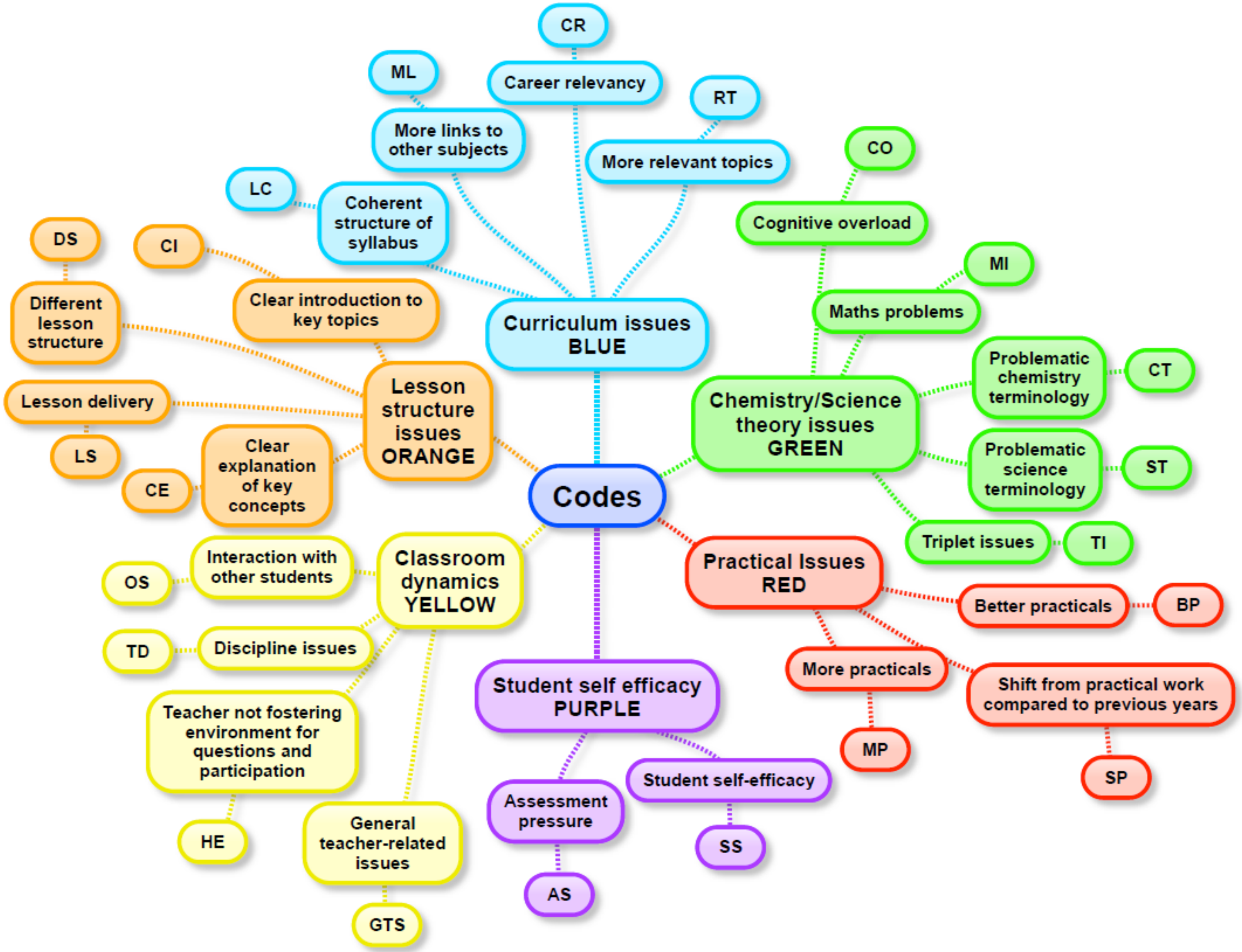


Figure 3-2 Map showing the 22 factors, their representative codes and the 6 overarching themes.

3.5.4 Third Cycle of Coding and Analysis of Coding Correlations

The codes that emerged from the analysis of the preliminary data covered the very broad range of issued faced by a cross-section of students across secondary education. The factors were initially grouped together by their common themes. As students' responses could be coded with multiple codes, an analysis of how the factors correlated with each other could be conducted using Nvivo, a qualitative data analysis software package (Ltd. 2012). During this analysis, attention was paid to the order in which students had ranked their responses. The first factor and the second factor (the factor the students' deemed to be most important and second most important respectively) were chosen for further analysis to ensure that the students' main areas of concern were properly explored.

The Excel spreadsheet was imported into Nvivo and the data were re-coded for the third and final time before export into statistical analysis program SPSS (Corp. 2013). Applying the program's Cross-tabulation function made it possible to see how often factor had been coded to a response individually, and how often it had been coded with other factors. As the factors had already been coded into six distinct themes, the analysis of the coding patterns was expected to provide a method of testing the validity and distinction of the themes as well as the factors.

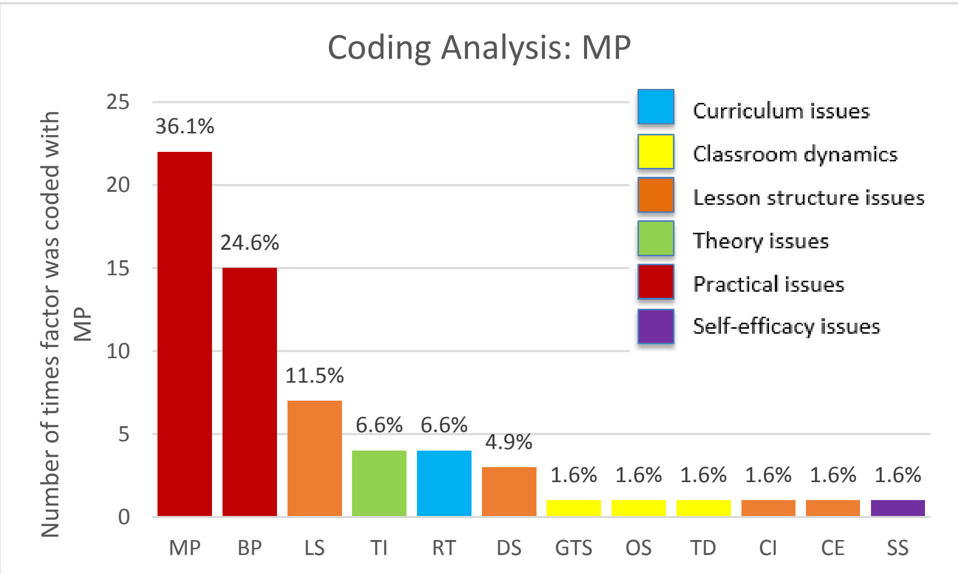


Figure 3-3 Chart displaying the correlation information for the MP – More Practical Work code. MP was coded independently of other factors 36.1% of its total usage, which suggests that it is an important standalone factor. MP was also coded with BP – Better Practical Work 24.2% of the time, which suggests that they are highly related constructs. Refer to Figure 3-2 for full code names and descriptions.

The relationships between all 22 factors were explored and analysed. Factors that correlated highly with others were expected to have a stronger relationship due to the codes representing the same construct, or that the factors were dependent on each other. Figure 3-3 shows the correlation graph for the MP – More Practical Work code for reference, and highlights the fact that MP code was coded individually to responses in 36.1% of incidences, and coded in conjunction with the BP – Better practicals code 24.6% of incidence. To determine between highly-correlated factors that measured the same construct and those that were based on the same theme but were distinctly different, the student responses for each disputed code were re-analysed for confirmation.

This led to two outcomes:

1. The simplification of the codes, by the integration and subsequent removal of factors/codes that were adequately represented by an existing code
2. The renaming of the main themes, based on the refinement of the underlying constructs.

The main aim of the preliminary research was to create a pool of potential question items developed by students to modify the ATCLS with. Therefore, the reduction in the number of separate factors that needed to be represented in the final survey was beneficial for keeping the time for administration relatively low. It also ensured that all year groups would be able to choose from the sample factors, which would allow for comparisons in attitudes and factors to be made across the year groups.

3.5.5 Refined codes

After the analysis of the themes and the codes, the initial mind map was re-created to represent the refined coding system in order to simplify the process of turning the factors into fully representative question items (see Figure 3-4). The process revealed that the majority of codes within a theme were either a problem, or a solution to another problem within the same theme. For example, the code CR corresponded to students reporting that they did not see their science/chemistry lessons as being relevant for their future careers. However this could be addressed by increasing the relevancy of the topics studied (RT code) which could be achieved by capitalising on the existing links between the different science disciplines and other subjects (ML code). This left 12 factors which were successfully turned into 12 question items for the multiple choice portion of the Modified Attitudes towards Chemistry and Science Lessons Survey:

1 DS/LS: I would prefer my science/chemistry lessons to be delivered in a more interactive way, because sometimes I don’t feel involved.

2 CI: I would prefer my science/chemistry lessons if there were clearer introductions, so I can recognise topics as chemistry.

3 CE: I would like clearer explanations of the topics in science/chemistry because I find them quite difficult.

4 OS: I would prefer to work with classmates more often in my science/chemistry lessons, because discussing topics helps me to learn.

5 TD: I would prefer my science/chemistry lessons if they were not disrupted by other students.

6 HE: I would like to feel more comfortable asking my teacher questions during my science/chemistry lessons.

7 RT/ML/CR: I would like to understand why the topics we learn in science/chemistry are important to my life.

8 MP: I would like to do more practical experiments because they help me to understand what I am learning.

9 BP: I would like to do practical work that relevant, up-to-date, and help to explain the topics we learn in science/chemistry.

10 MI: I would prefer my science/chemistry lessons if I was better at maths because I find it difficult.

11 CT: I find the scientific words we have to learn in chemistry very difficult.

12 ST: I find the scientific words we have to learn very difficult.

A random number generator was used to ensure that the question items appeared in no particular order in the online survey to minimise the influence the item order had on the participants.

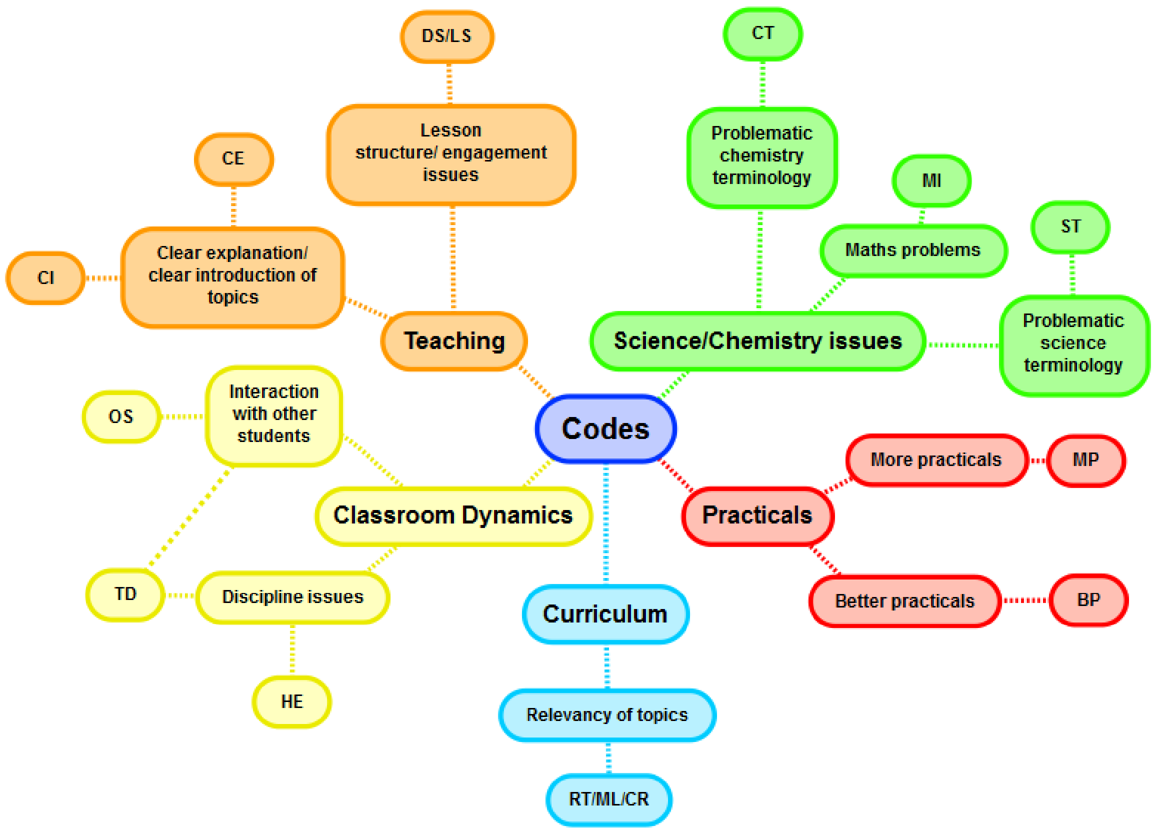


Figure 3-4 Refined coding system. Refer to Figure 3-2 for full code names and descriptions.

3.6 Integration of items into ATCLS and creation of Attitudes towards Chemistry and Science Lessons Survey (ATCSLS)

The aim of creating a bank of question items based on student opinions that would probe students into identifying the reasons behind their attitudes was achieved. The data confirmed that students in the three year groups (Years 7, 9, and 11) have a varied understanding, if any at all, about what constitutes chemistry lessons. For this reason, it was decided that the survey would investigate different attitudes depending on the year group of the student.

- Year 7 students would be queried on their attitudes towards science lessons only. This meant that that they would have a choice of statements 1 to 11 with the word 'chemistry' removed in the second half of the survey.
- Year 9 students would be queried on their attitudes towards science lessons and chemistry lessons, meaning that they would effectively take two surveys. The first survey would be the same survey taken by Year 7 students featuring multiple choice statements 1-11. The second survey would measure attitudes towards chemistry lessons, and present

multiple choice items based on statements 1-10 with the word ‘science’ removed and question 12.

- Year 11 students would be queried on their attitudes towards chemistry lessons only, meaning that they would only have a choice of the chemistry-based multiple choice items.

A random number generator was used in order to assign the numerical order in which the multiple choice statements appeared in the surveys. This was especially important for Year 9 students who had to take a survey with two similar halves, as ensuring the items appeared in different positions minimised the risk of them attempting to select the same items without reading the options.

3.7 Deployment of Final Attitudes towards Chemistry and Science Lessons (ATCSLS) Survey

The final survey was developed for online administration as it was deemed to be the most efficient method of receiving responses, due to the target respondents’ frequent use of the internet on multiple devices.

Before students could take the survey, they were presented with a screen that displayed the name of the survey they were taking along with a statement that thanked the volunteers for their participation, reminded them to read the question carefully, and that their answers were anonymous. Students were also required to tick a checkbox which confirmed their consent to taking part in the research before they could proceed.

The questions of the Attitudes towards Chemistry and Science Lessons survey (ATCSLS) were split into five distinct sections, with the first section containing demographic questions as demonstrated by Figure 3-5. The second section for students in Years 7 and 9 contained the Attitudes towards Science Lessons Likert scale (ATSLS) and the modified Attitudes towards Chemistry Lessons scale (ATCLS) for students in Years 10 and 11.

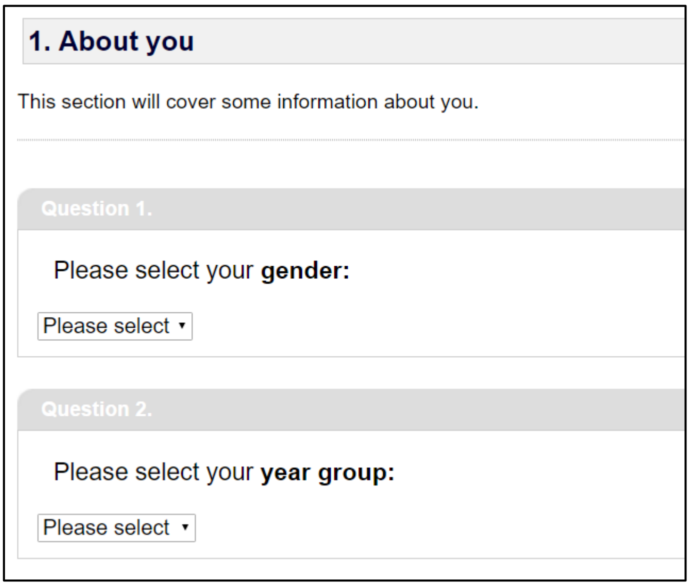


Figure 3-5 Questions 1.1 and 1.2 - Demographic questions of the online survey, as seen by all student participants.

The first two questions appeared as displayed in Figure 3-5 and asked the students to identify their gender and year group, the second of which led them to the corresponding survey.

Year 7 and 9 students were directed to the scale that measured their attitudes towards their science lessons, as shown in Figure 3-6, followed by a multiple choice question that required them to pick the 4 statements that would have the greatest positive effect on their science lessons out of a choice of 11.

A 5-point Likert scale was chosen instead of the original 7-point scale found in the ATCLS because research has shown that the more response options an item has, the greater the effect of central tendency bias (Bardo, Yeager et al. 1982). Research result has also suggested that the more options a scale has, the less reliable the resulting data is (Revilla, Saris et al. 2014). See Chapter 2.3 for more information.

Your attitude towards Science Lessons

Please answer the following questions about your *Science lessons*:

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
I like trying to solve new problems in science.	○	○	○	○	○
If I had a chance, I would do a project in science.	○	○	○	○	○
I find science lessons interesting.	○	○	○	○	○
Science is one of the most important subjects for people to study.	○	○	○	○	○
Science is useful for solving everyday problems.	○	○	○	○	○
I like to do science experiments.	○	○	○	○	○
I like science more than any other subject at school.	○	○	○	○	○
I am willing to spend more time reading science books.	○	○	○	○	○
Science is one of my favourite subjects.	○	○	○	○	○
When I do practical work, I feel I am doing something important.	○	○	○	○	○
People must understand science because it affects their lives.	○	○	○	○	○
Doing science experiments in school is fun.	○	○	○	○	○

Figure 3-6 Question 2a - Likert question items from the Attitudes towards Science section of the ATCSLS online survey, as seen by participants in Years 7 and 9.

Please read the following 11 statements (A - K). Pick the **four** that you think would improve your **science lessons**/you agree with the most.

A I would like to do practicals that are relevant, up-to-date, and help to explain the topics we learn in science.
B I would prefer to work with classmates more often in my science lessons, because talking about topics helps me to learn.
C I would prefer my science lessons if I was better at maths because I find it difficult.
D I would prefer my science lessons to be more interactive, because sometimes I don't feel involved.
E I would prefer my science lessons if there were clearer introductions, so I can recognise similar topics.
F I would like clearer explanations of the science topics we learn because I find them quite difficult.
G I would like to feel more comfortable asking my teacher questions during my science lessons.
H I would like to understand why the topics we learn in science are important to my life.
I I find the scientific words we have to learn very difficult.
J I would like to do more practical experiments because they help me to understand what I am learning.
K I would prefer my science lessons if they were not disrupted by other students.

Which statement do you think is most important?	Please select ▾
Which is your second most important statement?	Please select ▾
Which is your third most important statement?	Please select ▾
Which is your fourth most important statement?	Please select ▾

Figure 3-7 Question 3a of the online Attitudes towards Science survey, as seen by participants in Years 7 and 9.

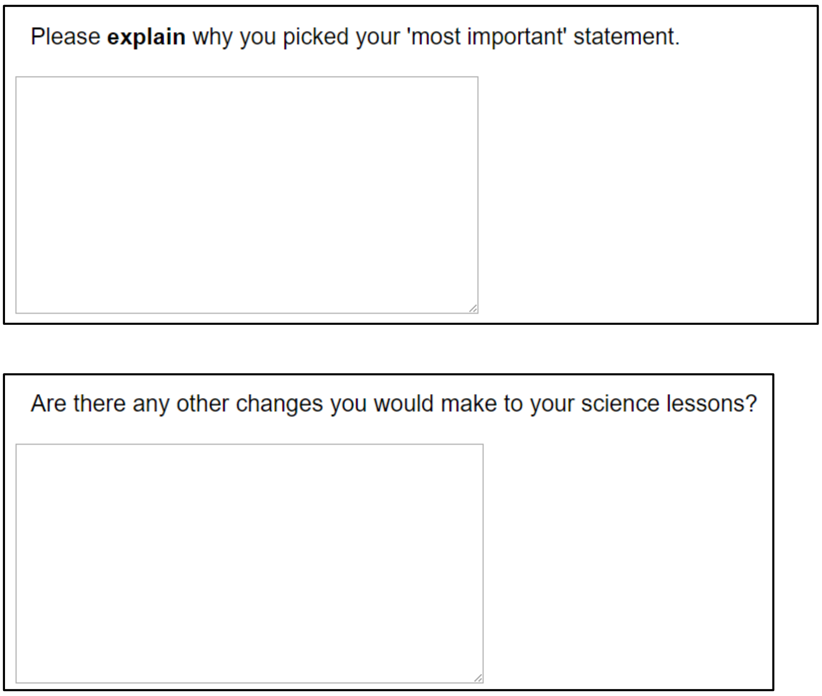


Figure 3-8 Questions 4a and 5a of the Attitudes towards Science survey, as seen by participants in Years 7 and 9.

This marked the end of the survey for Year 7 students. Year 9 students then completed the second half of the survey based on attitudes towards chemistry lessons, which is the only part of the survey that was completed by students in Years 10 and 11:

Your attitude towards Chemistry-based Science lessons

Chemistry is one of the three core sciences (chemistry, biology and physics) that you learn in your science lessons.
The following questions are about your attitude towards the science lessons in which you learn about **chemistry**.

Here are some of the chemistry topics on the KS4 syllabus, just to remind you what chemistry is about:

Atomic structure and the Periodic Table

Structure, bonding and the properties of matter

Energy changes (e.g. bond breaking, bond making)

Chemical and allied industries (e.g. carbon compounds, fractional distillation)

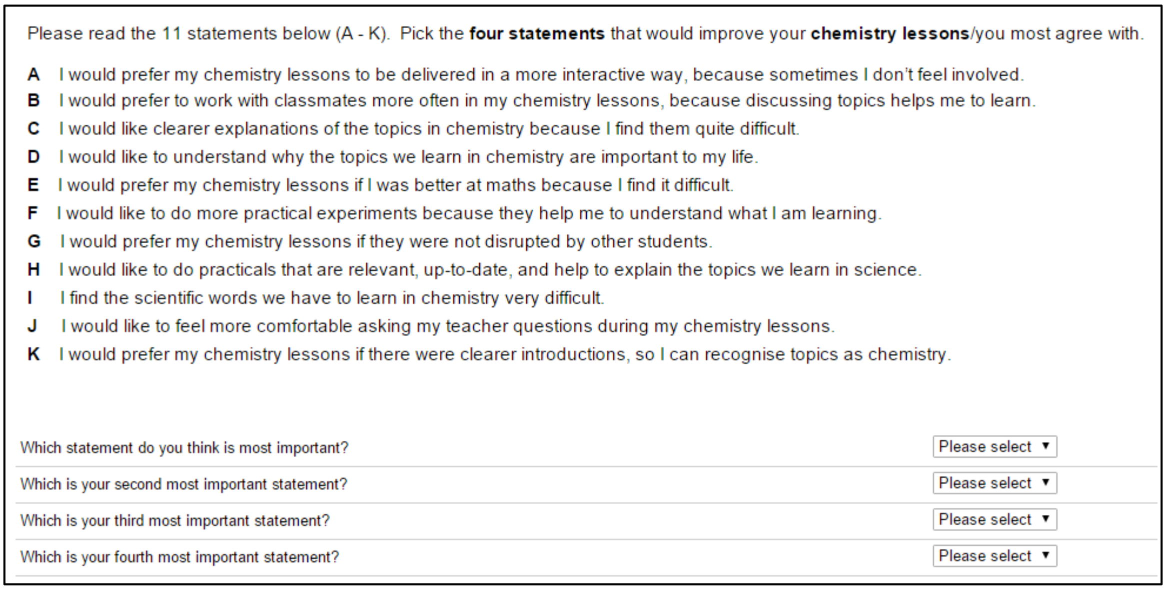
Earth and atmospheric science

Chemical analysis (e.g. distinguishing between pure and impure substances)

Please answer the following questions about the science lessons in which you learn about chemistry:

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
I like to do chemistry experiments.	○	○	○	○	○
I like chemistry more than any other subject at school.	○	○	○	○	○
I find chemistry lessons interesting.	○	○	○	○	○
Doing chemistry experiments in school is fun.	○	○	○	○	○
If I had a chance, I would do a project in chemistry.	○	○	○	○	○
Chemistry is one of the most important subjects for people to study.	○	○	○	○	○
Chemistry is one of my favourite subjects.	○	○	○	○	○
Chemistry is useful for solving everyday problems.	○	○	○	○	○
People must understand chemistry because it affects their lives.	○	○	○	○	○
When I do practical work, I feel I am doing something important.	○	○	○	○	○
I am willing to spend more time reading chemistry books.	○	○	○	○	○
I like trying to solve new problems in chemistry.	○	○	○	○	○

Figure 3-9 Question 2b - Likert question items from the Attitudes towards Chemistry section of the ATCSLS online survey, as seen by participants in Years 9, 10 and 11.

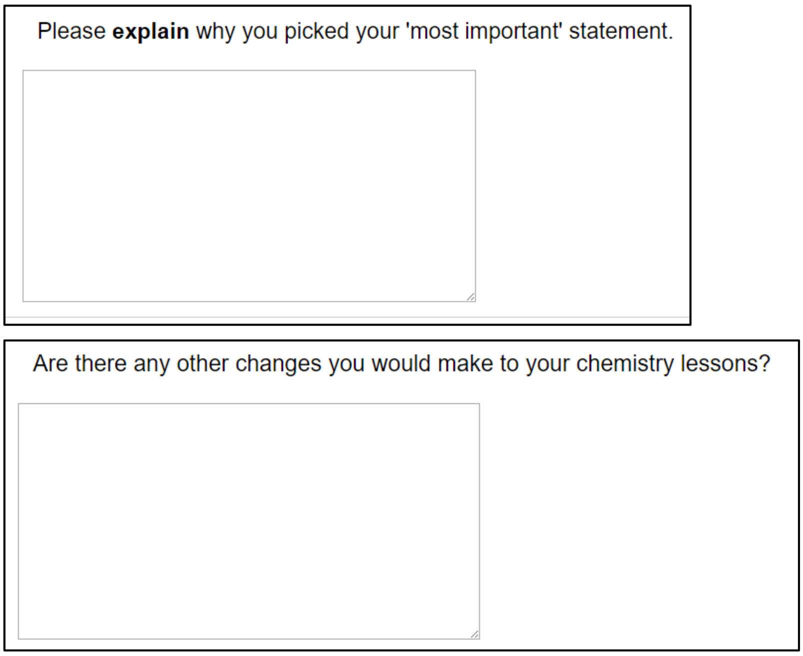


Please read the 11 statements below (A - K). Pick the **four statements** that would improve your **chemistry lessons**/you most agree with.

A I would prefer my chemistry lessons to be delivered in a more interactive way, because sometimes I don't feel involved.
B I would prefer to work with classmates more often in my chemistry lessons, because discussing topics helps me to learn.
C I would like clearer explanations of the topics in chemistry because I find them quite difficult.
D I would like to understand why the topics we learn in chemistry are important to my life.
E I would prefer my chemistry lessons if I was better at maths because I find it difficult.
F I would like to do more practical experiments because they help me to understand what I am learning.
G I would prefer my chemistry lessons if they were not disrupted by other students.
H I would like to do practicals that are relevant, up-to-date, and help to explain the topics we learn in science.
I I find the scientific words we have to learn in chemistry very difficult.
J I would like to feel more comfortable asking my teacher questions during my chemistry lessons.
K I would prefer my chemistry lessons if there were clearer introductions, so I can recognise topics as chemistry.

Which statement do you think is most important?	Please select ▼
Which is your second most important statement?	Please select ▼
Which is your third most important statement?	Please select ▼
Which is your fourth most important statement?	Please select ▼

Figure 3-10 Question 3b of the online Attitudes towards Chemistry survey, as seen by participants in Years 9, 10 and 11.



Please **explain** why you picked your 'most important' statement.

Are there any other changes you would make to your chemistry lessons?

Figure 3-11 Questions 4b and 5b of the Attitudes towards Chemistry survey, as seen by participants in Years 9, 10 and 11.

Chapter 4: Results Chapter 1 – Demographics of Respondents and Verification of ATCSLS

The Attitudes towards Chemistry and Science Lessons Survey (ATCSLS) was distributed to students in Years 7, 9, 10 and 11 by teachers who had agreed to take part in the research, and yielded 1654 responses from students in 18 different schools. As described in Chapter 3 the survey featured four main questions, with Question 2 consisting of a Likert attitudinal scale designed to assess students' attitudes towards science or chemistry lessons. Question 3 was a multiple choice question that was designed to persuade students to pick the four statements that would improve their science/chemistry lessons.

Respondents that did not fully complete Question 2 were removed from the dataset since missing data would have invalidated the statistical analyses of Likert scale data. This resulted in 1612 valid responses from the qualitative attitudinal scale section of the survey, and 1654 responses from the qualitative section of the survey.

Researchers have made various recommendations on the minimum sample size required for the statistical analyses employed in this research project such as confirmatory factor analysis (MacCallum, Widaman et al. 2001). For confirmatory factor analysis (CFA), the two main categories of recommendations give importance to either the absolute number of cases (N), or the subject-to-variable ratio, which is defined as the ratio of N to the number of variables in a model (ρ). The absolute number of cases refers to the total amount of distinct cases in the data, which in this case would refer to the total number of survey respondents. Researchers that support the notion that (N) is the most important factor have suggested that the acceptable minimum number of cases ranges from 100 through to 500 cases (MacCallum, Widaman et al. 2001). The total number of respondents to the quantitative section of the survey numbered 1612, which meant that minimum data requirements for CFA were exceeded.

4.1 Demographic information of respondents

4.1.1 What types of schools did the respondents attend?

As seen in Table 4-1a and 1-1b, students attending state schools accounted for between 84.2 – 84.8% of the total number of responses, whilst students from independent schools accounted for between 15.2 – 15.8% depending on the survey question that was used as the determining factor.

Table 4-1a (left) and 4-1b (right) - Tables showing the frequency of student respondents that completed the attitude scale questions of the ATCSLS (Question 2, left), and those that completed the qualitative questions of the ATCSLS (Question 3, right) from different types of schools.

Respondents to Question 2		
School Type	Frequency	Percent
Academy	894	55.5
Academy Grammar	341	21.2
Community	79	4.9
Comprehensive	44	2.7
Independent	254	15.8
Total	1612	100.0

Respondents to Question 3		
School Type	Frequency	Percent
Academy	937	56.7
Academy Grammar	341	20.6
Community	79	4.8
Comprehensive	45	2.7
Independent	252	15.2
Total	1654	100.0

These data were gathered to create an image of the demographics of the schools that were partaking in the research, with the aim of ensuring that the widest possible range of students in England were represented. It has been reported that in England, over 7% of students below age 16 are educated in independent schools (Council 2016) which demonstrates that students from that particular demographic were overrepresented in the ATCSLS. However, this did not affect the results negatively, as all responses were compared as percentages during data analysis. For the rest of the demographic analysis, the dataset in which students responded to Question 3 will be used so that the greatest number of participants are represented.

4.1.2 Gender and year groups

It was not possible to control the demographics of the survey participants as the administration was under the control of the teachers who had volunteered to participate in the research. Table 4-2 shows that there were significantly more responses from students in Years 7 and 9 compared to those in Years 10 and 11. As explained in Chapter 3, the inclusion of Year 10 participants was warranted to compensate for the anticipated difficulty of recruiting Year 11 students due to exam commitments. However, this still resulted in Year 10 and 11 responses making up only 22.9% of total responses, compared with 36.6% from Year 7s and 40.5% from Year 9s, which may have been due to science teachers feeling that they could not spare any time from the lessons of older students for this research. An even spread of male and female students was not present across the year groups; however, this did not present any problems as responses were converted to a percentage of the total number of responses for each demographic group. The volume of data gathered using the survey instrument meant that the relationships between factors such as gender, year group and attitude could be investigated statistically, as well as drawing upon the large amount of qualitative data generated by the student respondents.

Table 4-2 - Table showing the demographics of student responses to the qualitative section of the ATCSLS, Question 3.

		School Type					
Year group	Gender	Academy	Academy Grammar	Community	Comprehensive	Independent	Total
Year 7	Female	283	67	22	10	11	393
	Male	122	41	14	8	27	212
Total							605
Year 9	Female	217	110	7	8	39	381
	Male	117	60	13	7	92	289
Total							670
Year 10/11	Female	146	40	7	2	12	207
	Male	52	23	16	10	71	172
Total							379

4.1.3 Teacher administration of survey

Although participating teachers were not required to report their methods of administering the ATCSLS, some of the most popular methods were revealed through general email correspondence. The majority of the teachers involved in the project taught science which corresponded with the fact that they had previously expressed an interest in chemistry and science educational research. The methods employed involved:

- Setting the short survey as homework for students.
- Allowing students to complete the survey during form time by having registration in a computer room.
- Setting aside time during science lessons for students to complete the survey,
- Booking a computer room for a portion of their science lessons to allow students to complete the survey.

The survey was also accessible on mobile devices which allowed students to complete the survey in any environment.

4.2 Methods of analysis of Likert scale data

The large number of responses gathered by the ATCSLS resulted in a rich set of data which yielded many unique findings during analysis. In order to fully investigate and analyse the complex mix of quantitative and qualitative data, the analysis of quantitative and qualitative data were combined.

As a portion of the ATCSLS instrument included a qualitative Likert scale designed to produce data on four specific constructs or subscales of attitudes (liking for chemistry/science theory lessons, liking for chemistry/science practical work, behavioural tendencies to learn chemistry/science and evaluative beliefs about school chemistry/science), the construct validity of the data produced required statistical assessment in order to ensure the data represented the aforementioned constructs. This was achieved by using confirmatory factor analysis and will be discussed in detail in the Construct Validity of Data subchapter (page 59).

The five-point Likert scale featured in Question 1 of the online survey produced quantitative data. The 12 question items formed an attitudinal scale that measured student’s attitudes towards either chemistry or science lessons (depending on the year group of the respondent), with each attitude construct represented by three question items. The Likert scale responses were coded numerically as recommended by Likert (1932), see Table 4-3. It is important to note that the accepted definition of a Likert scale is that it is one composed of a series of four or more Likert-type items that are combined into a single composite score/variable during data analysis, where a Likert-type question item is simply a question that employs Likert scale responses (Boone 2012).

However, each of the attitudinal constructs under investigation in this project were represented by three questions instead of four in the ATCSLS. This is because the questions of the ATCSLS were based on the ATCLS (Cheung 2009), which featured three questions per subscale in its final iteration. This was deemed to be acceptable as the trial version of the ATCLS featured four questions per subscale which were tested on a sample of 777 Secondary 4-7 students (aged 16 to 19 years). Cheung tested the reliabilities of the student responses to the individual question items and the four subscales using item-total correlations. (More information on item-total correlations can be found in Chapter 2). The three question items with the highest item-total correlations were retained in the final version of the ATCLS to make the scale as short as possible, and to fulfil a basic principle in confirmatory factor analysis which is that at least three indicators are needed to define a factor adequately (Bollen 1989). The item-total correlations of the final question items were described by Cheung as being "moderately positive, giving support from the reliability of student data" (Cheung 2009).

Table 4-3 - Likert Scale responses and corresponding codes for quantitative analysis

Likert Scale response	Code
Strongly Agree	5
Agree	4
Neither Agree nor Disagree	3
Disagree	2
Strongly Disagree	1

There is much debate surrounding the different methods of analysing data produced by Likert scales, which often stems from a misunderstanding of the difference between the data produced by Likert-type questions and data produced by Likert scales (Allen and Seaman 2007, Boone 2012). As a Likert-type question must be accompanied by corresponding response options, some people refer to individual Likert-type items as being a 'scale'. A series of unrelated Likert-type items can also be presented together, and is often erroneously referred to as a "Likert scale". The term Likert scale should only be used when items can be combined to provide a "quantitative measure of a character, personality trait… or attitude" (Boone 2012).

In order to fully understand the debates researchers have engaged in over the correct method of analysis of any type of Likert data, it is important to understand which of the four levels of measurement of data, also known as the Steven's Scale of Measurement (Ary, Jacobs et al. 2013) Likert data represents. By assigning levels of measurement to data, the nature of the information within the numbers assigned to variables is revealed. The Steven's scale proposes that four categories of data exist, known as nominal, ordinal, interval and ratio. Nominal and ordinal data are considered as qualitative, and interval and ratio are considered as quantitative data. Likert data is measured as qualitative data, and can be treated as ordinal or interval depending on how the question items are used.

Nominal scales are considered to be the weakest level of measurement, as they are used for labelling variables without assigning any quantitative value to them. Examples of nominal data include race, eye colour and marital status.

Ordinal data is ranked by order of magnitude, but numbers assigned to ordinal data only represent a 'greater than' relationship as no information is given about how much greater one observation or response option is over the other. Therefore, a number in an ordinal scale only represents the order of the response. Examples of ordinal scale measures include letter grades, rankings and non-numeric concepts such as satisfaction or happiness.

Interval data improves on the information provided by ordinal data in that it possesses information about the exact differences between different numeric values. Examples of an interval scale are the measure of temperature in Celsius, IQ standardised tests and the time of day measured on a 12-hour clock, because difference between each value is the same. However, interval scales do not have an absolute zero; a point at which none of the measured quality exists. This means that certain analyses cannot be performed as ratios cannot be calculated using interval data.

Ratio data possesses all of the characteristics of interval data as well as having a clear definition of the start of the scale, which is 0.0. An example of ratio data is temperature in Kelvin.

Table 4-4 Suggested data analysis procedures for Likert-Type and Likert Scale data, adapted from (Boone, 2012)

	Likert-Type data	Likert Scale data
Central tendency	Median or mode	Mean
Variability	Frequencies	Standard deviation
Other statistics	Chi-square	ANOVA, t-test, regression

As Likert scale data is designed to infer meaning from the combination of multiple question items, researchers have concluded that it can be treated as interval data, with the mean being the best measure of central tendency. Suitable statistical approaches for both Likert-type data and Likert scale data can be found in Table 4-4.

4.3 Comparison of the Construct Validity of Scales and Data

Due to changes in the wording of certain question items for the sake of improved clarity, (see subchapter 2.4.1, page 23), the validity tests conducted by Cheung were no longer valid for the data collected by the modified survey. The two separate scales (Attitudes towards Science Lessons and Attitudes towards Chemistry Lessons) were assessed using confirmatory factor analysis in order to validate whether the scale measured the underlying latent constructs that it was designed to, as recommended by Tapia (2004). Models of the relationships between the question items and latent constructs were built in Amos before the confirmatory factor analyses were run.

The ability of the hypothesised four-construct model to fit the student data was judged by the same values of overall model fit indices as the original ATCLS (Cheung 2009):

- The goodness of fit index (GFI) is a measure of fit between the hypothesized model and the observed covariance matrix. Values close to 1 indicate that a model has perfect fit (Baumgartner and Homburg 1996).
- The adjusted goodness of fit index (AGFI) corrects the GFI, which is affected by the number of indicators of each latent variable. Values close to 1 indicate that a model has perfect fit (Baumgartner and Homburg 1996).
- The normed fit index (NFI) analyses the discrepancy between the chi-squared value of the hypothesized model and the chi-squared value of the null model. Values close to 1 indicate that a model has perfect fit (Bentler and Bonett 1980).
- The comparative fit index (CFI) analyses the model fit by examining the discrepancy between the data and the hypothesized model, while adjusting for the issues of sample size inherent in the chi-squared test of model fit, and the normed fit index. A CFI value of 0.90 or larger is generally considered to indicate acceptable model fit (Hu and Bentler 1999).
- The root mean square error of approximation (RMSEA) is useful as it avoids issues of sample size by analysing the discrepancy between the hypothesized model, with optimally chosen parameter estimates (Hooper, Coughlan et al. 2008). Values of 0.06 or less have been suggested to be an indication of a model possessing good fit in relation to

the degrees of freedom, with a score of 0.0 indicating perfect fit. However, a score of 0.0 has been described as “unrealistic” (Hu and Bentler 1999).

Chi-square based statistics are often used as a measure of model fit, but they have been reported to be sensitive to large sample sizes which is why Cheung did not employ them during the analysis of his data (Smith, Schumacker et al. 1998, Cheung 2009).

The original ATCLS possesses good model fit by the standards of GFI, AGFI, NFI and CFI, however the value of 0.073 for RMSEA is higher than desired (see Table 4-5). The calculated fit indices for the modified Attitude towards Chemistry Lessons (modified ATCLS) scale designed and tested in this research project indicate that the modified model fitted the data less well than the original scale and its resulting data.

Upon closer inspection, it was revealed that the differences between the two year groups (Year 9 and 10/11) that the modified ATCLS scale tried to account for and measure was the cause of the relatively poor calculated fit indices. Chemistry students in Year 9 and Year 10/11 displayed large measurable differences in attitudes towards three of the four subscales, which may have caused the model to exhibit poor fit. However, this simply indicates that the attitudes of students in Year 9 and Year 10/11 are too different to accurately measure using one scale, and is not a comment on the results of the data. This contrasts with the fit indices of the Attitudes towards Science Lessons scale, which suggested that the model for measuring students’ attitudes towards science lessons had a better fit than the original ATCLS. This can be rationalised by examining the attitudes of science students across Year 7 and Year 9, which shows that there is less variation in attitudes towards the subscales between students in different year groups compared to chemistry students (see Figure 5-1). This also suggests that the 777 Chinese Secondary 4-7 chemistry students that completed the original ATCLS survey held more congruent attitudes towards chemistry lessons compared with the British students that completed the modified ATCLS.

It is also important to note that the original ATCLS featured Likert scales with 7 possible response options, whereas the ATCSLS featured 5 response options, which renders a direct comparison between the original ATCLS and the modified ATCLS scale as impractical. This decision was influenced by research linking an increase in possible response options with an increase in central tendency bias, which occurs when respondents avoid using extreme response categories, such as strongly agree or strongly disagree (Bardo, Yeager et al. 1982).

Table 4-5 Table displaying the fit indices for the Modified Attitudes towards Chemistry Lessons scale, Cheung's Attitudes towards Chemistry Lessons scale and the Attitudes towards Science Lessons scale. n = number of respondents.

Scale	Goodness of fit index (GFI)	Adjusted goodness of fit index (AGFI)	Normed fit index (NFI)	Comparative fit index (CFI)	Root mean square error of approximation (RMSEA)
Attitudes towards Chemistry Lessons Scale – Cheung (n = 954)	0.95	0.92	0.95	0.96	0.073
Modified Attitude towards Chemistry Lessons Scale (n = 1020)	0.83	0.72	0.82	0.82	0.151
Attitudes towards Science Lessons Scale (n = 1232)	0.96	0.94	0.96	0.97	0.066

Table 4-6, Table 4-7 and Table 4-8 display the correlations between the scores of the four different subscales for the original ATCLS, the modified ATCLS and the ATSLS scales respectively. Cheung noted that the correlations between the four subscales of the original ATCLS were 'positive and considerable, indicating that student responses to the four subscales were fairly consistent' (Cheung 2009).

Table 4-6 Correlations among the four attitudinal subscales for the original Attitudes towards Chemistry Lessons scale

Subscale	AC	BC	CC	DC
AC – Liking for chemistry theory lessons	1.00			
BC – Liking for chemistry lab work	0.56	1.00		
CC – Evaluative beliefs about school chemistry	0.57	0.59	1.00	
DC – Behavioural tendencies to learn chemistry	0.81	0.67	0.75	1.00

Table 4-7 Correlation among the four attitudinal subscales for the modified Attitudes towards Chemistry Lessons scale

Subscale	AC	BC	CC	DC
AC – Liking for chemistry theory lessons	1.00			
BC – Liking for chemistry practical work	0.16	1.00		
CC – Evaluative beliefs about school chemistry	0.56	0.69	1.00	
DC – Behavioural tendencies to learn chemistry	0.66	0.64	0.92	1.00

Table 4-8 Correlation among the four attitudinal subscales for the Attitude towards Science Lessons scale

Subscale	AS	BS	CS	DS
AS – Liking for science theory lessons	1.00			
BS – Liking for chemistry practical work	0.60	1.00		
CS – Evaluative beliefs about school science	0.71	0.48	1.00	
DS – Behavioural tendencies to learn science	0.89	0.67	0.77	1.00

The correlation between the scores of the AC and DC subscale was the highest for the original ATCLS and the ATSLS, which suggests that students who liked theory lessons tended to have a mental state of readiness to learn additional chemistry or science, and vice versa. The correlation between the scores of the CC and DC subscale was the highest for the modified ATCLS at 0.92, which indicates that chemistry students with a strong belief in the importance of chemistry to their lives are more likely to have a positive attitude towards learning more chemistry. The subscales with the lowest correlation within the modified ATCLS were AC and BC, which suggests that students that enjoy chemistry theory lessons are less likely to enjoy practical work (See Figure 5-6).

The standardised factor loadings for each of the question items illustrate the correlation between the item and the attitudinal subscales they are designed to measure. All factors loadings from the modified ATCLS and the ATSLS were acceptable, and are displayed in Table 4-9 and Table 4-10.

Table 4-9 Table displaying factor loadings for question items in the Modified Attitudes towards Chemistry Lessons Scale. n = number of respondents.

Modified Attitudes towards Chemistry Lessons Scale - Factor Loadings		
Subscale and item (n = 1020)		Standardised factor loadings of items under each subscale
Liking for chemistry theory lessons		
A1C	I like chemistry more than any other school subject.	0.79
A2C	I find chemistry lessons interesting.	0.56
A3C	Chemistry is one of my favourite subjects.	0.97
Liking for chemistry practical work		
B1C	I like to do chemistry experiments.	0.80
B2C	When I do practical work in chemistry lessons, I feel I am doing something important.	0.54
B3C	Doing chemistry experiments in school is fun.	0.78
Evaluative beliefs about school chemistry		
C1C	Chemistry is useful for solving everyday problems.	0.73
C2C	People must understand chemistry because it affects their lives.	0.78
C3C	Chemistry is one of the most important subjects for people to study.	0.69
Behavioural tendencies to learn chemistry		
D1C	I am willing to spend more time reading chemistry books.	0.64
D2C	I like trying to solve new problems in chemistry.	0.79
D3C	If I had a chance, I would do a project in chemistry.	0.72

Table 4-10 Table displaying factor loadings for question items in the Attitude towards Science Lessons Scale. n = number of respondents.

Attitudes towards Science Lessons Scale - Factor Loadings		
Subscale and item (n = 1232)		Standardised factor loadings of items under each subscale
Liking for science theory lessons		
A1S	I like science more than any other subject at schools.	0.82
A2S	I find science lessons interesting.	0.81
A3S	Science is one of my favourite subjects.	0.88
Liking for science practical work		
B1S	I like to do science experiments.	0.81
B2S	When I do practical work, I feel I am doing something important.	0.66
B3S	Doing science experiments in school is fun.	0.86
Evaluative beliefs about school science		
C1S	Science is useful for solving everyday problems.	0.72
C2S	People must understand science because it affects their lives.	0.68
C3S	Science is one of the most important subjects for people to study.	0.73
Behavioural tendencies to learn science		
D1S	I am willing to spend more time reading science books.	0.67
D2S	I like trying to solve new problems in science.	0.77
D3S	If I had a chance, I would do a project in science.	0.67

The results from the confirmatory factor analysis of the student data of the scales confirmed that the proposed attitudinal model consisting of four latent constructs (Liking for theory lessons, Liking for practical work, Evaluative beliefs and Behavioural tendencies to learn) fitted the data adequately.

Chapter 5: Results Chapter 2 – Attitudes towards Science Lessons Scale Results

The scale mean scores for each of the four attitudinal subscales measured by the modified Attitudes towards Science Lessons scale and the Attitudes towards Chemistry Lessons scale were calculated by averaging students' scores from the question items corresponding to the subscale. Full tables containing the scale means, standard deviations (SD) and relative standard deviations corresponding to the Attitudes towards Science Lessons subscales can be found in Table 5-2, Table 5-3 and Table 5-4.

There were 1232 responses to the Attitudes towards Science Lessons scale after the screening of data and removal of responses with missing data by the statistical software SPSS, with a total of 592 responses from Year 7 and 640 responses from Year 9 students. Reference should be made to Table 4-3 which describes the question response and their corresponding number codes (e.g. 3 = 'neither agree nor disagree').

Analysis focused on students' first choice responses in order to gain a more focused insight into the reasons behind the attitudes of science students. The subscale mean scores were analysed alongside responses to the multiple choice questions deemed to be most relevant to each subscale for the following reasons:

- Response items relating to practical issues (items A and J) were analysed in conjunction with the 'Liking for science practical work' subscale. This allowed for the investigation of whether a link between students' attitudes towards science practical work and the likelihood of feeling that additional changes to the practical work will improve their overall attitude towards science lessons existed.
- Response items relating to curriculum issues (item H) were analysed in conjunction with the 'Evaluative beliefs about school science' subscale, which allowed for a direct comparison between students' attitudes towards the importance of school science and students' desire to have a greater understanding of the importance of the science curriculum.
- Response items relating to lesson structure issues (items D, E and F) and classroom dynamics were analysed in conjunction with the 'Liking for science theory lessons' subscale. Although issues relating to classroom dynamics and lesson structure can have an effect on a students' attitude towards all four of the attitudinal subscales, the preliminary research suggested that they were linked to question items related to the

‘Liking for science theory lessons’ subscale. Questions from the subscale such as ‘Science is my favourite lesson’ and ‘I like science more than any other subject at school’ encompassed a students’ opinion towards the general classroom learning environment.

- Response items relating to science theory issues (items C and I) were analysed in conjunction with the ‘Behavioural tendencies to learn science’ subscale, as the preliminary research suggested that the question items associated with the subscale such as “I like trying to solve new problems in science” and “I am willing to spend more time reading science books” were directly linked to whether students’ find the content in science lessons difficult. This is confirmed in the Comparison of the Construct Validity of Scales and Data subchapter (page 59), as confirmatory factor analysis demonstrates the correlation between the ‘Liking towards science lessons’ and ‘Behavioural tendencies to learn science’ subchapters.

The 12 multiple choice items featured in Question 3 of the Attitude towards Science Lessons survey are detailed in Table 5-1 for reference. Response items that were chosen by a high percentage of students, or that deviated from the average for a particular year group or gender in any way were discussed in the corresponding results section, with supporting quotes from the open answer response Question 4 which asked students to explain the reasons behind their choice of response for Question 3.

All graphs displaying information about students’ first choice responses can be found in Appendix B, and all graphs displaying the distribution of students’ mean scores to each subscale can be found in Appendix C.

Table 5-1 Multiple choice items from Question 3 of the Attitudes towards Science Lessons survey. Red question items represent practical issues faced by students, yellow question items represent classroom dynamics, orange question items represent lesson structure issues, green question items represent science theory issues and blue items represent curriculum issues.

A I would like to do practicals that are relevant, up-to-date, and help to explain the topics we learn in science.
B I would prefer to work with classmates more often in my science lessons, because talking about topics helps me to learn.
C I would prefer my science lessons if I was better at maths because I find it difficult.
D I would prefer my science lessons to be more interactive, because sometimes I don't feel involved.
E I would prefer my science lessons if there were clearer introductions, so I can recognise similar topics.
F I would like clearer explanations of the science topics we learn because I find them quite difficult.
G I would like to feel more comfortable asking my teacher questions during my science lessons.
H I would like to understand why the topics we learn in science are important to my life.
I I find the scientific words we have to learn very difficult.
J I would like to do more practical experiments because they help me to understand what I am learning.
K I would prefer my science lessons if they were not disrupted by other students.

5.1.1 Years 7 and 9 – Attitudes towards Science Lessons Scale

Figure 5-1 illustrates the differences between students' attitudes towards science lessons in Years 7 and 9. The error bars display the 95% confidence interval, which reflects the range of values in which there is 95% certainty that the full range of mean scores lie. Differences between two independent groups (such as year groups and genders) can be inferred to be statistically significant if the error bars representing the different groups do not overlap. T-tests were conducted to determine whether differences between two sets of data were statistically significant in cases where a clear difference between two confidence intervals could not be confirmed by observation alone, with a p value ≤0.05 signifying statistically different means (Field 2013).

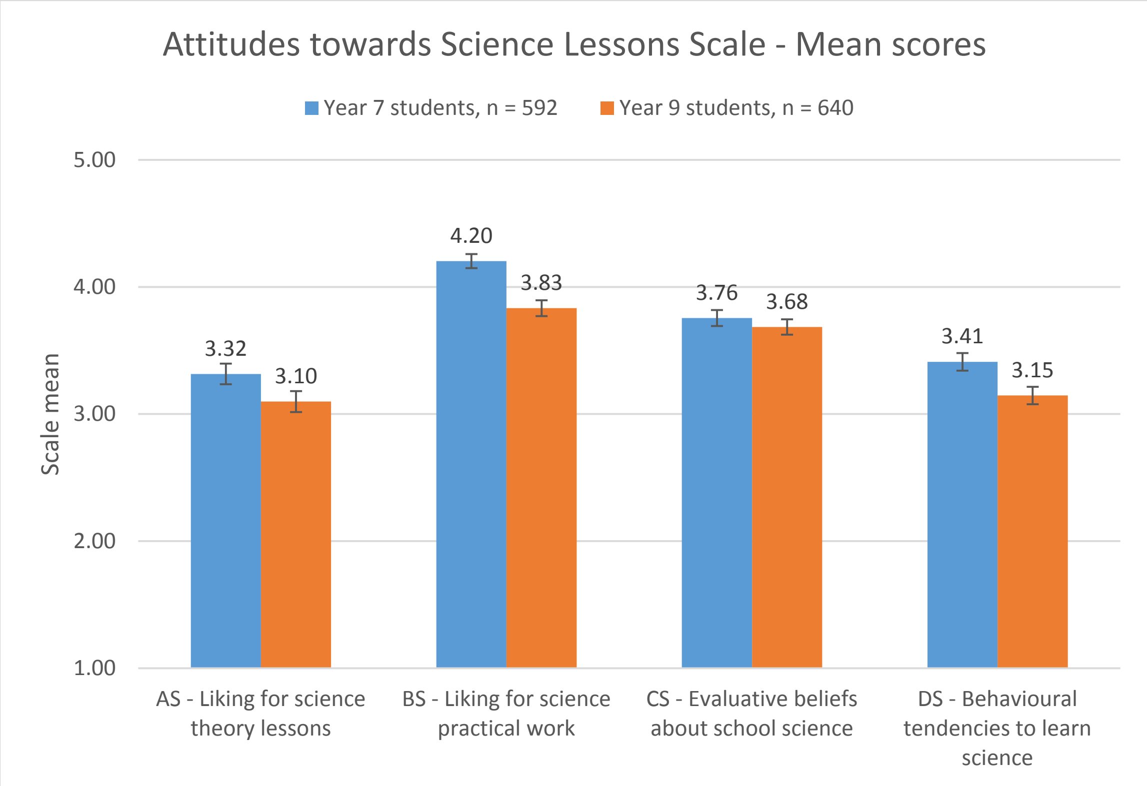


Figure 5-1 Graph comparing attitudes towards science lessons between Year 7 and 9 students. Error bars show the 95% confidence interval.

AS – Liking for science theory lessons:

The subscale with the lowest scale mean for students in Year 7 and 9 was the 'AS – Liking for science theory lessons' subscale, which had mean scores of 3.32 (Year 7) and 3.10 (Year 9). The scores suggests that Year 7 students sampled held more positive attitudes towards science theory lessons than Year 9 students. The relative SDs for Year 7 and Year 9 were 30.4%% and 34.2% respectively, which proposes that science students in Years 7 and 9 hold highly varied attitudes towards science theory lessons. As the scale means are close to the value of 3.00 which represents an overall response of 'Neither agree nor disagree' (see Table 4-3), the results imply that the majority of science students hold neutral attitudes towards their science theory lessons, with students in Year 7 exhibiting more positive attitudes towards science theory lessons than students in Year 9.

The percentage of students that picked responses related to Classroom Dynamics issues (D, E and F) increased significantly from Year 7 to Year 9 (D: Year 7 = 4.5%, Year 9 = 7.0%, E: Year 7 = 3.0%, Year 9 = 5.7%, F: Year 7 = 6.0%, Year 9 = 10.6%). This suggests that there is a negative correlation between students' attitudes towards science theory lessons and how 'involved' the students feel in their lessons, and between the percentage of students that would like clearer introductions and explanations of topics.

"Sometimes we are just copying off the board or out of a text book all lesson it's really boring"

"Because Normally in science lessons we would listen to the teacher, write a few notes on the subject and then maybe do a small practical, however I think that if we got a bit more involved in learning for example maybe role play, it would be easier for us to remember and understand what we are learning about"

The quotes from two female Year 9 Academy school students are indicative of the popular sentiment of feeling uninvolved in their science lessons exhibited by students that picked D as their first choice response. These findings were supported by Myers and Fouts' (1992) discovery of a positive correlation between classroom environment and student attitude towards science. Their study involving 699 American high school students found that students with the most positive attitudes towards science also reported high levels of involvement, very high levels of personal support, strong positive relationships with classmates and the use of a variety of learning activities.

The importance of effective pedagogy is supported by Cooper and McIntyre (1996), who identified aspects of teaching that both teachers and students found to be effective:

- clear goals for pupil learning;
- clarity of communication of lesson goals and agenda to pupils;
- use of preview and review of lesson content;
- helping students to contextualise content in terms of their own experience and knowledge, as well as in terms of other teaching goals and learning experiences;
- some willingness to allow pupils to have input into goal and agenda setting;
- a supportive social context designed by the teacher to help pupils feel accepted, cared for and valued;
- an ability and willingness to allow for different cognitive styles and ways of engaging with the learning process among pupils, through multiple exemplification, and the use of different types of illustration and mode of presentation, and offering pupils a choice from a menu of possible ways of engaging;
- a willingness to take into account pupil circumstances and to modify/pace/structure learning tasks accordingly. (Osborne, Simon et al. 2003)

The students' viewpoints are supported by the research of Osborne and Collins (2000), who suggested that the contemporary science curriculum suffered from an excessive emphasis on "undemanding activities" such as recall, copying and a "lack of intellectual challenge" (Osborne, Simon et al. 2003).

BS – Liking for science practical work

The subscale with the highest overall mean score for both Year 7 and 9 students was 'BS – Liking for science practical work', with mean scores of 4.20 (Year 7) and 3.83 (Year 9). The results suggest that although science students hold positive attitudes towards science practical work, Year 7 students hold significantly more positive attitudes towards the subscale than Year 9 students. The mean scores were relatively representative of the spread of students' responses, as the relative SDs for the Year 7 and 9 results were calculated to be 16.2% and 20.9%; the lowest for any of the Attitude towards Science Lessons subscales within each year group.

The multiple choice item with the highest percentage of responses across science students in Year 7 was A (21.2%), closely followed by J (20.0%), which implies that a large percentage of science students in Year 7 would prefer their science lessons if their concerns about practical work were addressed. Students wanted an increase in the quality of the practical work (A) and an increase in the amount of practical work (J), which is in addition to the fact that their subscale scores indicate an existing positive attitude towards science practical work. This finding gives support to Osborne and Collin's (2000) suggestion that students desire more opportunities to engage in practical work during science lessons. A similar percentage of Year 9 science students picked A as their first choice (22.2%), however the percentage of students that picked J dropped to 13.1%, which indicates that fewer Year 9 students believe that an increase in the amount of practical work will improve their science lessons.

> *"I pick A because I find sometimes doing that we do the same experiments over and over again"*
>
> *"because they don't always work so we need more up to date experiments"*

The quotes are from two Year 9 state school students and illustrates the two main schools of thought of students that picked A as their first choice response; the choice of practical work needs to be improved because students are finding themselves doing them over again, and that some practical experiments are simply not working. The results suggests that the there is a correlation between the fall in positive attitudes towards science practical work seen in Year 9 students and the increase in concern about quality of the practical experiments they have access to, rather than the quantity favoured by Year 7 students.

The findings are supported by Sharpe's (2012) analysis of the attitudes of UK students in Years 7 – 10 towards practical work in science, in which she found that Year 7 students were more likely to feel positively towards practical work because they believed that they were learning from them, as they enjoyed the work and could 'get hands on with the equipment' (Sharpe 2012) p. 296.

However, the decrease in positive attitude when students' reached Year 10 was found to be due to their concerns about their ability to learn from them, which suggests that external factors, such as examinations have an impact on students' attitudes towards practical work.

CS – Evaluative beliefs about school science lessons

The subscale with the second highest overall mean score for both Year 7 and 9 students was 'CS – Evaluative beliefs about school science lessons', with mean scores of 3.76 (Year 7) and 3.68 (Year 9). As there were no statistically valid differences between students across Years 7 and 9, it can be said that the mean scores imply that science students perceive science to be important. The calculated relative SDs for Year 7 and 9 results were 20.7% and 21.2% respectively, which suggests that the spread of students' scores across both year groups were similar and reinforces the finding of no statistically valid differences between science students in Years 7 and 9 towards the subscale.

8.6% of Year 7 students picked H as their first choice response compared with 10.6% of Year 9 students. This suggests that there is a positive correlation between the year group of science students and their level of interest towards understanding how the topics they learn in science lessons are important to their lives. However, the small increase in percentage between Year 7 and Year 9 students reflects the statistically negligible difference in the students' attitudes towards the Evaluative beliefs towards science subscale.

> *"I like science but sometimes I would like to know how this effects my everyday life. This would make it easier to understand as I could relate it to something."*

The quote from a female Year 7 Academy grammar school student was highly representative of the opinions of students that picked H as their first choice response and highlights the idea that students find it difficult to relate their school science lessons to their everyday lives. The findings concur with Ebenezer and Zoller's (1993) study of 1564 Grade 10 students (16 year olds) in which 72% indicated that they believed science to be valuable, 73% indicated that they believed science in schools was important but nearly 40% indicated that they found science classes boring. The results from both of these studies suggests that science students still believe that schools science lessons are overtly theoretical and decontextualized, and far removed from the socially relevant perception of science held by many.

DS – Behavioural tendencies to learn science:

'DS – Behavioural tendencies to learn science' was the subscale with the second lowest overall mean score for both Year 7 and 9 students, with mean scores of 3.41 (Year 7) and 3.15 (Year 9). The results suggest that Year 7 students hold significantly more positive attitudes towards learning science than students in Year 9. However, as the scale mean score of Year 9 students was close to the value of 3.00, it can be said that the majority of science students in Year 9 surveyed hold neutral attitudes towards their behavioural tendencies to learn science. The results are characteristic of the general decline in attitudes towards science lesson subscales observed in the data, which is supported by research by Breakwell and Beardsell (1992) and Hadden and Johnstone (1992) that indicated that students' attitudes towards science decline from age 11.

1.3% of Year 7 science students picked response C as their first choice, which rose to 2.2% of students in Year 9. This suggests that the maths content of science lessons hinders a very small number of students across the year groups, although the number of students effected increases as they progress from Year 7 to Year 9, as the amount of mathematical content rises and/or increases in difficulty.

> *"I would like to be better at math as what we are doing now is usually about working out equations which you need maths for"*

The response of a male Year 9 Independent school student that picked response C as their first choice was representative of the responses of other Year 9 students, and supports the idea that the maths content of the science curriculum increases as students progress academically. Supporting evidence is found in the National Curriculum, as the subject content of Chemistry and Physics in KS3 requiring more difficult calculations are typically taught later in the curriculum (Education 2013).

> *"because i think i am very bad at maths and if i was better at maths i think science would be easier to understand."*

The response of a female Year 7 Academy school student that picked response C as their first choice demonstrates the difference in reasoning between students in Year 7 and 9; the majority of Year 7 students that picked C tended to link their perceived inability or negative attitude towards maths with their ability to do science. The extent of the effect is not known, and no studies were found on the topic.

However, the opposite is true concerning the percentage of science students that picked response I as their first choice: 2.6% of Year 7 students and 1.3% of Year 9 students. This suggests that number of students that would enjoy their science lessons more if they were not hindered by scientific terminology decreases as students get older, signifying that students become more accustomed to learning new terminology as they mature. As Year 9 students have less positive attitudes towards the 'Behavioural tendencies to learn science' subscale compared to Year 7 students, the data suggests that maths issues may play more of a role in the decrease in positive attitude than scientific terminology. Currently, no studies are available on these topics for comparison or discussion.

Table 5-2 Attitudes towards Science Lessons Scale statistical results table, where N=number of responses, SD=standard deviation.

Attitudes towards Science Lessons scale										
			Year 7				Year 9			
Scale	Item		N	Scale Mean	SD	Relative SD	N	Scale Mean	SD	Relative SD
AS - Liking for science theory lessons	A1S	I like science more than any other subject at school.	592	3.32	1.01	30.4%	640	3.10	1.06	34.2%
	A2S	I find science lessons interesting.	592				640			
	A3S	Science is one of my favourite subjects.	592				640			
BS - Liking for science practical work	B1S	I like to do science experiments.	592	4.20	0.68	16.2%	640	3.83	0.80	20.9%
	B2S	When I do practical work, I feel I am doing something important.	592				640			
	B3S	Doing science experiments in school is fun.	592				640			
CS - Evaluative beliefs about school science	C1S	Science is useful for solving everyday problems.	592	3.76	0.78	20.7%	640	3.68	0.78	21.2%
	C2S	People must understand science because it affects their lives.	592				640			
	C3S	Science is one of the most important subjects for people to study.	592				640			
DS - Behavioural tendencies to learn science	D1S	I am willing to spend more time reading science books.	592	3.41	0.86	25.2%	640	3.15	0.89	28.3%
	D2S	I like trying to solve new problems in science.	592				640			
	D3S	If I had a chance, I would do a project in science.	592				640			

5.1.2 Gender differences – Attitudes towards Science Lessons scale

The mean scores for each subscale were categorised by the respondents' gender and year group in order to identify differences in attitudes of students of the same gender in different year groups, and students of different genders in the same year group.

5.1.2.1 Gender differences – Year 7

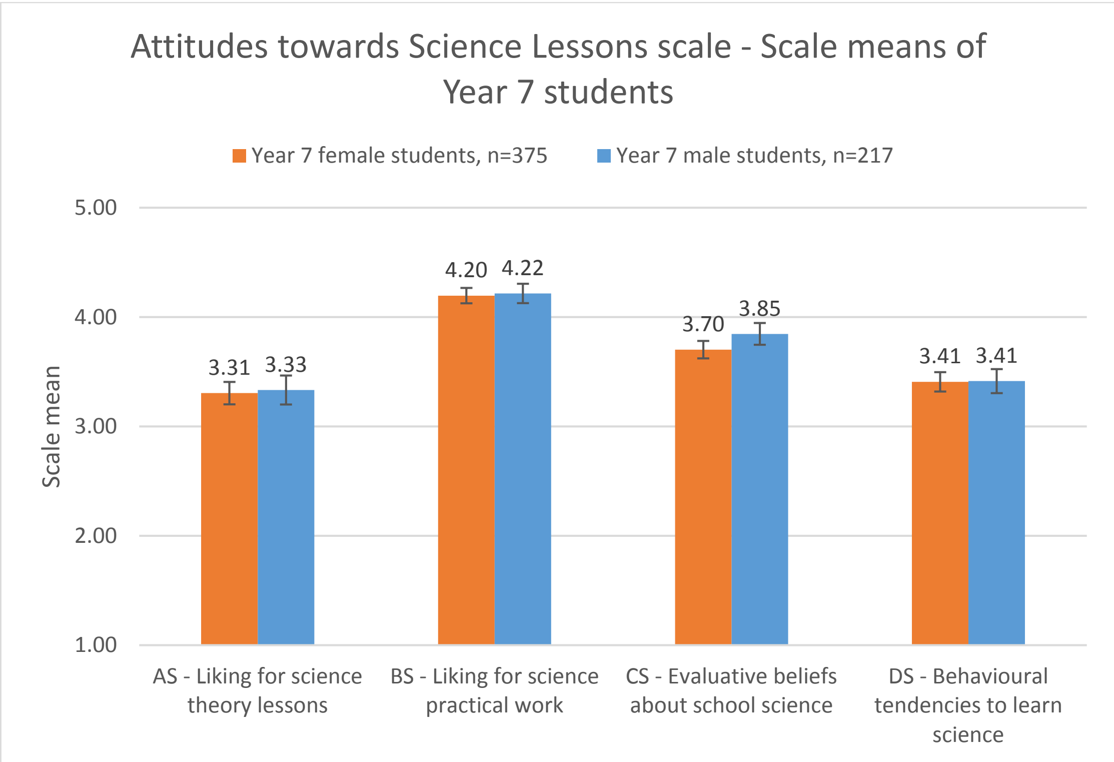


Figure 5-2 Graph showing the differences between Year 7 female and male students' subscale means. Error bars display the 95% confidence interval.

Figure 5-2 shows that although small differences between the attitudes of female and male students in Year 7 exist, none were statistically significant. The data implies that male and female students in Year 7 hold very similar attitudes towards science lessons. This contradicts Weinburgh's (1995) meta-analysis of the literature in which she found that male students consistently held more positive attitudes towards science than females, and that the effect was greater for 'general science' lessons such as the ones attended by Year 7 students in the UK.

Practical Issues

Practical issues were important to Year 7 students of both genders, as 20.6% of female Year 7 students picked response J as their first choice on the multiple choice survey question compared with 18.9% of male students which suggests that a similar percentage of female and male students consider an increase in the amount of practical work as a method of improving their science lessons. However, 27.8% of male students picked response A compared with 17.6% of female students, which indicates that a higher percentage of male students are interested in increasing the quality of their practical work as a method of improving their science lessons. However, this did not have a noticeable effect on their attitudes towards practical work.

Classroom Dynamics

Issues pertaining to classroom dynamics were prominent in the responses of Year 7 students, as 18.9% of males picked response B compared with 15.3% of female students which indicates that more male students are effected by a perceived lack of group work with their classmates. Nevertheless the percentage of responses for both genders indicates that this is an important factor across Year 7 students. 15.5% of female students chose response K as their first choice compared to 9.4% of male students, which indicates that disruption in lessons caused by other students affects a greater percentage of female students compared with male students.

> *"because i have 'boy 1' 'boy 2' and 'boy 3' and other people who shout and laugh all the time and i sit next to some of them and they annoy me"*

The reply from a female Year 7 state school student that picked response K as her first choice highlights the idea that many female students feel that they affected by classroom disruption from male students. Caroline Hoxby's (2000) study on peer effects in the classroom found that in maths lessons, male students tended to perform better in classrooms that had a higher percentage of females despite the fact that prior to the study, no significant difference between the academic performance students of both genders was found. The results of this research suggest that male students may have a negative effect on the dynamics of a classroom environment, however it is possible that the effect may be reversed by having a higher percentage of female students in each class.

Lesson Structure Issues

Response F was the first choice of 7.4% of female Year 7 students compared with 3.3% of male students, which suggests a greater percentage of female students feel that they would benefit from clearer explanations of the science topics.

5.1.2.2 Gender differences – Year 9

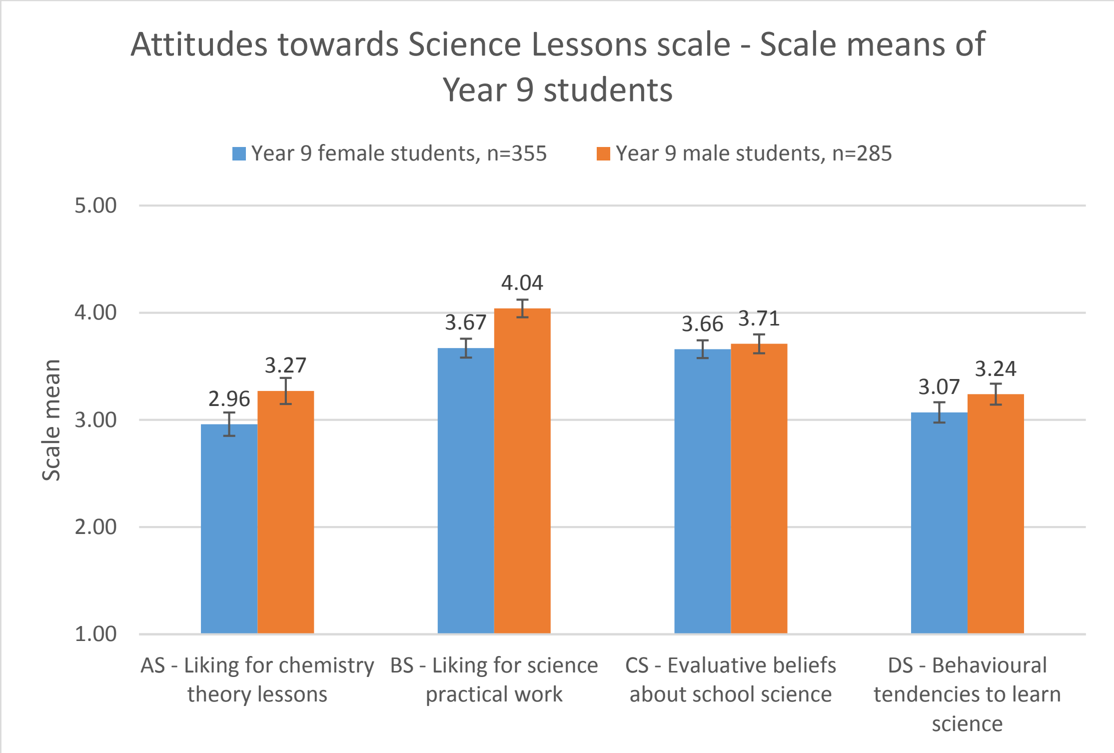


Figure 5-3 Graph showing the differences between Year 9 male and female students' subscale means. Error bars display the 95% confidence interval.

The differences between the attitudes of female and male students in Year 9 are more visible, as demonstrated by Figure 5-3. Male students hold significantly more positive attitudes than their female counterparts towards three subscales: AS, BS and DS, which follows the same trend of subscale scoring between Year 7 students and Year 9 students (see Figure 5-1). This suggests that Year 9 male students hold significantly more positive attitudes towards science theory lessons, science practical work and behavioural tendencies to learn science compared to their female counterparts.

The idea of male students holding more positive attitudes towards science lessons than female students has been supported by the findings of Weinburgh's (1995) meta-analysis of literature concerning gender differences in attitudes towards sciences, and the research of Lightbody and Durndell (1996). Their research suggested that male students consistently held more positive attitudes towards science lessons than female students, whereas the findings of this research suggest that no significant differences exist between male and female students in Year 7 and that gender differences occur in later years. The research undertaken by the TIMSS survey (Beaton

1996) also suggests that the decline in student attitudes is not linear, but accelerates rapidly from age 14 onwards.

Year 9 students' responses to Question 3 illustrate that female students find a varied range of factors important for the improvement of their science lessons, compared to the smaller range of factors suggested by male students.

Practical issues

Practical issues dominated the suggestions of male Year 9 students, with 31.8% choosing response A and 15.9% choosing response J. When compared with female students (A = 15%, J = 11%), t the data clearly suggests that a very large percentage of male students believe that an increase in the quality of practical work is the key to improving their science lessons.

> *"Doing science experiments helps me understand things."*

> *"practical experiments are more fun than textbooks and they help me to understand the topic better. practicals would help me in the end of year tests and it is important to keep up with whats happening"*

These answers were from a male Year 9 student from an independently funded school and a female student from an Academy school respectively, and were characteristic of the two main types of justifications for picking response A. It has been suggested that as students progress through UK secondary education, their attitudes towards practical work become less positive due to an increase in concern about their ability to learn from them (Sharpe 2012). However, the responses to survey Question 4 suggest that science students in Year 9 link practical work with the quality of their understanding of scientific topics. The responses to Question 3 also indicate that there may be a gender split – a higher percentage of male students compared to female students appear to link practical work with their cognitive understanding of science topics.

Lesson Structure Issues

Female Year 9 students appear to show more of an affinity towards factors grouped under Lesson Structure Issues than male students. The response with the highest percentage was F, as it was chosen by 16% of female students compared to 3.5% of male students. This suggests that female science students in Year 9 feel less confident about their understanding of science topics compared to male students. This may indicate the existence of a correlation between Lesson Structure Issues and students' attitudes towards theory lessons (Myers and Fouts 1992, Cooper and McIntyre 1996), as female students also reported more negative attitudes towards the construct compared to male students.

> *"Because some of my science teachers don't explain things well enough for me to understand fully and then I don't do as well on tests."*

This response was from a female Year 9 science student from an Academy school, and is indicative of the link between explanations and exam results made by a large proportion of female students. Many students mentioned 'GCSEs' directly, which suggests that many female science students in Year 9 associate their understanding of science directly with their performance in exams.

5.1.2.3 **Differences between female students in Years 7 and 9**

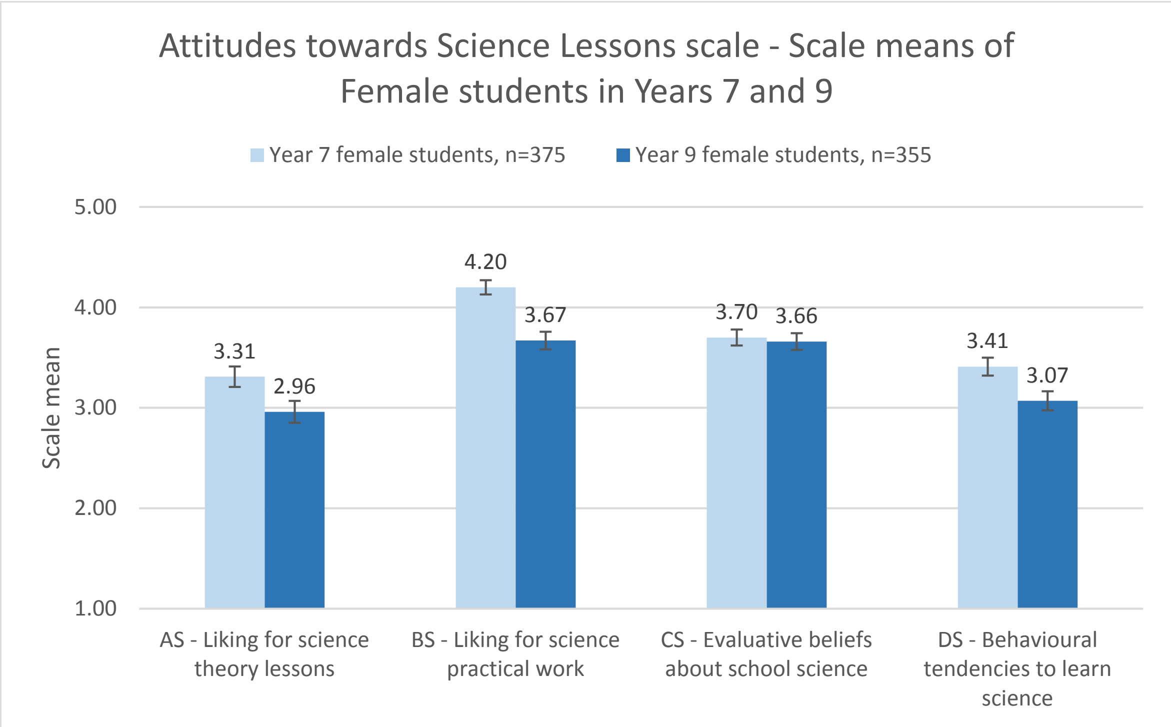


Figure 5-4 Graph showing the differences between female respondents' scale means to the Attitude towards Science Lessons scale. Error bars display the 95% confidence interval.

Figure 5-4 illustrates the differences between female respondents to the ATSLS in Years 7 and 9, and suggests that the attitudes of female students towards AS – Liking for science theory lessons, BS – Liking for science practical work and DS – Behavioural tendencies to learn science decrease as they progress from Year 7 to 9. The responses of female science students to Question 3 show that as female students progress from Year 7 to Year 9, the factors that hold importance towards the improvement of their science lessons change significantly. As noted previously, female Year 9 students chose a wide range of different factors as their first choices which contrasts with the concentrated range of factors favoured by students across Year 7.

Practical Issues

Responses related to practical issues dominate the responses of female Year 7 students, with J = 20.6% and A = 17.6%. However, this dropped to 15% for response A and 11% for response J which suggests that the practical issues become less important for female science students in Year 9. Similar to male Year 9 students, female Year 7 students appear to hold a more positive attitude towards science practical work compared to female Year 9 students and have picked responses relating to practical work because they would like to focus more on the aspects of science that they enjoy. The findings supports the idea that students' attitudes towards practical work become less positive over time (Sharpe 2012).

Lesson Structure Issues

The response with the highest percentage of answers from female Year 9 students was F with 16%, which suggests many female students find the science topics to be poorly explained in lessons. Response F gained 7.4% of the responses from Year 7 students. A negative correlation between lesson structure issues and attitudes towards science theory lessons has been observed by Myers (1992), however the data suggests that the effect is greater for female students as they progress through school.

5.1.2.4 Differences between male students in Years 7 and 9

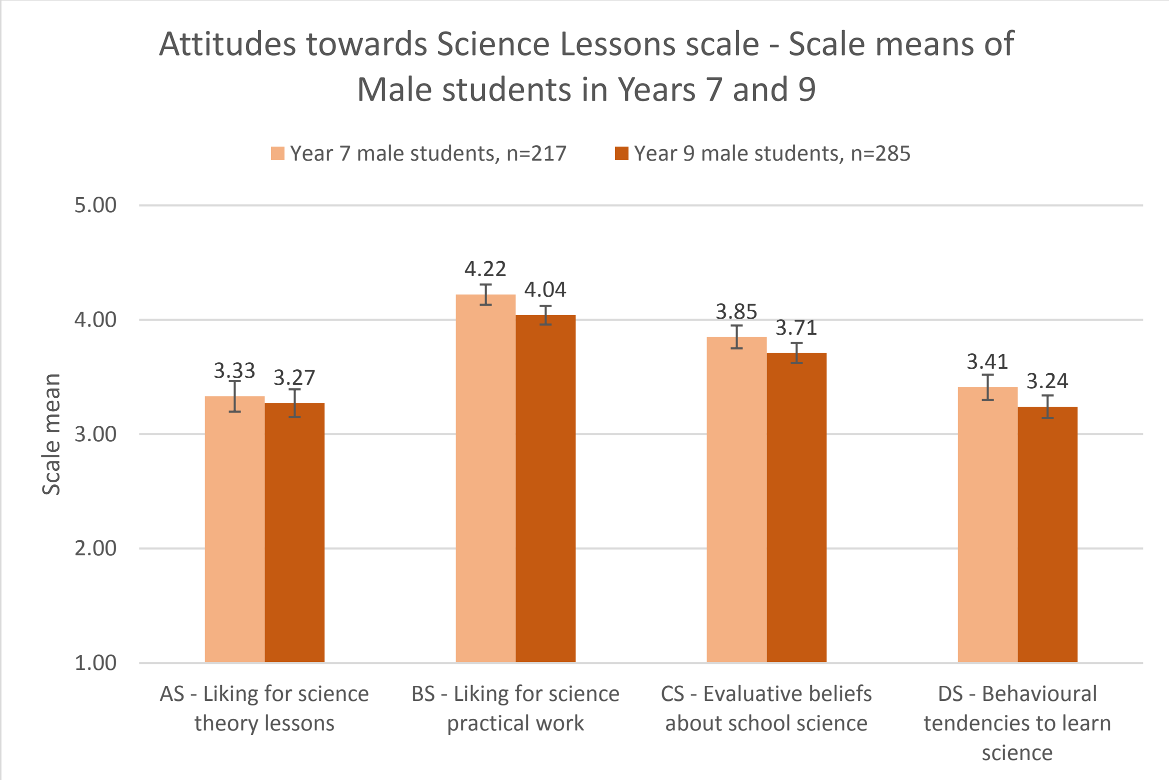


Figure 5-5 Graph showing the differences between male respondents to the Attitudes towards Science Lessons scale. Error bars show the 95% confidence interval.

Figure 5-5 shows that the scale means of male students across the two year groups were very similar, as only one of the four subscales featured a statistically significant difference between male students in Year 7 and 9: 'BS – Liking for science practical work'. The data suggests that although male students across both year groups hold very positive attitudes towards science practical work (Year 7 = 4.22 and Year 9 = 4.04), the attitudes of male Year 9 students are less positive than those in Year 7.

The first choice responses to Question 3 for male science students helps to illuminate the reasons behind the lack of statistically valid differences between the mean scores of male students in Years 7 and 9, as the choices of male students across both year groups are very similar.

Practical Issues

Response A featured the highest percentage of responses from male students across both year groups, with 27.8% from Year 7 and 31.8% from Year 9 students. The higher percentage of male students of Year 9 that picked response A suggests that the quality of practical work affects the attitudes of older male students more than younger male students.

> *“I don't really think many of them are at all necessary. But I think learning about the up-to-date subjects is necessary.”*

This quote from a male Year 9 Academy school student highlights the popular idea amongst male Year 9 students that picked response A of feeling that the practical work they undertake in science lessons is irrelevant to their lives. A similar percentage of male students picked response J as their first choice (Year 7 = 18.9%, Year 9 = 15.9%), however the lower percentage of male Year 9 students suggests a decrease in the level of perceived enjoyment and/or usefulness of practical work compared to Year 7 students, which is reflected in their mean scores to the Liking for science practical work attitudinal subscale. Similar results concerning students’ attitudes towards practical work were found by Sharpe (2012).

Classroom Dynamics

Response B gained 17% of male Year 7 responses and 12.8% of male Year 9 responses, which suggests that a greater percentage of male students in Year 7 would prefer to engage in more group work than Year 9 students. However, response B was the third most popular response for male science students which indicates that group work is an important factor regardless of the year group of the male student. A larger percentage of male students in year 9 picked response K compared with Year 7 students (Year 7 = 9.4%, Year 9 = 12.1%), which suggests that the effect of classroom disruption is greater on male students in Year 9 compared to Year 7. The results suggest that levels of classroom disruption increase from Year 7 to Year 9.

Table 5-3 Attitudes towards Science Lessons Scale – Gender differences statistical results table, where N=number of responses, SD=standard deviation.

Attitude towards Science Lessons scale – Gender differences																	
			Year 7 female students				Year 7 male students				Year 9 female students				Year 9 male students			
Scale	Item		N	Scale Mean	SD	Relative SD	N	Scale Mean	SD	Relative SD	N	Scale Mean	SD	Relative SD	N	Scale Mean	SD	Relative SD
AS - Liking for chemistry theory lessons	A1S	I like science more than any other subject at school.	375	3.31	1.01	30.5%	217	3.33	1.00	30.0%	355	2.96	1.05	35.5%	285	3.27	1.05	32.1%
	A2S	I find science lessons interesting.	375				217				355				285			
	A3S	Science is one of my favourite subjects.	375				217				355				285			
BS - Liking for science practical work	B1S	I like to do science experiments.	375	4.20	0.69	16.4%	217	4.22	0.67	15.9%	355	3.67	0.56	15.3%	285	4.04	0.70	17.3%
	B2S	When I do practical work, I feel I am doing something important.	375				217				355				285			
	B3S	Doing science experiments in school is fun.	375				217				355				285			
CS - Evaluative beliefs about school science	C1S	Science is useful for solving everyday problems.	375	3.70	0.79	21.4%	217	3.85	0.75	19.5%	355	3.66	0.79	21.6%	285	3.71	0.76	20.5%
	C2S	People must understand science because it affects their lives.	375				217				355				285			
	C3S	Science is one of the most important subjects for people to study.	375				217				355				285			
DS - Behavioural tendencies to learn science	D1S	I am willing to spend more time reading science books.	375	3.41	0.88	25.8%	217	3.41	0.83	24.3%	355	3.07	0.92	30.0%	285	3.24	0.84	25.9%
	D2S	I like trying to solve new problems in science.	375				217				355				285			
	D3S	If I had a chance, I would do a project in science.	375				217				355				285			

5.1.3 School type differences – Attitudes towards Science scale

The schools that student respondents attended could be grouped into two distinct sets by whether they were independently funded or state funded. The state funded schools involved in this research fell under four additional categories with distinct differences depending on the level of state involvement (see Table 4-1a and b), which left the funding status as the clearest way of differentiating between independent schools and non-independent schools. The mean scores of all respondents to the Attitudes towards Science Lessons scale were averaged to create a scale mean for each type of school, and compared. A comparison of all respondents from Year 7 and 9 was conducted instead of a comparison across the distinct year groups, due to the comparatively small number of Year 7 respondents from independent schools compared to state-funded schools. The disparity in sample size would have made the comparison statistically less meaningful (Field 2013).

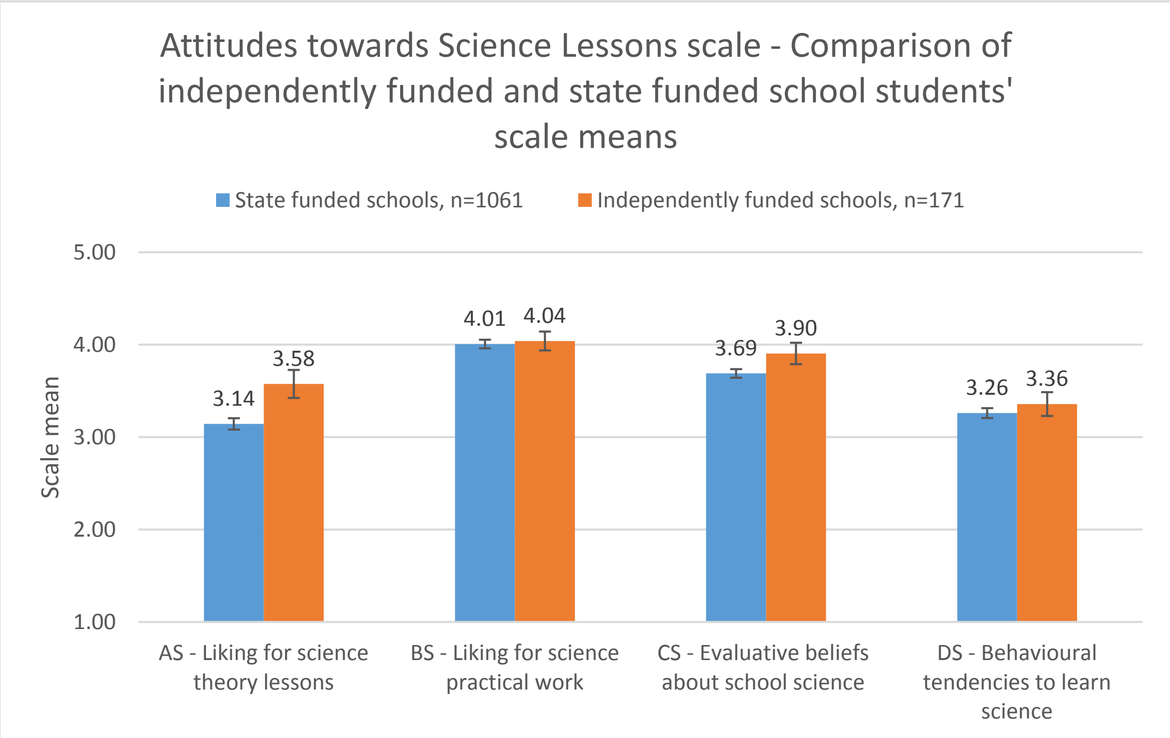


Figure 5-6 Graph comparing the scale means of all respondents to the Attitudes towards Science Lessons scale from independently funded and state funded schools. Error bars display the 95% confidence interval.

Figure 5-6 illustrates that two subscales, AS and CS have statistically significant differences between independently funded and state funded schools. This suggests that students from independently funded schools hold more positive attitudes towards science theory lessons and evaluative beliefs about school science than their counterparts in state funded schools. As the number of students from independently funded schools were significantly less than those from state funded schools, the confidence intervals for the data corresponding to independently funded students are larger which corresponds to the increased error when attempting to extrapolate the data to fit the wider population. The larger confidence interval for respondents in independently funded schools may also be due to a larger range of mean scores within the average scale mean, which can be seen by the larger relative SDs in Table 5-4. This suggests that science students in independently funded schools hold a wider range of attitudes towards their science lessons compared with students in state funded schools.

The scale means for the AS subscale were 3.14 for state funded students and 3.58 for independently funded students, which suggests that students in state funded schools hold less positive attitudes towards science theory lessons than students in independently funded schools. The scale means for the CS subscale suggest that students in independently funded schools have a slightly more positive attitude regarding evaluative beliefs about school science than students in state funded schools, with scores of 3.69 and 3.90 respectively. The scale means for the BS and DS subscales imply that students from both independently funded and state funded schools hold similar attitudes towards science practical work and behavioural tendencies to learn science, as there was no statistically valid difference between their scores.

Responses relating to practical issues were popular for students in both types of school, with a slightly larger percentage of students in independently funded schools picking response A (independently funded schools = 24.9%, state funded schools = 21.8%). This contrasts with the percentage of students that picked response J (independently funded schools = 10.1%, state funded schools 20.8%), which suggests that whilst students in independent schools are more content with the amount of practical work that they have compared to students in state funded schools, a large percentage of students in independent schools would like a high quality of practical work.

> *"I feel as though we do not do enough practicals in lesson although I know that There are a lot of people in the school for more practicals to be done."*

This quote from a female Year 9 state school student that picked J as their first choice response is indicative of the idea that resources are more stretched in state run schools, which leads to a lack of student satisfaction with the amount of practical work that they partake in. A larger proportion of students in state funded schools picked responses relating to issues with classroom dynamics compared to students in independently funded schools (B: independently funded schools =

10.1%, state funded schools = 16.3%, K: independently funded schools = 4.7%, state funded schools = 14%).

> *"because we have a big class so often there is a lot of chatting, so it is hard to focus"*

The responses from state funded school students seemed to indicate a negative correlation between class size and classroom discipline. This response was from a female Year 9 state school student that picked K as their first choice response, and was characteristic of the majority of state school students that picked response K. The results suggest that students in independent schools partake in more group work during their science lessons than students in state funded schools, and that students experience lower amounts of classroom disruption from other students possibly due to generally smaller class sizes.

A slightly larger percentage of students from independent schools selected response G than state school students (G: independent schools = 4.1%, state funded schools = 3.9%) which could indicate that science students in independent schools do not feel as comfortable asking questions during their science lessons compared to students in state funded schools. This could be an effect of higher levels of classroom discipline, which would explain the comparatively lower levels of classroom disruption in independent schools indicated by the responses, however the difference in percentages is too small to attribute such large differences to.

17.2% of students in independent schools picked response H compared with 9.3% of students in state funded schools, which suggests that a larger number of students in independent schools feel that their science lessons would be improved by placing a greater emphasis on why the topics learned are important to their lives.

> *"I think that understanding how what you are learning will affect your life makes you engage more and remember it for longer."*

This response was received from a male Year 7 independent school student, and was typical of students that picked H as their first choice response. The open answer responses suggest that students in independent schools picked response H due to a greater general interest in how the content of their topics would affect their lives and held generally optimistic and open minded views towards the relevance of science, whilst students in state funded schools tended to pick the same response because they felt that the content of their science lessons were deeply irrelevant to their future. The following response from a female Year 9 Academy grammar school (state funded) student illustrates a popular line of reasoning with students in state schools who did not see how their science lessons could help them in their future outside school.

"I picked this statement because I don't see how counting electrons is going to help us in the future, e.g. getting a job. Most of what we learn will never be used again (unless you become a scientist, which I am not) because it does not help us in our everyday lives; Looking at wavelengths and testing plants for starch is not going to help us buy a house."

Table 5-4 Attitudes towards Science Lessons scale – School type differences statistical results table, where N=number of responses, SD=standard deviation.

Attitudes towards Science Lessons scale - School type differences										
			Students state funded schools				Students in independently funded schools			
Scale	Item		N	Scale Mean	SD	Relative SD	N	Scale Mean	SD	Relative SD
AS - Liking for science theory lessons	A1S	I like science more than any other subject at school.	1061				171			
	A2S	I find science lessons interesting.	1061	3.14	1.03	32.8%	171	3.58	1.01	28.2%
	A3S	Science is one of my favourite subjects.	1061				171			
BS - Liking for science practical work	B1S	I like to do science experiments.	1061				171			
	B2S	When I do practical work, I feel I am doing something important.	1061	4.01	0.79	19.7%	171	4.04	0.68	16.8%
	B3S	Doing science experiments in school is fun.	1061				171			
CS - Evaluative beliefs about school science	C1S	Science is useful for solving everyday problems.	1061				171			
	C2S	People must understand science because it affects their lives.	1061	3.69	0.78	21.1%	171	3.90	0.78	20.0%
	C3S	Science is one of the most important subjects for people to study.	1061				171			
DS - Behavioural tendencies to learn science	D1S	I am willing to spend more time reading science books.	1061				171			
	D2S	I like trying to solve new problems in science.	1061	3.26	0.88	27.0%	171	3.36	0.86	25.6%
	D3S	If I had a chance, I would do a project in science.	1061				171			

Chapter 6: Results Chapter 3 - Attitudes towards Chemistry Lessons Scale Results

The numerical results from the Attitudes towards Chemistry Lessons attitudinal scale will be detailed in this subchapter, along with supporting qualitative evidence from the multiple choice question (Question 3) and the open response questions (Question 4) from the surveys. The scale means, standard deviations (SD) and relative standard deviations corresponding to the Attitudes towards Science Lessons subscales can be found in Table 6-2, Table 6-3 and Table 6-4.

There were 1020 responses to the modified Attitudes towards Chemistry Lessons scale after the screening of data and removal of responses with missing data by the statistical software SPSS. 640 responses were from Year 9 students and 380 responses were from students in Year 10/11. Reference should be made to Table 4-3 which describes the response options for the Likert scale and their corresponding number codes (e.g. 3 = 'neither agree nor disagree'). The distribution of mean scores within each scale mean will also be discussed in order to give a better representation of the various attitudes expressed within the sample population.

The 12 multiple choice items featured in Question 3 of the Attitude towards Chemistry Lessons survey are detailed in Table 6-1 for reference. Response items that were chosen by a high percentage of students, or that deviated from the average for a particular year group or gender in any way were discussed, with supporting quotes from the open answer response Question 4 which asked students to explain the reasons behind their choice of response for Question 3.

All graphs displaying information about students' first choice responses can be found in Appendix B, and all graphs displaying the distribution of students' mean scores to each subscale can be found in Appendix C.

Table 6-1 Multiple choice items from Question 3 of the Attitudes towards Chemistry Lessons survey. Red question items represent practical issues faced by students, yellow question items represent classroom dynamics, orange question items represent lesson structure issues, green question items represent science theory issues and blue items represent curriculum issues.

A I would like to do practicals that are relevant, up-to-date, and help to explain the topics we learn in chemistry.
B I would prefer to work with classmates more often in my chemistry lessons, because talking about topics helps me to learn.
C I would prefer my chemistry lessons if I was better at maths because I find it difficult.
D I would prefer my chemistry lessons to be more interactive, because sometimes I don’t feel involved.
E I would prefer my chemistry lessons if there were clearer introductions, so I can recognise similar topics.
F I would like clearer explanations of the chemistry topics we learn because I find them quite difficult.
G I would like to feel more comfortable asking my teacher questions during my chemistry lessons.
H I would like to understand why the topics we learn in chemistry are important to my life.
I I find the scientific words we have to learn in chemistry very difficult.
J I would like to do more practical experiments because they help me to understand what I am learning.
K I would prefer my chemistry lessons if they were not disrupted by other students.

6.1.1.1 Attitudes towards Chemistry Lessons – Years 9 and 10/11

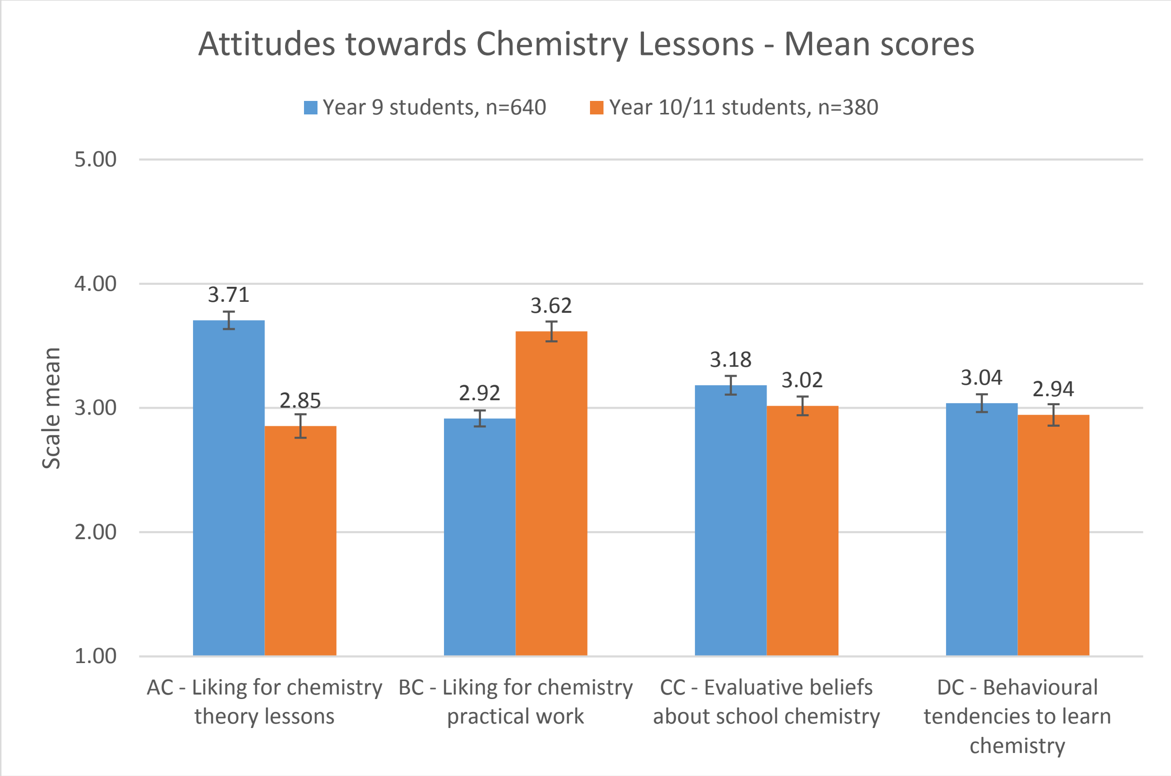


Figure 6-1 Graph comparing attitudes towards chemistry lessons between Year 9 and Year 10/11 students. Error bars show the 95% confidence interval.

Figure 6-1 illustrates the differences between students' attitudes towards chemistry lessons in Years 9 and 10/11, and shows that there were statistically significant differences between the attitudes of chemistry students towards three out of four subscales: AC, BC and CC. The data suggests that as students' progress from Year 9 to Year 10/11, their attitudes towards chemistry theory lessons and evaluative beliefs towards chemistry become less positive whilst their attitudes towards chemistry practical work become more positive. However, no significant differences between the attitudes of chemistry students towards behavioural tendencies to learn chemistry was observed.

AC – Liking for chemistry theory lessons:

The subscale with the second highest mean score from all chemistry students was 'AC – Liking for chemistry theory lessons', although Figure 6-1 illustrates that stark differences between the attitudes of chemistry students in Years 9 and 10/11 exists. The overall scale means for Year 9 and Year 10/11 students were 3.71 and 2.85 respectively, which suggests that chemistry students in Year 9 hold positive attitudes towards chemistry theory lessons whilst chemistry students in Year

10/11 hold negative attitudes towards the subscale. The corresponding relative SDs of the mean scores for each year group were calculated to be 24.3% and 33% for Year 9 and Year 10/11 respectively (see Table 6-2). The relative SD for Year 9 students was the lowest of any of the subscales, whilst the relative SD for Year 10/11 was the highest of all the subscales which suggests that the attitudes of Year 9 students towards chemistry theory lessons are relatively congruent when compared to the statistically varied attitudes of Year 10/11 students.

The percentage of students with mean scores equal to '3.00' across both year groups was found to be very similar (Year 9 = 11.0%, Year 10/11 = 10.3%), which indicates that the percentage of students with neutral attitudes towards chemistry theory lessons does not change significantly as students progress from Year 9 to Year 10/11, and that the major shift in attitude is towards the negative.

Students' responses to Question 3 in which they explained the reasons behind their attitudes helped to illuminate key issues that may have been responsible for the shift from positive to negative attitudes between younger and older chemistry students. The multiple choice item with the highest percentage of Year 10/11 respondents was B with 17.7%, which suggests that the attitudes of a large percentage of chemistry students may be affected because they do not feel that they engage in enough group work during their lessons. Response B was the third most popular option for Year 9 students which shows that group work is important to a large percentage of chemistry students across the year groups.

> *"Talking to others about topics reinforces the knowledge and becomes much easier to recall for an exam or test."*
> An answer from a female Year 10/11 student from a Comprehensive school that picked response B as their first choice.

> *"because I feel more comfortable working with friends so that I express my opinion without feeling pressured"*
> An answer from a female Year 9 student from an Academy school that picked response B as their first choice.

The quotes highlight two popular schools of thought amongst students that picked response B as their first choice. Students either believed that group work was important because it ultimately helped them with their exam results, or that it relieved the pressure they felt in a classroom environment. Other studies into science lessons and practical work have shown that students get older, they prefer the opportunity 'to work and chat in groups' as subjects get harder whilst younger students ‘prefer being able to show the teacher they can do it themselves’ (Sharpe 2012) p. 292. The findings suggest that as students become teenagers, they become more uncomfortable in classroom environments and this corroborates Breakwell and Beardsell’s (1992) findings that students’ attitudes towards science based lessons become less positive as students become older.

The multiple choice item with the highest percentage of Year 9 respondents was D with 17.9% compared to the 11.9% of responses from Year 10/11 chemistry students, which suggests that a greater percentage of Year 9 chemistry students feel that their chemistry lessons are not interactive enough. However, the scale means for the ‘Liking for chemistry theory lessons’ subscale demonstrates that Year 9 students hold positive attitudes towards chemistry lessons compared with the negative attitudes held by Year 10/11 students, which suggests that the factor may not have a direct effect on the attitudes of Year 9 students towards chemistry theory lessons.

6.3% of Year 9 students picked response E as their first choice compared to 2.1% of Year 10/11 students, which suggests that a larger percentage of Year 9 students find it difficult to identify chemistry topics compared with older students. This could be due to Year 9 students in certain schools not receiving separate chemistry, physics and biology lessons until they start preparing for GCSEs (see chapter 3.1) which would hinder their ability to differentiate between chemistry and general science lessons. There was also a strong focus on students wanting clearer explanations because they believed that it would help them revise better, which highlights the increasing impact exams have on how and why students learn.

> *“because sometimes I don't know what science I am doing.”*
> Quote from a female Year 9 Comprehensive school student that picked response E as their first choice.
>
> *“Again I don't understand what is happening and it would help if it was clearer on what the teacher was saying or I will fail my tests!”*
> Response from a male Year 9 Academy grammar school student that picked E as their first choice.

An additional reason for the difference in attitude scores may be found in the lower percentage of Year 9 students that picked K as their first choice (Year 9 = 4.8%, Year 10/11 = 11.1%), which suggests that the chemistry lessons of students in Year 10/11 are more affected by disruption compared with Year 9 lessons.

"Because my lessons are always disturbed by other students who find the lesson boring, hard, or would just rather be plain rude and not listen to the teacher, talk back to them, and stop me from learning. It's annoying because I would like to do well in my Chemistry Exam but am being held back by other people who think it's funny to mess around and not think of others."
A response from a female Year 10/11 student from an Academy school that picked response K as their first choice.

This quote indicates that the levels of classroom disruption from other students may be perpetuated by students that find the content of the chemistry lessons 'hard' or 'boring'; adjectives which are synonymous with a negative attitude towards chemistry lessons. The results suggest that a negative correlation exists between the attitudes of students towards chemistry theory lessons and the levels of classroom disruption, which would explain the increased level of student disruption as students progress from Year 9 to Year 10/11.

BC – Liking for chemistry practical work

The subscale with the highest overall mean score was 'BC – Liking for chemistry practical work', with mean scores of 2.92 for Year 9 and 3.62 from Year 10/11 students (see Table 6-2). The results suggest that students in Year 9 have relatively negative attitudes towards chemistry practical work and students in Year 10/11 hold positive attitudes, which contrasts with the findings of Sharpe's research that suggested that a negative correlation existed between attitudes towards chemistry practical work and the year group of students (Sharpe 2012). It is interesting to note that as students progress from Year 9 to Year 10/11, the percentage that hold mean scores equal to a neutral score of '3.00' decreased significantly from 17.8% to 7.6% of students. This indicates that there is a positive correlation between the amount of exposure students have with chemistry practical work and their attitudes towards chemistry practical work.

The percentage of chemistry students that picked responses related to practical issues for their first choice were quite similar across the year groups, with a slightly larger percentage of Year 10/11 students picking response A – 'I would like to do practical work that is relevant, up-to-date, and help to explain the topics we learn in science' compared to students in Year 9 (Year 9 = 9.1%, Year 10/11 = 11.4%).

"Most experiments we do are tiny, boring and unimaginative. We have out dated equipment and the experiments don't provide any extra understanding towards the topics."

A response from a male Year 10/11 student from a community school that picked A as their first choice response.

The responses for this subscale and AC subscale suggest that although the percentages of students that feel that the quality of their chemistry work can be improved, older chemistry students still hold more positive attitudes towards chemistry practical work because they are better able to distinguish chemistry practical work from other sciences, and recognise the learning potential associated with effective practical activities. This response is also indicative of students' beliefs that the chemistry practical work that they engage in is somehow 'out-of-date' and irrelevant to modern chemistry, which was mirrored by the findings of Osborne et al. (2003). Sharpe (2012) also found that as students progressed through school, they began to feel that practical work lacked relevance to real life, especially in physics and chemistry where they struggled to see the links between their lives. However, the findings of this research has not found a link between the perceived irrelevance of chemistry practical work and students' attitudes towards chemistry practical work.

Although the percentages of chemistry students that picked response J for their first choice were similar across the year groups (Year 9 = 9.9%, Year 10/11 = 9%), the open answer responses reveal that Year 9 students associate an increase in the amount of practical work with an increase in their perceived level of understanding and learning of chemistry topics, which was found to be characteristic of younger students by Sharpe (2012):

"i love doing practicals because they are fun and I remember the lesson more and take on board what we are learning."
A response from a male Year 9 chemistry student from an Academy school that picked J as his first choice response.

This suggests that the low Year 9 subscale mean for 'Liking for chemistry practical work' may also be linked with Year 9 students' general lack of ability to identify chemistry as a separate construct, as most responses from Year 9 students implied a positive attitude towards general practical work. The multiple choice option that had the highest percentage of respondents from students in Year 9 was D – 'I would prefer my chemistry lessons to be more interactive, because sometimes I don't feel involved', which also indicates that the practical work that they are engaging in has little effect on how interactive they feel their lessons are.

CC – Evaluative beliefs about school chemistry

The subscale with the second lowest overall mean score was ‘CC – Evaluative beliefs about school chemistry’, which had mean scores of 3.18 for Year 9 students and 3.02 for Year 10/11 students. The scores indicate that students in Year 9 hold more positive evaluative beliefs about school chemistry compared to students in Year 10/11. The percentage of students that had mean scores of ‘3.00’ increased from 12.8% to 20.3% from Year 9 to Year 10/11, which suggests that as students progress academically, the number of students that hold neutral attitudes towards the CC subscale increases.

The percentages of chemistry students that picked response H as their first choice were similar across the two year groups (H: Year 9 = 12.2%, Year 10/11 = 13.5%), which suggests that a slightly larger percentage of chemistry students in Year 10/11 compared with those in Year 9 are interested in understanding why the chemistry topics they study are important to their lives. Response H featured the 4th highest response rate across the year groups, which suggests that curriculum issues are important to a large percentage of students. The scale means of chemistry students suggested that the majority of them held no strong opinions about their evaluative beliefs about school chemistry which coincides with a lack of understanding about the importance of the topics they learn in their lessons.

> *“Because as a teenager, in everything I do I like to see why it is relevant to the 'real' world and I believe it would also help others understand and learn better if they could see how science will and is affecting their lives and how science can improve their lives.”*
> A response from a male Year 9 student from an independent school that picked H as their first choice response.

This quote was representative of chemistry students that picked response H as their first choice, and indicates that chemistry students find it hard to identify the relevance of chemistry to their everyday lives. Students sometimes compared chemistry with biology, a subject that many students could see the relevance of. Osborne et al. (2003) identified that secondary school students were more likely to recognise the importance of biology over the physical sciences due to the fact that their “self-interest in their own bodies and concerns about health and disease” tend to be addressed.

> *“Compared to other elements of science, there is never anything that explains chemistry in the context of real life, compared to biology or physics.”*
> A response from a male Year 9 students from an Academy school that picked H as their first choice.

Another aspect to consider is the idea that as a result of a lack of specialist chemistry teachers in the UK, chemistry lessons are more likely to be taught by a biology specialist due to a heavy weighting of biology teachers in the school system (Osborne and Dillon 2010). No literature was found to suggest that this caused noticeable differences for students pre-A-level, but it is worth mentioning that a teachers' knowledge of a subject has been proven to be a determinant of effective teaching (Osborne and Simon 1996).

DC – Behavioural tendencies to learn chemistry

The subscale with the lowest overall mean score was 'DC – Behavioural tendencies to learn chemistry', with mean scores of 3.04 for Year 9 students and 2.94 for Year 10/11 students. The results suggest that students' behavioural tendencies to learn chemistry become more negative as they progress from Year 9 to Year 10/11. Although the percentage of students with neutral opinions decreases from Year 9 to Year 10/11, the number of students with mean scores corresponding to strongly negative or strongly positive attitudes also decreases from Year 9 to Year 10/11. This indicates that younger chemistry students have more polarised attitudes towards behavioural tendencies to learn chemistry, whereas older chemistry students have mildly positive or negative attitudes.

A small percentage of chemistry students picked response items that corresponded to chemistry theory issues (C: Year 9 = 1.8%, Year 10/11 = 2.65%, I: Year 9 = 3%, Year 10/11 = 1.6%) which suggests that the majority of chemistry students do not experience problems with maths and chemistry terminology that significantly hinder their experience of chemistry lessons. It is interesting to note that the percentage of students that picked response C doubled from Year 9 to Year 10/11, whereas the percentage of students that picked response J decreased by almost half from Year 9 to Year 10/11. This suggests that the percentage of students that struggle with the maths content in chemistry lessons increases as students progress from Year 9 to Year 10/11, whilst the percentage of students that struggle with chemistry terminology decreases.

> *"I have no natural talent for Chemistry."*
> A response from a female Year 10/11 student from an independent school that picked C as their first choice.

It appeared that while many students that picked response C believed that their perceived inability to "do" chemistry was due to their lack of ability in maths, some students picked response C as a method of declaring that they lacked some kind of intrinsic chemical capability, such as the student featured in the aforementioned quote. It may be difficult to identify and understand the issues facing such students, as the survey may not have provided an option that they found suitable. The trends in theory issues were mirrored in the results of the Attitude towards Science Lessons survey between Year 7 and Year 9 science students.

Table 6-2 Attitudes towards Chemistry Lessons scale statistical results table, where N=number of responses, SD=standard deviation.

Attitudes towards Chemistry Lessons scale										
			Year 9				Year 10/11			
Scale	Item		N	Scale Mean	SD	Relative SD	N	Scale Mean	SD	Relative SD
AC - Liking for chemistry theory lessons	A1C	I like chemistry more than any other subject at school.	640	3.71	0.90	24.3%	380	2.85	0.94	33.0%
	A2C	I find chemistry lessons interesting.	640				380			
	A3C	Chemistry is one of my favourite subjects.	640				380			
BC - Liking for chemistry practical work	B1C	I like to do chemistry experiments.	640	2.92	0.83	28.4%	380	3.62	0.79	21.8%
	B2C	When I do practical work, I feel I am doing something important.	640				380			
	B3C	Doing chemistry experiments in school is fun.	640				380			
CC - Evaluative beliefs about school chemistry	C1C	Chemistry is useful for solving everyday problems.	640	3.18	0.98	30.8%	380	3.02	0.75	24.8%
	C2C	People must understand chemistry because it affects their lives.	640				380			
	C3C	Chemistry is one of the most important subjects for people to study.	640				380			
DC - Behavioural tendencies to learn chemistry	D1C	I am willing to spend more time reading chemistry books.	640	3.04	0.92	30.3%	380	2.94	0.86	29.3%
	D2C	I like trying to solve new problems in chemistry.	640				380			
	D3C	If I had a chance, I would do a project in chemistry.	640				380			

6.1.2 Gender differences - Attitudes towards Chemistry Lessons scale

The mean scores for each subscale were categorised by the respondents' gender and year group in order to identify differences in attitudes of students of the same gender in different year groups, and students of different genders in the same year group.

6.1.2.1 Gender differences – Year 9

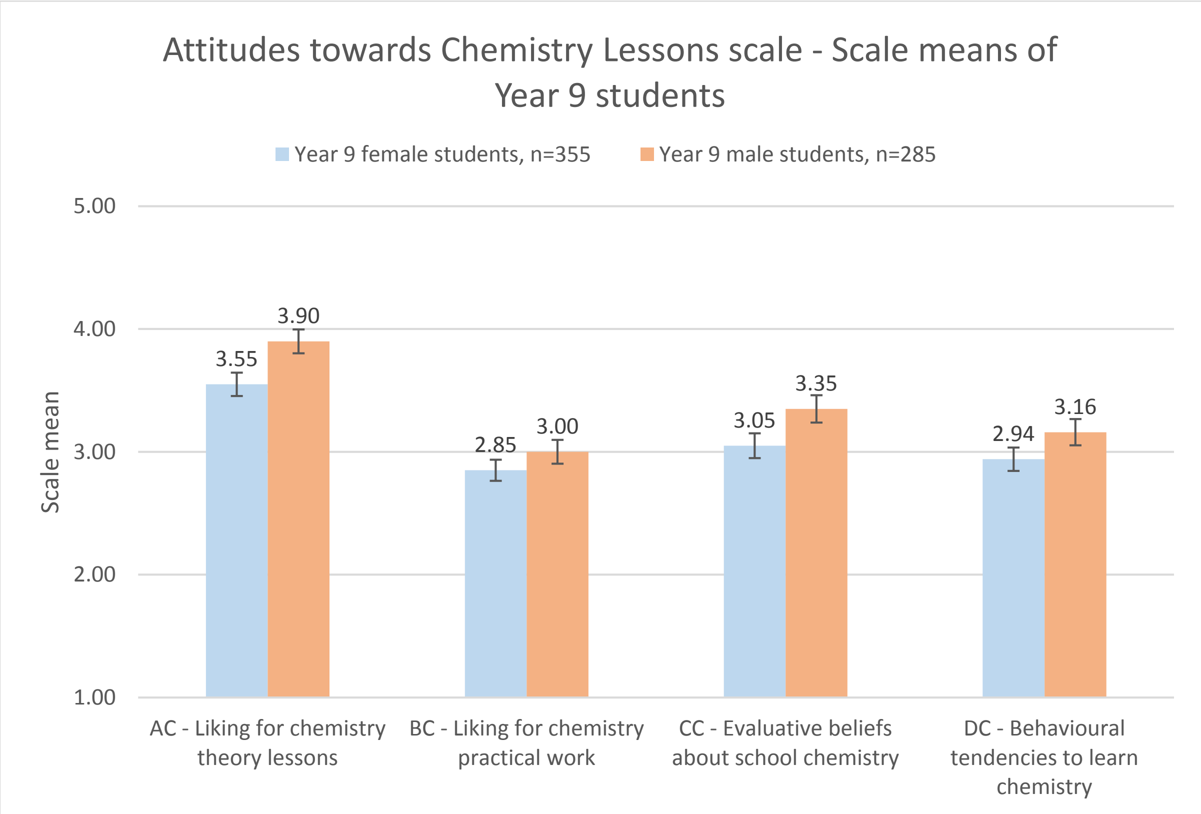


Figure 6-2 Graph showing the differences between Year 9 female and male students' subscale means. Error bars show the 95% confidence interval.

Figure 6-2 highlights that there are statistically significant differences between the attitudes of male and female students in Year 9 towards the AC, CC and DC subscales. The data suggests that Year 9 male students have more positive attitudes towards liking for chemistry theory lessons, evaluative beliefs about school chemistry and behavioural tendencies to learn chemistry than female students in Year 9. However, there are no statistical differences between the attitudes of male and female Year 9 students towards chemistry practical work, which suggests that students of both genders have neutral to mildly negative attitudes towards chemistry practical work. It is interesting to note that the scale means of both students of genders follow the same trends, which suggests that although statistically valid differences between female and male students' attitudes exist, they are not dissimilar.

Lesson Structure and Theory Issues

22.6% of female Year 9 students picked response F as their first choice response compared with 8% of male Year 9 students, which indicates that a larger proportion of female students feel that they would benefit from clearer explanations of chemistry topics compared with male students. This may be linked to female students' less positive attitude towards chemistry theory lessons when compared to male students. Kahle and Lakes (1983) suggested that female students tend to have less positive attitudes towards science in general as an effect of cultural socialisation which offers young girls considerably less opportunity to "tinker with technological devices and use common measuring instruments" outside of a school environment (Osborne, Simon et al. 2003). More importantly, Kahle argued that her data showed that a "lack of experiences in science leads to a lack of understanding *of* science and contributes to negative attitudes to science" (italics stress that emphasis should be placed on the word 'of'), which would suggest that female students have fewer external "experiences" of science. Unfortunately, this was not an avenue of investigation that could have been explored in this research. Although one may argue that the recent rise of personal technology has increased opportunities for "tinkering", a more recent study by Jones et al. (2000) in which they explored the experiences and interests of 437 Grade 6 students (11-12 year olds) suggests that the situation has remained relatively unchanged. Other researchers have argued that female students are more likely to make comparative judgements across academic domains than male students, which could mean that their declining perception of their ability to do chemistry may reflect that they simply perceive themselves to be better at other subjects (Jovanovic and King 1998).

Response D gained the largest percentage of votes from male Year 9 students with 21.8%, compared with 15% of female votes, which suggests that a large percentage of male students do not feel that their chemistry lessons are interactive enough.

> *"We don't do as many experiments in chemistry"*
> A response from a male Year 9 student at an Academy school that picked response D as their first choice.

This quote demonstrates a typical response from male students that picked response D, which indicates that male students are more likely to associate interactive learning solely with practical work, whereas female students are more likely to associate interactive lessons with an increase in being able to “concentrate” and “understand”.

The attitudinal scale indicated that male students held a more positive attitude towards chemistry theory lessons than female students, which suggests that a lack of understanding of chemistry topics has a greater effect on the attitude female students towards the subscale. The data also implies that a lack of interactive chemistry lessons does not negatively affect the attitudes of male students towards chemistry theory lessons in relation to the attitudes of female students towards the subscale.

Curriculum Issues

A greater percentage of male students picked response H as their first choice response than female students (H: male students = 14.2%, female students = 10.8%) which suggests that male students are more concerned about the relevance of chemistry topics to their lives. The higher percentage of male students interested in having more relevant topics combined with their slightly more positive attitude towards the ‘Evaluative beliefs about school chemistry’ subscale indicates that male students consider chemistry to be important to their lives but do not see this reflected in their chemistry lessons.

> *“Compared to other elements of science, there is never anything that explains chemistry in the context of real life, compared to biology or physics.”*
> A response from a male Year 9 student from an Academy school that picked H as his first choice response.

This response also suggests that the inability of chemistry lessons to be relevant to students’ lives is harming its reputation in relation to other science disciplines, a finding supported by the research of Osborne et al. (2003).

6.1.2.2 Gender differences – Year 10/11

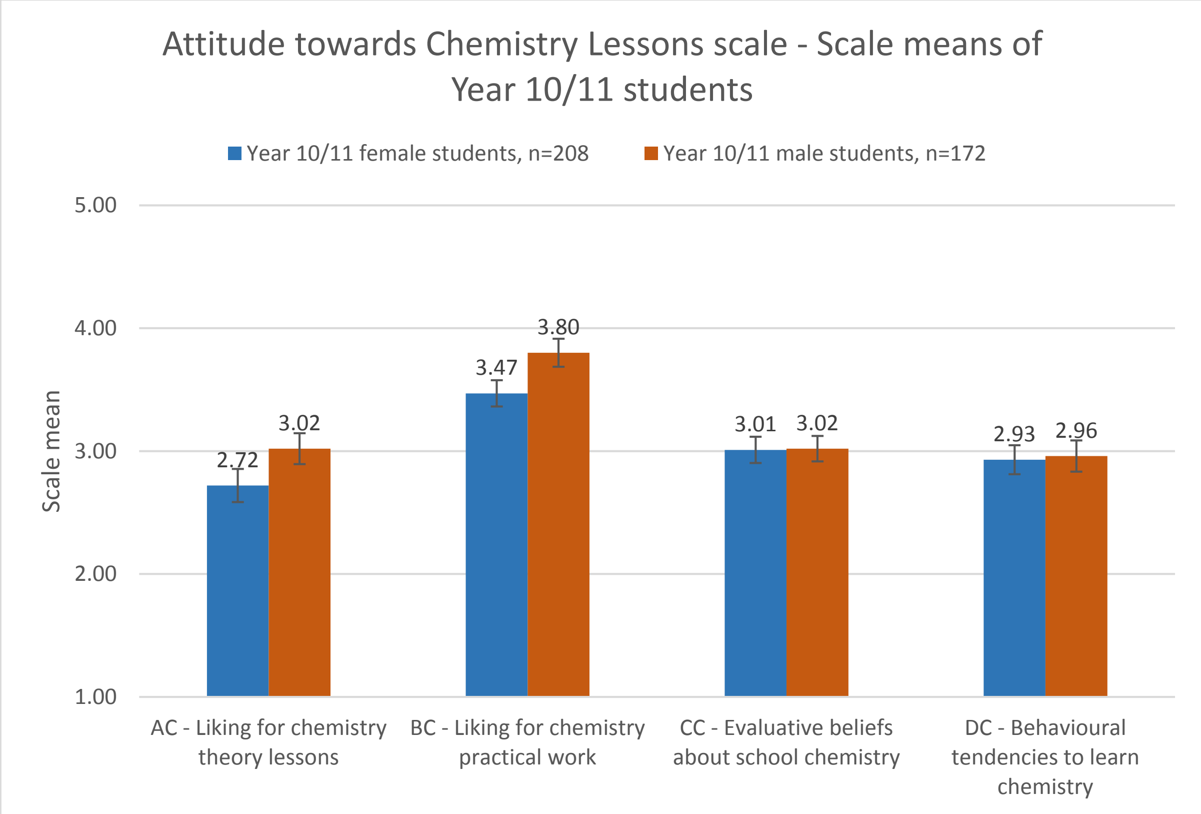


Figure 6-3 Graph showing the differences between Year 10/11 female and male students' subscale means. Error bars show the 95% confidence interval.

Figure 6-3 illustrates the differences between female and male students in Year 10/11, and shows that students across this year group held the most neutral/mildly negative attitudes towards chemistry lessons. The data shows that male chemistry students hold more positive attitudes towards chemistry theory lessons and chemistry practical work than female students, however the only subscale that featured scale means suggesting a strongly positive attitude across both genders was BC – Liking for chemistry practical work. The scale means of students of both genders suggests that chemistry students in Year 10/11 hold neutral/mildly negative attitudes towards evaluative beliefs about school chemistry (CC) and behavioural tendencies to learn chemistry (DC).

Classroom Dynamics and Lesson Structure Issues

The data suggests that the attitudes held by female chemistry students in Year 10/11 towards chemistry theory lessons are mildly negative in comparison to those held by male students in the same year group. Students' responses to Question 3 indicate that a large proportion of female students are affected by what they feel to be a lack of group work (response B = 19.4%), a lack of clear explanations of chemistry topics (response F = 18.4%) and a significant amount of classroom disruption from other students (response K = 10.5%). 15% of female students picked response H as their first choice, which indicates that their negative attitudes towards theory lessons are linked to beliefs that chemistry topics are irrelevant to their lives.

Lesson Structure Issues

Although male students technically hold more positive attitudes towards chemistry theory lessons in relation to female students, the data suggests that their attitudes are indifferent as they are close to 3.00 (see Table 4-3). The high percentage of male students that picked factors related to lesson structure issues suggest that their indifferent attitudes are related to a perceived lack of clear explanations of topics (response F = 15.7%) and interactive lessons (response D = 14%).

Practical Issues

Although female students in Year 10/11 hold slightly less positive attitudes towards chemistry practical work than male students, responses concerning practical work formed 6.3% (response A) and 8.3% (response J) of female students' first choices compared with 17.4% (response A) and 9.9% (response J) of male students' answers. This suggests that the majority of female Year 10/11 chemistry students do not consider practical work as being the aspect that if improved, would have the most positive impact on their attitudes towards chemistry lessons. In comparison, the data suggests that a large percentage of male students in Year 10/11 believe that an improvement in the quality of chemistry practical work would have the most positive impact on their attitudes towards chemistry lessons, which links with their more positive attitudes towards the subscale.

> *"I like practicals and feel they help my learning"*
> A response from a male Year 10/11 student from an Academy grammar school that picked J as their first choice response.

This response was typical of many male students that linked their enjoyment of practical work with a perception that it must help their learning, which suggests that male students do not experience the increase in negative attitudes towards practical work observed by Sharpe (2012) due to older students believing that they do not aid conceptual understanding.

6.1.2.3 Differences between female students in Years 9 and 10/11

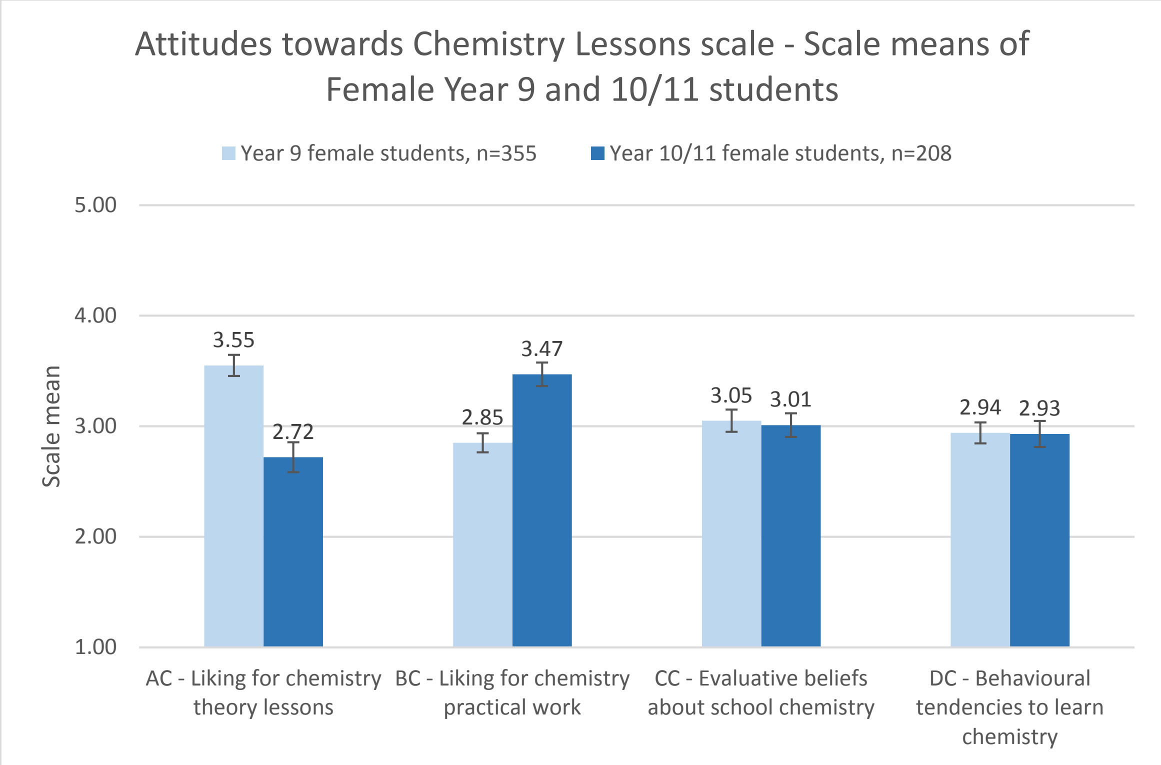


Figure 6-4 Graph showing the differences between female respondents' scale means to the Attitudes towards Chemistry Lessons scale. Error bars show the 95% confidence interval.

Figure 6-4 illustrates the differences between the attitudes of female chemistry students across Year 9 and Year 10/11. The data suggests that female students in Year 9 hold positive attitudes towards chemistry theory lessons whereas female students in Year 10/11 hold mildly negative attitudes. The opposite is true with attitudes towards chemistry practical work, in that female Year 9 students hold mildly negative attitudes towards the subscale, which contrasts with the positive attitudes held by female Year 10/11 students. Female students across both year groups hold similar attitudes towards evaluative beliefs about school chemistry (relatively neutral) and behavioural tendencies to learn chemistry (neutral/negative).

Classroom Dynamics, Lesson Structure Issues and Curriculum Issues

Responses to Question 3 suggest that the attitudes of female students in Year 10/11 towards chemistry theory lessons are strongly linked to their beliefs that chemistry lessons lack satisfactory levels of group work (response B = 19.4%), clear explanations of topics (response F = 18.4%) and relevant topics (response H = 15%).

> *"I feel as though we are not told how this relates to our everyday lives. It is more as though you have to learn this, just so you can pass your exams not because it is a fun and interesting part of doing chemistry"*
> A response from a female Year 10/11 student from an academy school that picked H as their first choice.

10.8% of female students in Year 9 picked response H compared with 15% of female students in Year 10/11. This quote is representative of the reasoning provided by the majority of female Year 10/11 that picked response H and indicates that female students become more disconnected from the relevance of chemistry lessons as they get older. The percentage of female students that picked response K – 'I would prefer my chemistry lessons if they were not disrupted by other students' increased from 3.4% of Year 9 students to 11.7%, which suggests that older female students are more affected by classroom disruption than younger students.

A higher percentage of female students in Year 9 picked response F and a reoccurring theme within the open answer responses was that female Year 9 students struggled with differentiating chemistry topics from other scientific disciplines. This indicates that their relatively positive attitudes towards the subscale is due to a lack of experience and understanding about what chemistry consists of. This may be as a result of Year 9 students in certain schools not receiving separate chemistry, physics and biology lessons until they start preparing for GCSEs (more information can be found in Chapter 3.3, page 30).

Practical Issues

The relatively negative attitude female students in Year 9 possess towards chemistry practical work can be rationalised by the high percentages of students that picked factors suggesting a desire for more interactive lessons (response D: Year 9 females = 15%, Year 10/11 females = 10.2%).

> *"Because I found it easier to learn when the lesson is interactive for example making a poster or doing an experiment"*
> A response from a female Year 9 chemistry student from an Academy school that picked D as her first choice response.

This response was indicative of the viewpoints of the majority of Year 9 female students that picked response D, and suggests that younger female students are more likely to consider other forms of activities as "interactive" in addition to practical work. The percentages of female students that picked responses related to practical issues were not dissimilar (response A: Year 9 females = 6%, Year 10/11 females = 6.3%) (Response J: Year 9 females = 9.4%, 8.3%), which indicates that younger female students simply prefer other forms of “interactive” activities other than practical work. The increase in positive attitudes towards chemistry practical work exhibited by female students in Year 10/11 appears to be linked to their need for more group work (B: Year 9 = 15.7%, Year 10/11 = 19.9%), as the qualitative responses seem to indicate that as female students grow older, they are more appreciative of chemistry practical work due to an increased appreciation for group based activities.

6.1.2.4 Differences between male students in Years 9 and 10/11

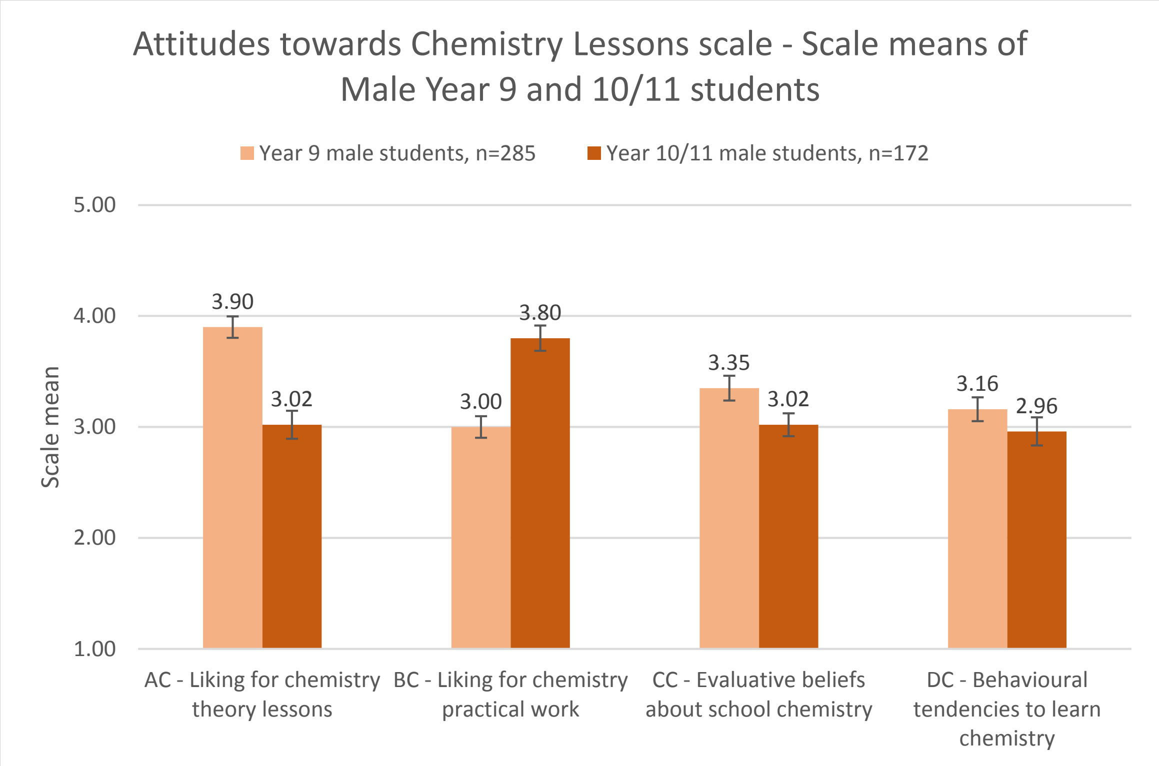


Figure 6-5 Graph showing the differences between male respondents' scale means to the Attitudes towards Chemistry Lessons scale. Error bars show the 95% confidence interval.

Figure 6-5 shows that there are notable differences between the attitudes of male students in Years 9 and 10/11, which follow a similar trend to the differences between female students in Years 9 and 10/11 in that there are large differences in attitude between students in different year groups towards the AC and BC subscales. Male students in Year 9 hold positive attitudes towards chemistry theory lessons whilst having neutral attitudes towards chemistry practical work, while the opposite is true for male students in Year 10/11. Male Year 9 students hold slightly more positive attitudes towards evaluative beliefs about school chemistry but there is no statistically valid difference between the attitudes of male chemistry students towards their behavioural tendencies to learn chemistry.

Classroom Dynamics

As male chemistry students progress from Year 9 to Year 10/11, the data suggests that they find their chemistry lessons more interactive and that their ability to recognise chemistry topics as belonging to the discipline of chemistry increases. This could be directly related to the fact that during Year 10/11, students are actively preparing to take GCSE exams which usually results in the separation of science into its three constituent subjects (Education 2013).

The responses of male chemistry students to Question 3 suggest that the attitudes of male students in Year 10/11 towards chemistry theory lessons are indifferent (scale mean = 3.02) because they find the topics difficult (response F = 15.7%), the levels of group work (response B = 15.7%) and interaction with chemistry lessons to be lacking (response D = 14%). Classroom disruption also appears to be an issue that affects a larger percentage of male Year 10/11 students more than those in Year 9 (K: Year 9 = 6.6%, Year 10/11 = 10.5%), which could also be linked to the less positive attitude towards chemistry theory lessons held by male Year 10/11 students.

Practical Issues

Factors relating to practical work were the 4th and 5th most popular response for male students in Year 9 (A = 13.1%, J = 10.1%), compared with response A which was the most popular response for male students in Year 10/11 (A = 17.4%). This suggests that as male chemistry students mature in age, the importance of having high quality practical work increases.

> *"The practical experiments we usually perform are very simple, already proven and outdated. I would like to perform experiments that reveals data that could not be found through a simple Google search."*
> A response from a male Year 10/11 Academy school student that picked response A as his first choice response.

This quote is indicative of the reasoning of the majority of male students in Year 10/11 that picked response A as their first choice and implies there is a correlation between their attitude towards chemistry practical work and the extent to which they see practical work as useful and important to their learning. Once again, these findings contradict the research of Sharpe (2012) into students' attitudes towards practical work, as this research suggests that although students' attitudes towards practical work declines over the academic years, students' attitudes towards chemistry practical work increase from Year 9 to Year 10/11.

Table 6-3 Attitudes towards Chemistry Lessons scale – Gender differences statistical results table, where N=number of responses, SD=standard deviation.

Attitude towards Chemistry Lessons scale – Gender differences																		
			Year 9 female students				Year 9 male students				Year10/11 female students				Year 10/11 male students			
Scale	Item		N	Scale Mean	SD	Relative SD	N	Scale Mean	SD	Relative SD	N	Scale Mean	SD	Relative SD	N	Scale Mean	SD	Relative SD
AC - Liking for chemistry theory lessons	A1C	I like chemistry more than any other subject at school.	355				285				208				172			
	A2C	I find chemistry lessons interesting.	355	3.55	0.92	25.9%	285	3.90	0.84	21.4%	208	2.72	0.99	36.4%	172	3.02	0.84	30.0%
	A3C	Chemistry is one of my favourite subjects.	355				285				208				172			
BC - Liking for chemistry practical work	B1C	I like to do chemistry experiments.	355				285				208				172			
	B2C	When do practical work, I feel I am doing something important.	355	2.85	0.83	29.0%	285	3.00	0.84	27.9%	208	3.47	0.79	22.7%	172	3.80	0.76	17.3%
	B3C	Doing chemistry experiments in school is fun.	355				285				208				172			
CC - Evaluative beliefs about school chemistry	C1C	Chemistry is useful for solving everyday problems.	355				285				208				172			
	C2C	People must understand chemistry because it affects their lives.	355	3.05	0.97	31.8%	285	3.35	0.96	28.7%	208	3.01	0.79	21.4%	172	3.02	0.69	18.9%
	C3C	Chemistry is one of the most important subjects for people to study.	355				285				208				172			
DC - Behavioural tendencies to learn chemistry	D1C	I am willing to spend more time reading chemistry books.	355				285				208				172			
	D2C	I like trying to solve new problems in chemistry.	355	2.94	0.91	31.0%	285	3.16	0.92	29.3%	208	2.93	0.87	21.4%	172	2.96	0.85	27.4%
	D3C	If I had a chance, I would do a project in chemistry.	355				285				208				172			

6.1.3 School type differences – Attitudes towards Chemistry Lessons scale

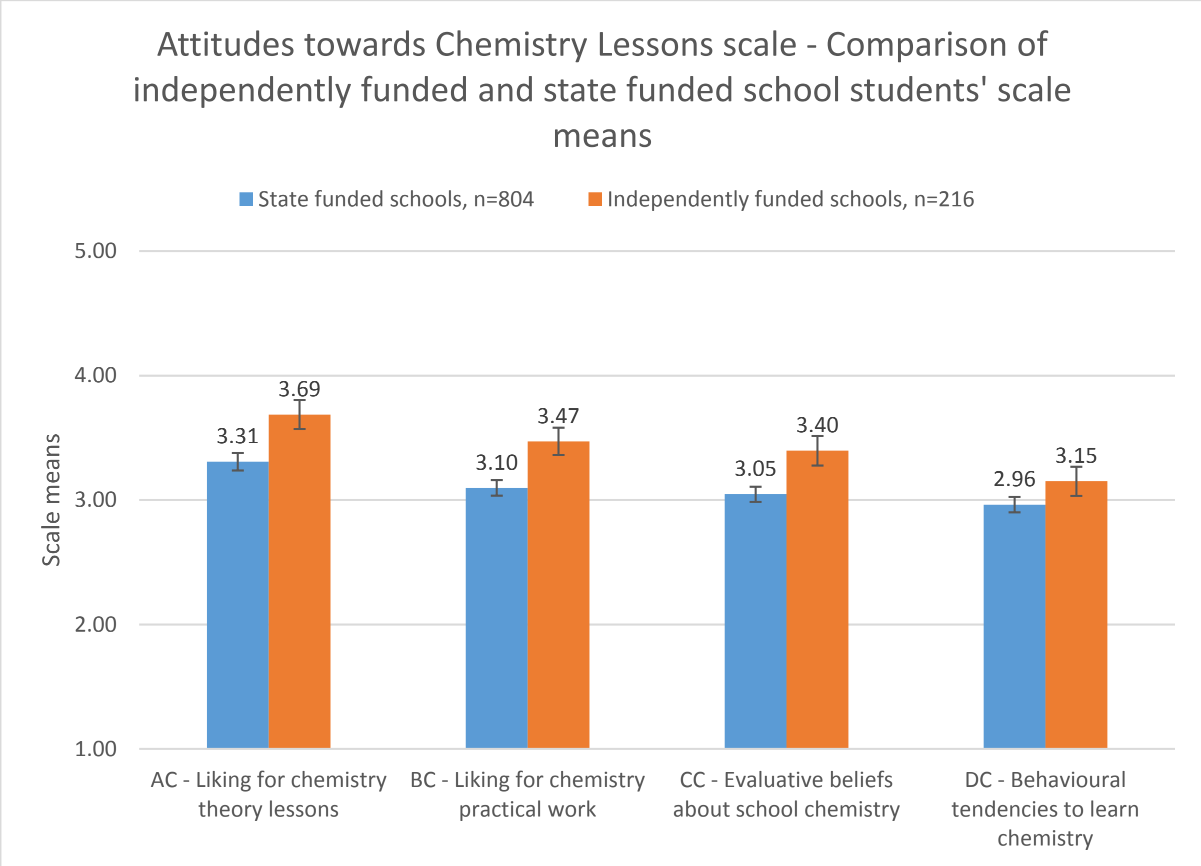


Figure 6-6 Graph comparing the scale means of all respondents to the Attitudes towards Chemistry Lessons scale from independently funded and state funded schools. Error bars display the 95% confidence interval.

Figure 6-6 shows that chemistry students from independently funded schools hold more positive attitudes towards all of the attitudinal subscales compared with chemistry students from state funded schools. As the scale means from students studying at state funded schools are close to the value of 3.00, the data suggests that chemistry students are indifferent towards chemistry lessons. However, chemistry students across all schools appear to share the same trends in attitude in which there is a decrease in positive attitude from subscale AC to DC.

Classroom Dynamics and Lesson Structure Issues

The responses to Question 3 suggest that a higher percentage of students in state funded schools are dissatisfied with the amount of group work (response B: independently funded schools = 11.7%, state funded schools = 17.7%) and interactive components (response D: independently funded schools = 12.1%, state funded schools = 16.7%) in their chemistry lessons compared with

those in independently funded schools.
A slightly greater percentage of students in independent schools picked response K than students in state funded school, which suggests that more independent school students are affected by classroom disruption caused by other students. However, the open answer responses show that students in different types of schools have very diverse descriptions of what they consider to be classroom disruption. Students in independent schools tended to consider low level disruptions like loud talking from other students as being problematic, whilst students in state funded schools that picked response K as their first choice tended to complain about higher levels of disruption that often resulted in the prevention of teaching.

> *'I understand and learn topics in Chemistry better if I can figure them out on my own. Working in a group is not helpful.'* A response from a female Year 10/11 student from an independently funded school that picked response K as her first choice response.

> *'BECAUSE I CAN'T CONCENTRATE SOMETIMES WHEN THERE IS TALKING'* A response from a male Year 9 student from an independently funded school that picked K as his first choice response.

> *'Because my lessons are always disturbed by other students who find the lesson boring, hard, or would just rather be plain rude and not listen to the teacher, talk back to them, and stop me from learning. It's annoying because I would like to do well in my Chemistry Exam but am being held back by other people who think it's funny to mess around and not think of others.'* A response from a female Year 10/11 student from a state funded school that picked K as her first choice response.

Practical Issues

The percentage of students in state funded schools that expressed an interest in increasing the amount of practical work was more than double the percentage of students from independently funded schools. Conversely, the percentage of students in independently funded schools that wanted better quality practical work was almost double the percentage of state school students that picked the same response. This suggests that a larger percentage of state school students are unsatisfied with the level of chemistry practical work they have, compared with students from independent schools.

> *'Sometimes we do experiments which are interesting, but I'm not clear on exactly what's going on. It can be simply a matter of following the method and not understanding the*

> *chemistry.'* A response from a male Year 10/11 student from an independent school that picked A as his first choice response.

However, this quote was representative of the majority of respondents from independent schools that picked response A, and indicates that students from independent schools may be experiencing 'quantity over quality' when it comes to chemistry practical work which explains their interest in improving the standard.

Table 6-4 Attitudes towards Chemistry lessons scale – School type differences statistical results table, where N=number of responses, SD=standard deviation.

Attitude towards Chemistry Lessons scale – School type differences										
			Students in state funded schools				Students independently funded schools			
Scale	Item		N	Scale Mean	SD	Relative SD	N	Scale Mean	SD	Relative SD
AC - Liking for chemistry theory lessons	A1C	I like chemistry more than any other subject at school.	804	3.31	1.02	30.8%	216	3.69	0.88	23.8%
	A2C	I find chemistry lessons interesting.	804				216			
	A3C	Chemistry is one of my favourite subjects.	804				216			
BC - Liking for chemistry practical work	B1C	I like to do chemistry experiments.	804	3.10	0.88	28.4%	216	3.47	0.83	23.9%
	B2C	When do practical work, I feel I am doing something important.	804				216			
	B3C	Doing chemistry experiments in school is fun.	804				216			
CC - Evaluative beliefs about school chemistry	C1C	Chemistry is useful for solving everyday problems.	804	3.05	0.89	29.2%	216	3.40	0.90	26.5%
	C2C	People must understand chemistry because it affects their lives.	804				216			
	C3C	Chemistry is one of the most important subjects for people to study.	804				216			
DC - Behavioural tendencies to learn chemistry	D1C	I am willing to spend more time reading chemistry books.	804	2.96	0.90	30.4%	216	3.15	0.87	27.6%
	D2C	I like trying to solve new problems in chemistry.	804				216			
	D3C	If I had a chance, I would do a project in chemistry.	804				216			

Chapter 7: Conclusion

The research project had four main aims which were all achieved successfully:

1. To assess the suitability of existing attitudinal scales in order to find one suitable for the purpose of quantitatively measuring the attitudes of secondary school students towards science and chemistry lessons in the UK across KS3 and KS4 (Year 7 – 11)

The original Attitudes towards Chemistry Lessons Survey (Cheung 2009) was identified as being a suitable starting point for the investigation of students' attitudes towards science and chemistry lessons in the UK. The full discussion of existing attitudinal scales can be found in Chapter 2 - The Development and Validation of Existing Attitudinal Surveys.

2. To identify a range of factors that affect students' attitudes towards science and chemistry lessons by interviewing students in focus groups

A preliminary research phase was conducted in order to identify the factors that most impacted students' attitudes towards science and chemistry lessons. Focus groups were conducted with 69 students from Years 7 – 11 in four different secondary schools using the novel Post-It note method, and the resulting qualitative data were coded in order to identify the most common factors. This resulted in the creation of a map of factors that detailed the issues affecting students' attitudes towards science and chemistry lessons, and a core of 11 factors that were implemented into a multiple choice question. More information can be found in Chapter 3 - Modification of the ATCLS – Findings of the Preliminary Research.

3. To modify the survey by the addition of qualitative questions created from the factors revealed by the focus groups and preliminary research, with the purpose of allowing students to explain the reasoning behind their attitudes

The addition of new questions to the original ATCLS and separation into two scales measuring both attitudes towards chemistry and science lessons heralded the creation of the ATCSLS. A full description of the process can be found in Chapter 3 - Modification of the ATCLS – Findings of the Preliminary Research.

4. To deploy the survey online, and identify whether any trends persist between the attitudes of students of different genders, year groups or types of schools (state funded or fee paying)

The newly created ATCSLS was deployed to secondary school teachers and resulted in responses from 1654 students from the UK. The construct validity of the resulting data was tested using confirmatory factor analysis which confirmed that the scale was suitably reliable. The findings of the survey will be not be discussed in detail in this chapter as they have been explored in depth in the previous results chapters, however the key results from the attitudinal scales will be summarised in order to conclude the research.

7.1 Summary of survey results - Attitudes towards Science Lessons

Students' attitudes towards science lessons were measured according to their attitudes towards four distinct subscales, and the attitudes of various demographics of students towards each of the subscales were compared. Full details including the discussion of the multiple choice questions in which students were asked to explain their reasoning behind their attitudes towards science lessons can be found in Results Chapter 2 (page 65).

Liking for science theory lessons

Younger students were found to hold the most positive attitudes towards science theory lessons, as Year 7 students (3.32) had a higher mean score for the subscale than Year 9 students (3.10). However, the scores also indicate that the positive attitudes held by science students are not strong as the scores are close to the neutral score of 3.00.

Female students consistently held less positive attitudes towards science theory lessons across both year groups, however the difference between the scores of male and female students was observed to be greater in Year 9. The results of the scale indicated that female students in Year 9 held attitudes that could be considered to be mildly negative to neutral towards science theory lessons (2.96).

Science students in state funded schools held less positive attitudes towards science theory lessons when compared to science students in independently funded schools, with mean scores of 3.14 and 3.58 respectively.

Liking for science practical work

Year 7 students were found to have strong, positive attitudes towards science practical work, with a mean score of 4.20. Although the attitudes of Year 9 students towards practical work were positive, they were still significantly less positive than those held by younger students, at 3.83.

The attitudes of male and female students in Year 7 towards science practical work were found to be very similar and strongly positive, however the attitudes of female students in Year were found to be significantly lower, although still positive. Although the attitudes of male students in Year 9 were also less positive than the attitudes of male students in Year 7, there were less positive by a smaller margin.

The attitudes of students attending both state funded and independently funded schools were similarly very positive, with no statistically significant differences.

Evaluative beliefs about school science lessons

Science students across Year 7 and 9 were found to have positive attitudes towards the evaluative beliefs about school science subscale, and no statistically significant differences were found between the two year groups.

No statistically valid differences between the attitudes of male and female students across the two year groups were found, and all students were found to have positive attitudes towards evaluative beliefs about school science lessons.

Science students in independent schools held more positive attitudes towards evaluative beliefs about school science lessons compared with students in state funded schools, with mean scores of 3.69 and 3.90 respectively.

Behavioural tendencies to learn science

The attitudes of science students towards the behavioural tendencies to learn science subscale were consistently the lowest of all the attitudinal subscale, however the attitudes of Year 7 students were more positive than the attitudes of Year 9 students, with mean scores of 3.41 and 3.15 respectively.

Male and female students in Year 7 were found to have positive attitudes towards behavioural tendencies to learn science, and even shared the same mean score of 3.41. However, the attitudes of female Year 9 students were closer to neutral (3.07) than the mildly positive attitudes held by male students in the same year group (3.24).

No statistically significant differences were found between the attitudes of students in different types of schools towards the behavioural tendencies to learn science subscale. Science students across all schools were found to have mildly positive attitudes towards behavioural tendencies to learn science, with mean scores of 3.26 for students in state funded schools and 3.36 for students in independently funded schools.

7.2 Summary of survey results - Attitudes towards Chemistry Lessons

Students' attitudes towards chemistry lessons were measured according to their attitudes towards four distinct subscales, and the attitudes of various demographics of students towards each of the subscales were compared. Full details including the discussion of the multiple choice questions in which students were asked to explain the reasoning behind their attitudes towards chemistry lessons can be found in and Results Chapter 3 (page 89).

Liking for chemistry theory lessons

The attitudes of Year 9 students towards chemistry theory lessons were found to be positive, however the attitudes of students in Year 10/11 were found to be mildly negative, with mean scores of 3.71 and 2.85 respectively.

Female students across both year groups were found to have more negative attitudes towards chemistry theory lessons compared to their male counterparts, however the attitudes of students of both genders became more negative as students progressed from Year 9 to Year 10/11. Female students in Year 10/11 had a mean score of 2.72 which indicated a mildly negative attitude towards chemistry theory work, compared to the mean score of 3.55 from female students in Year 9.

Students in independently funded schools held more positive attitudes towards science theory lessons compared with students in state funded schools, with mean scores of 3.69 and 3.31 respectively.

Liking for chemistry practical work

Year 9 students were found to hold positive attitudes towards chemistry practical work whilst students in Year 10/11 were found to have mildly negative attitudes, with scale means of 3.71 and 2.85 respectively.

Female students in Year 9 held mildly negative attitudes towards chemistry practical work whilst female students in Year 10/11 held positive attitudes, with mean scores of 2.85 and 3.47 respectively. The same trend in attitudes was observed amongst male students across the two year groups in that younger male students held more negative attitudes towards practical work compared older students. Male students also tended to have more positive attitudes towards practical work when compared with female students in the same year group.

Students in state funded schools held more negative attitudes towards chemistry practical work than students in independently funded schools, with mean scores of 3.10 and 3.47 respectively.

Evaluative beliefs about school chemistry

No statistically valid differences were found between the attitudes of students across the two year groups towards the evaluative believes about school chemistry subscale. Their attitudes towards the subscale were found to be mildly positive/neutral.

The attitudes of female students in Year 9 and 10/11 towards evaluative beliefs about school chemistry were found to stay consistently neutral across the two year groups. However, the attitudes of male students became less positive as students progressed from Year 9 to Year 10/11, with mean scores of 3.35 and 3.02 respectively.

Students in state funded schools were found to hold more neutral attitudes towards evaluative beliefs about school chemistry than students in independently funded schools who were found to hold positive attitudes, with mean scores of 3.05 and 3.40 respectively.

Behavioural tendencies to learn chemistry

No statistically valid differences in attitude were found between students in Year 9 and 10/11 towards the behavioural tendencies to learn chemistry subscale. Students were found to have neutral attitudes towards behavioural tendencies to learn chemistry.

No statistically significant differences were found between the attitudes of students of different genders towards the behavioural tendencies to learn chemistry subscale. Students were found to have neutral attitudes towards behavioural tendencies to learn chemistry.

Students in independent schools were found to have more positive attitudes towards behavioural tendencies to learn chemistry (3.15) compared to students in state schools who were found to have mildly negative/neutral attitudes towards the subscale (2.96).

7.3 Implications of the research on teaching and the classroom

The research revealed that although there are many distinct factors that affect students' attitudes towards science and chemistry lessons, there are a number of factors that seem to have a significant effect on a large number of secondary school students (see graphs in Appendix B). Issues such as the quality and quantity of practical work, the amounts of group work in lessons and a lack of understanding of why topics are relevant to students all play important roles in students' perception and attitude towards science and chemistry lessons, which means that the question that must now be addressed is "How can these issues be addressed successfully in the classroom environment?".

The data suggest that as students progress through the academic system, greater emphasis should be placed on delivering content that students can relate to, to prevent them from losing interest in science and chemistry lessons. The qualitative results of the survey point to many changes that can be made to KS3 and KS4 science/chemistry curriculums to encourage students to engage more with their lessons, such as moving the delivery of linked topics in chemistry, biology, physics and other subject closer together to help enforce the interconnected nature of science across the curriculum, or modifying the content of the science curriculum to include more modern topics that students can relate better to.

The results of this research and that of Rachael Sharpe (2012) imply that the decisions students make regarding their education and the subjects they choose to pursue are increasingly influenced by exams and their associated pressures. This is increasingly problematic because for students to make the most of their education, they must make the transition from teacher-led instruction to self-directed learning. However, students are unlikely to make the transition whilst studying under the current educational system, as it is one that places the majority of emphasis on exam performance, which allows and somewhat encourages students to regurgitate information for an exam instead of encouraging them to engage with the content on a long-term basis. Poet and children's laureate Michael Rosen argues that the current exam culture swings the focus of education too heavily on "retrieval" and "inference", which minimises the amount of "interpretation" that students are allowed to apply to topics that should be open to interpretation (Rosen 2015). Researchers have described this as the key difference between "schooling" and "education"; schooling is the process of "banking", where deposits of knowledge are made to students by educators (Freire 2014), which appears to be the way the current system operates. The process of education has been described by John Dewey as one "of living and not a preparation for future living", which implies that education should be a fluid process where students and educators are free to share and engage fully (Dewey 1916).

In recent years, developments in neuroscience have demonstrated that learning takes place both in the body and as a social activity (Smith 2015). As a result, it is important for educators to focus creating environments and relationships for learning rather than trying to "deposit" information for retrieval during exams. The flipped learning model can provide a remedy to some of the issues, by shifting the focus of the lesson from the teacher to the learner(s) whilst freeing up classroom time to allow for more meaningful learning opportunities. This can be achieved by a mixture of activities designed to be completed prior to the lesson, such as video lessons, text readings and online collaborative discussions, which can all help to encourage students to take ownership of their education. The results from this project imply that these interventions become increasingly important as students progress through secondary education, as the traditional model appears to be doing nothing to stop students from losing interest in science and chemistry lessons.

The results of the survey also suggest that classroom disruption and lack of group work plays an increasingly detrimental role in the attitudes of students towards science and chemistry lessons as they get older. These factors appear to have a stronger effect on female students than male students. Although female students report classroom disruption as being more of a problem than male students, it would be beneficial for students of all genders to be present in a classroom environment – a sentiment that is reiterated by the research of Caroline Hoxby (2000), which found that male students performed better in mixed ability maths classes when compared to single sex maths classes. To combat these issues, science and chemistry lessons could be taught with smaller groups of students so that teachers can manage the classroom environment more effectively.

7.4 Further Work

The participation of 1654 students resulted in the generation of a large amount of data, especially content rich qualitative data. Unfortunately, due to the time restrictions of this project, the responses to ‘What other changes would you made to your science/chemistry lesson?’ were not utilised fully. In the future, the data resulting from the question should be fully analysed as they may yield interesting and useful information about the true nature of students’ attitudes towards science and chemistry lessons.

The ATCSLS has been successfully used to quantitatively measure students’ attitudes towards science and chemistry lessons, whilst providing a qualitative insight into the reasoning behind students’ attitudes. The findings of this research could help educators and researchers to plan more effective lessons to ensure that students develop and maintain positive attitudes towards chemistry and science lessons. Problems could be made directly addressable during the delivery of lessons, thus reducing the likelihood of students rejecting the sciences as a possible area of further study.

The ATCSLS could be modified to measure students’ attitudes towards biology and physics lessons in future, which would provide a useful, unified tool for the measurement of student attitudes.

The ATCSLS was used to investigate the attitudes of students in the UK towards science and chemistry lessons, but it is important to remember its international origins as the original ATCLS was developed to measure the attitudes of Chinese students. It would be interesting to employ the ATCSLS as it currently stands, or after the necessary modifications to measure the attitudes of students towards science and chemistry lessons in different countries, as researchers would be able to investigate the differences between students’ attitudes across the world using a statistically valid survey instrument.

Finally, the qualitative and quantitative results of the ATCSLS highlight that the current arrangement for delivering science and chemistry content to secondary school students in the UK loses effectiveness as students age. In the future, the ATCSLS should be trialled with a larger sample size of students across the UK in order to further reinforce the message that changes need to be made to the way lessons and education are delivered, and to the organisation of the science and chemistry curricula.

Appendices

Appendix A

Appendix A contains all documents pertaining to the ERGO ethics application.

Introductory verbal statement for focus groups and interview:

Hello, my name is Rachel Koramoah and I am a master's student at the University of Southampton.

For my project, I am investigating the different reasons and factors that affect students' attitudes toward science and chemistry lessons. These factors are important because they could be the difference between you enjoying chemistry/science, or not! In order to do that, I need your help with discovering what those factors are. So today, I am here to ask you a few questions about how you feel about science and/or chemistry.

If at any point you do not want to answer any of the questions, you do not have to. You have been chosen by your teacher to help me with my study, but if you decide that that is not what you want to do, you can leave at any time and your teacher will not hold this against you! If you stay, I will take that to mean that you consent to being involved in the study.

(For recorded group interviews) I will record the group interview on my university laptop so I can transcribe this session later, but before any of the answers you give are used in my study, the answers will be coded so that they are no longer linked to your identity. This means that your answers cannot be traced back to you; so don't be afraid to tell me how you really feel.

(For non-recorded focus groups) All your answers will remain anonymous and cannot be traced back to you; so don't be afraid to tell me how you really feel.

January 2012

Risk Assessment Form

- Please see Guidance Notes for completing the risk assessment form at the end of this document.

Researcher's name: Rachel Koramoah

Part 1 – Dissertation/project activities
What do you intend to do? (Please provide a brief description of your project and details of your proposed methods.) I intend to identify the factors that affect students' attitudes toward science and chemistry lessons in UK schools. This will be achieved by holding a mixture of focus groups and group interviews with students in year 7, 9 and 11, which will be used to inform the design of the main survey. The main survey will be sent out to various schools, and the response from students will be analysed and used to answer the research questions.
Will this involve collection of information from other people? (In the case of projects involving fieldwork, please provide a description of your proposed sample/case study site.) This will involve the collection of information from other people, in the form of group interviews, focus groups and the main survey. The sample size for the initial focus groups/ group interview is around 45-60 students from 4 different schools in the Hampshire area. The sample size for the main survey is hard to determine currently, as a similar project conducted by an undergraduate student received 600 responses, and we are expecting a greater response. As I cannot know how many students will end up taking the survey, the proposed sample size for the second part of the study could be anywhere from 700-5000 students.
If relevant, what location/s is/are involved? Secondary schools in the Hampshire area for the interviews and focus groups. Secondary schools in the UK for the online survey.
Will you be working alone or with others? I will be working alone, under the supervision of David Read and Paul Duckmanton.
Part 2 – Potential safety issues / risk assessment.
Potential safety issues arising from proposed activity? There are no potential safety issues associated with focus groups, group interviews or surveys.
Person/s likely to be affected? None

Likelihood of risk? None
Part 3 – Precautions / risk reduction
Existing precautions: Each school will have their own safety precautions in place.
Proposed risk reduction strategies if existing precautions are not adequate: None

***CONTINUED BELOW** …*

Part 4 – International Travel
If you intend to travel overseas to carry out fieldwork then you must carry out a risk assessment for each trip you make and attach a copy of the International Travel form to this document Download the Risk Assessment for International Travel Form Guidelines on risk assessment for international travel at can be located at: www.southampton.ac.uk/socscinet/safety ("risk assessment" section). Before undertaking international travel and overseas visits all students must: • Ensure a risk assessment has been undertaken for all journeys including to conferences and visits to other Universities and organisations. This is University policy and is not optional. • Consult the University Finance/Insurance website for information on travel and insurance. Ensure that you take a copy of the University travel insurance information with you and know what to do if you should need medical assistance. • Obtain from Occupational Health Service advice on any medical requirements for travel to areas to be visited. • Ensure next of kin are aware of itinerary, contact person and telephone number at the University. • Where possible arrange to be met by your host on arrival. If you are unsure if you are covered by the University insurance scheme for the trip you are undertaking and for the country/countries you intend visiting, then you should contact the University's Insurance Office at insure@soton.ac.uk and check the Foreign and Commonwealth Office website.

Risk Assessment Form for **International Travel attached**	**NO**	**(Delete as applicable)**

Appendix A

Guidance Notes for completing the risk assessment form

The purpose of assessing risks is to ensure everyone works safely. To carry out a Risk Assessment, ask yourself:

- How can the activity cause harm?
- Is it safe to carry out this activity without additional protection/support?
- If someone else is going to do the work, can they do it safely?

Activity

Give a brief outline of the activity/project including the methods to be used and the people to be involved

- Think about everything you are going to do, from start to finish.
- Ensure that you complete the assessment before you commence any work. If you are unsure if your proposed work carries any risk, go ahead and complete the form as the process could highlight some issues which otherwise may not have been aware of.

Potential Safety Issues

- Only list those hazards that you could reasonably expect to cause significant harm or injury.
- Talk to people who have experience of the activity.
- Will the activity involve lone working or potential exposure to violence? For more guidance see the Social Research Association website at www.the-sra.org.uk under Staying Safe.
- Are there any significant hazards due to where the work is to be done?

Who might be affected?

- List anyone who might be affected by the hazards.
- Remember to include yourself, co-workers, your participants and others working in or passing through the area of activity.
- Those more vulnerable or less experienced should be highlighted as they will be more at risk (e.g. children, disabled people or those with medical conditions, people unfamiliar with the area of activity).

Precautions/Risk Reduction

- List the control measures already in place for each of the significant hazards.
- Is the hazard dealt with by the School Health & Safety Policy, or a generic safety method statement?
- Appropriate training is a control measure and should be listed.
- Is the risk a low as is reasonably practical?
- List any additional control measures/risk reduction strategies for each significant hazard (e.g. practical measures, training, improved supervision).

Risk Evaluation

- With all the existing control measures in place do any of the significant hazards still have a potential to cause significant harm? Rank as Low, Medium or High.

Remember

- Risk Assessments need to be suitable and sufficient, not perfect.
- Are the precautions reasonable?
- Is there something to show that a proper check was made?

This information is based on “An Introduction to Risk Assessment” produced by the Safety Office and the Training & Development Unit of the University of Southampton.

UNIVERSITY OF Southampton

ERGO application form – Ethics form

All mandatory fields are marked (M*). Applications without mandatory fields completed are likely to be rejected by reviewers. Other fields are marked "if applicable". Help text is provided, where appropriate, in italics after each question.

1. APPLICANT DETAILS

1.1 (M*) Applicant name:	Rachel Koramoah
1.2 Supervisor (if applicable):	David Read
1.3 Other researchers/collaborators (if applicable): ***Name, address, email, telephone***	

2. STUDY DETAILS

2.1 (M*) Title of study:	What are the different factors that affect the attitude of students towards chemistry as a subject throughout the educational system in the UK?
2.2 (M*) Type of study (*e.g. Undergraduate, Doctorate, Masters, Staff*):	Masters
2.3 i) (M*) Proposed start date:	08/11/2014
2.3 ii) (M*) Proposed end date:	23/12/2015

2.4 (M*) What are the aims and objectives of this study?
Identify the different factors that affect student's attitudes towards chemistry and science Measure student's attitudes toward chemistry across different academic year groups (year 7-11) Identify trends in attitudinal data and factoral data

2.5 (M*) Background to study (*a brief rationale for conducting the study*):
The attitude that a student holds toward a particular subject has been shown to affect the attainment in that particular subject, as well as shaping their academic choices later on in their education. Previous research has highlighted that student attitudes toward science subjects decrease as students move to different key stages through education. There is a lack of research that specialises in the attitudes of UK secondary students toward chemistry, and even less that attempts to identify the factors behind the attitudes of students. This information could be pivotal in helping researchers and educational practitioners to gain a better understanding of the factors affecting students of chemistry, and can ensure that relevant, effective interventions are developed and implemented.

2.6 (M*) Key research question (*Specify hypothesis if applicable*):

UNIVERSITY OF Southampton

ERGO application form – Ethics form

All mandatory fields are marked (M*). Applications without mandatory fields completed are likely to be rejected by reviewers. Other fields are marked "if applicable". Help text is provided, where appropriate, in italics after each question.

1. APPLICANT DETAILS

1.1 (M*) Applicant name:	Rachel Koramoah
1.2 Supervisor (if applicable):	David Read
1.3 Other researchers/collaborators (if applicable): ***Name, address, email, telephone***	

2. STUDY DETAILS

2.1 (M*) Title of study:	What are the different factors that affect the attitude of students towards chemistry as a subject throughout the educational system in the UK?
2.2 (M*) Type of study (***e.g. Undergraduate, Doctorate, Masters, Staff***):	Masters
2.3 i) (M*) Proposed start date:	08/11/2014
2.3 ii) (M*) Proposed end date:	23/12/2015

2.4 (M*) What are the aims and objectives of this study?
Identify the different factors that affect student's attitudes towards chemistry and science Measure student's attitudes toward chemistry across different academic year groups (year 7-11) Identify trends in attitudinal data and factoral data

2.5 (M*) Background to study (***a brief rationale for conducting the study***):
The attitude that a student holds toward a particular subject has been shown to affect the attainment in that particular subject, as well as shaping their academic choices later on in their education. Previous research has highlighted that student attitudes toward science subjects decrease as students move to different key stages through education. There is a lack of research that specialises in the attitudes of UK secondary students toward chemistry, and even less that attempts to identify the factors behind the attitudes of students. This information could be pivotal in helping researchers and educational practitioners to gain a better understancing of the factors affecting students of chemistry, and can ensure that relevant, effective interventions are developed and implemented.

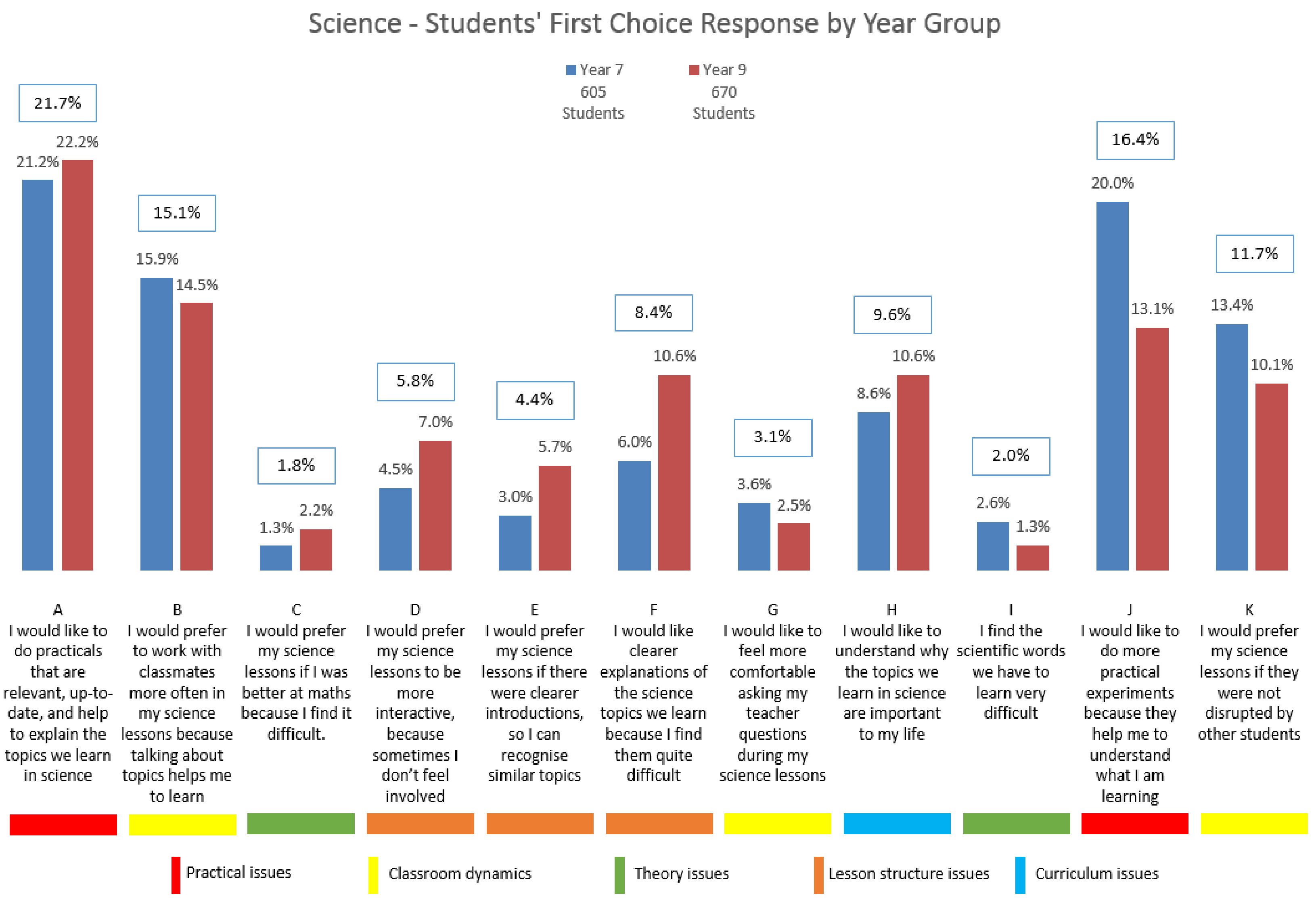
2.6 (M*) Key research question (***Specify hypothesis if applicable***):

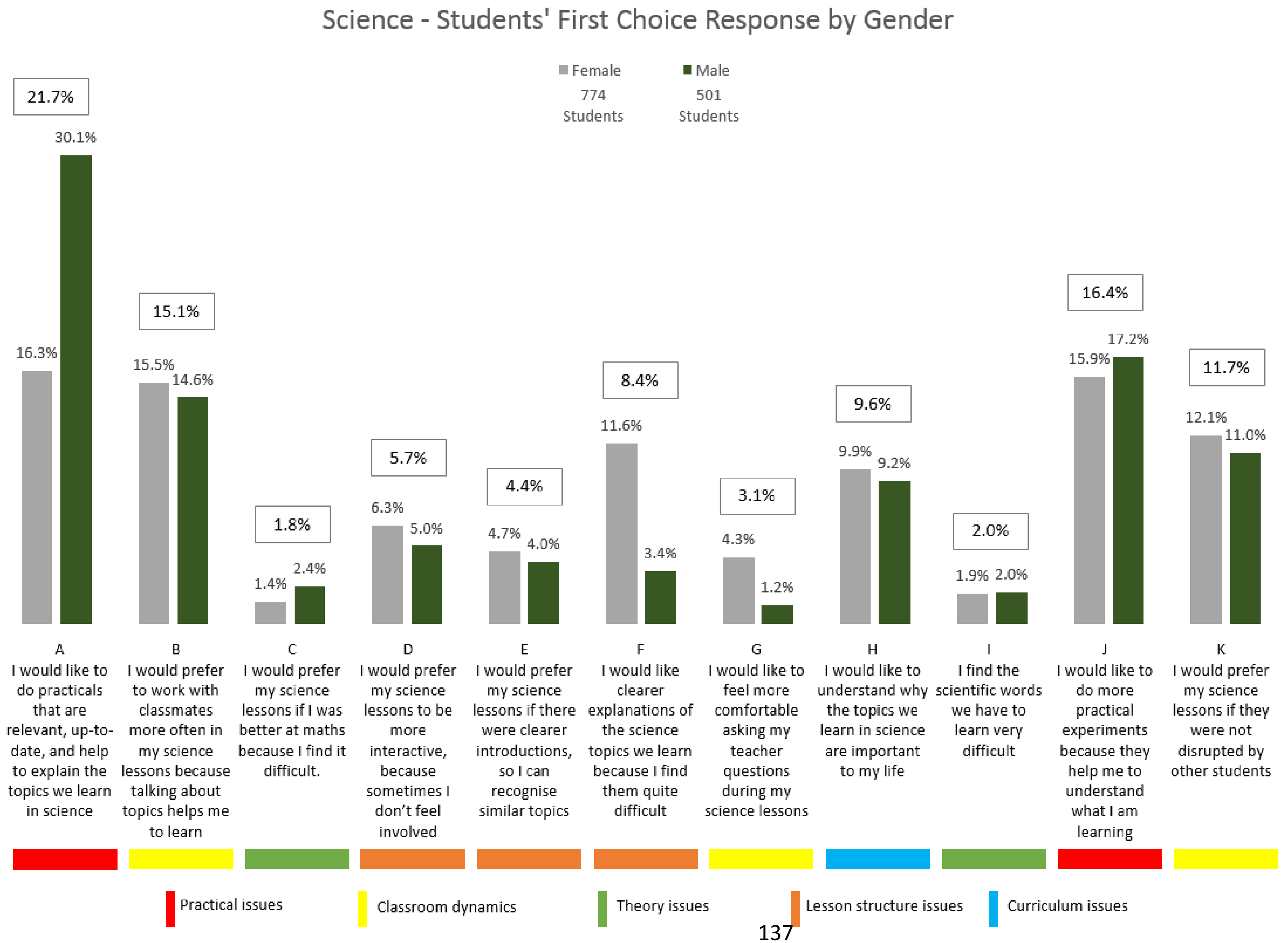
Appendix B

Appendix B contains all graphs that display the percentages of students' first choice responses for each factor, in response to survey Question 3.

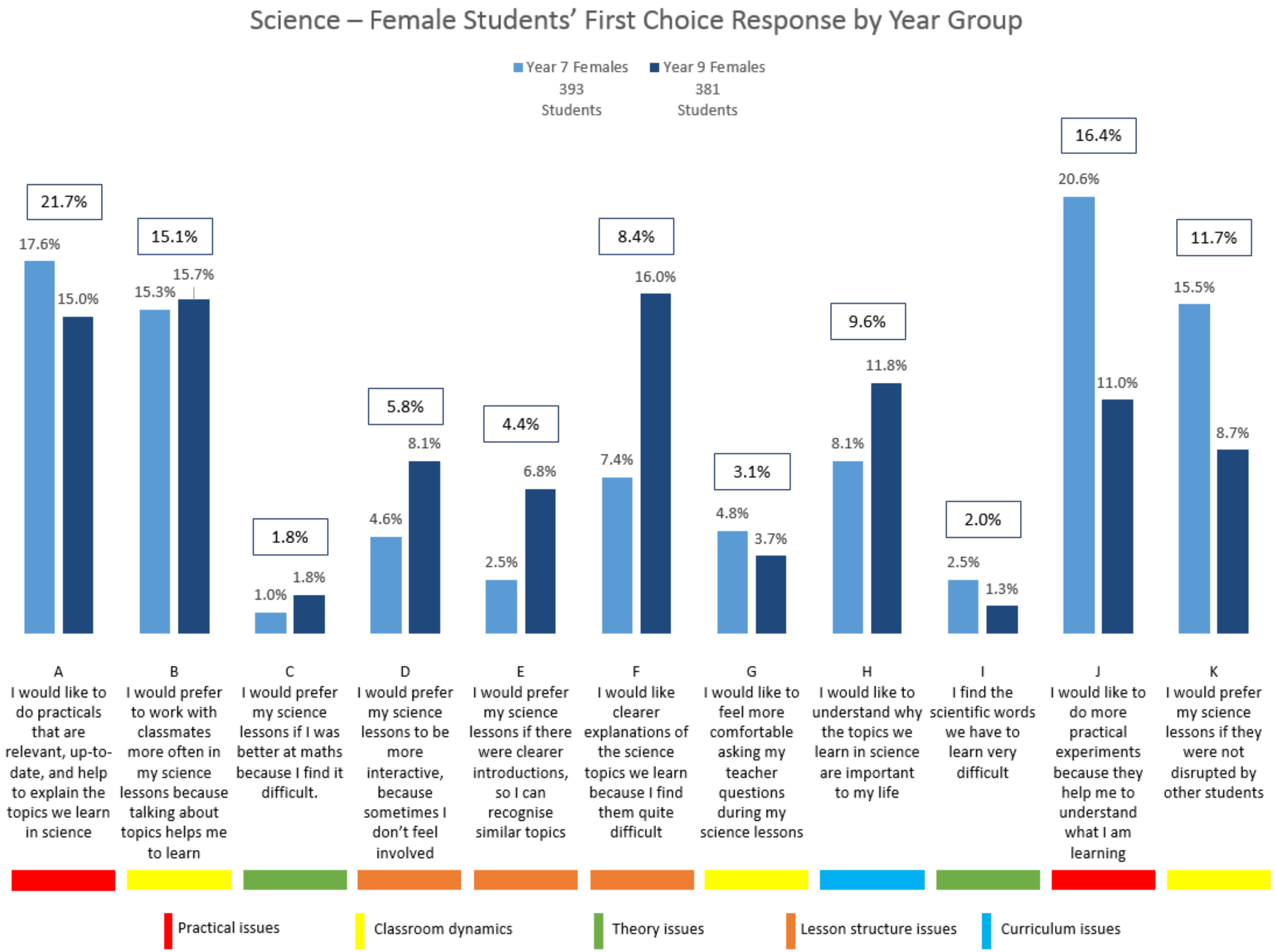
Percentages in boxes are the average percentage of respondents across the demographic, e.g. all science students or all chemistry students.

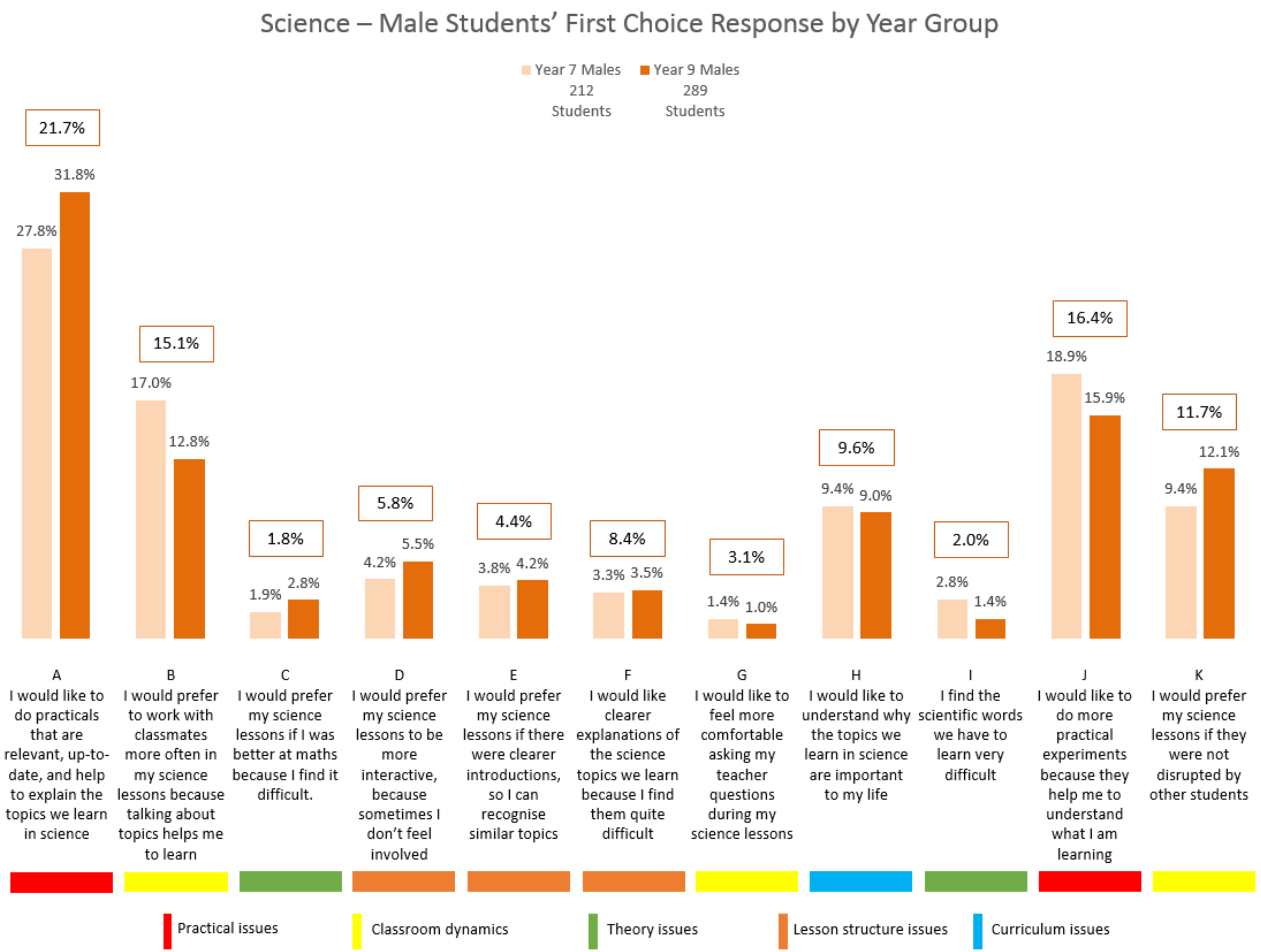
Appendix B


Science - Students' First Choice Response by Year Group
Year 7
605 Students
Year 9
670 Students
21.7%
21.2%
22.2%
15.1%
15.9%
14.5%
1.8%
1.3%
2.2%
5.8%
4.5%
7.0%
4.4%
3.0%
5.7%
8.4%
6.0%
10.6%
3.1%
3.6%
2.5%
9.6%
8.6%
10.6%
2.0%
2.6%
1.3%
16.4%
20.0%
13.1%
11.7%
13.4%
10.1%
A
I would like to do practicals that are relevant, up-to-date, and help to explain the topics we learn in science
B
I would prefer to work with classmates more often in my science lessons because talking about topics helps me to learn
C
I would prefer my science lessons if I was better at maths because I find it difficult.
D
I would prefer my science lessons to be more interactive, because sometimes I don't feel involved
E
I would prefer my science lessons if there were clearer introductions, so I can recognise similar topics
F
I would like clearer explanations of the science topics we learn because I find them quite difficult
G
I would like to feel more comfortable asking my teacher questions during my science lessons
H
I would like to understand why the topics we learn in science are important to my life
I
I find the scientific words we have to learn very difficult
J
I would like to do more practical experiments because they help me to understand what I am learning
K
I would prefer my science lessons if they were not disrupted by other students
Practical issues
Classroom dynamics
Theory issues
Lesson structure issues
Curriculum issues

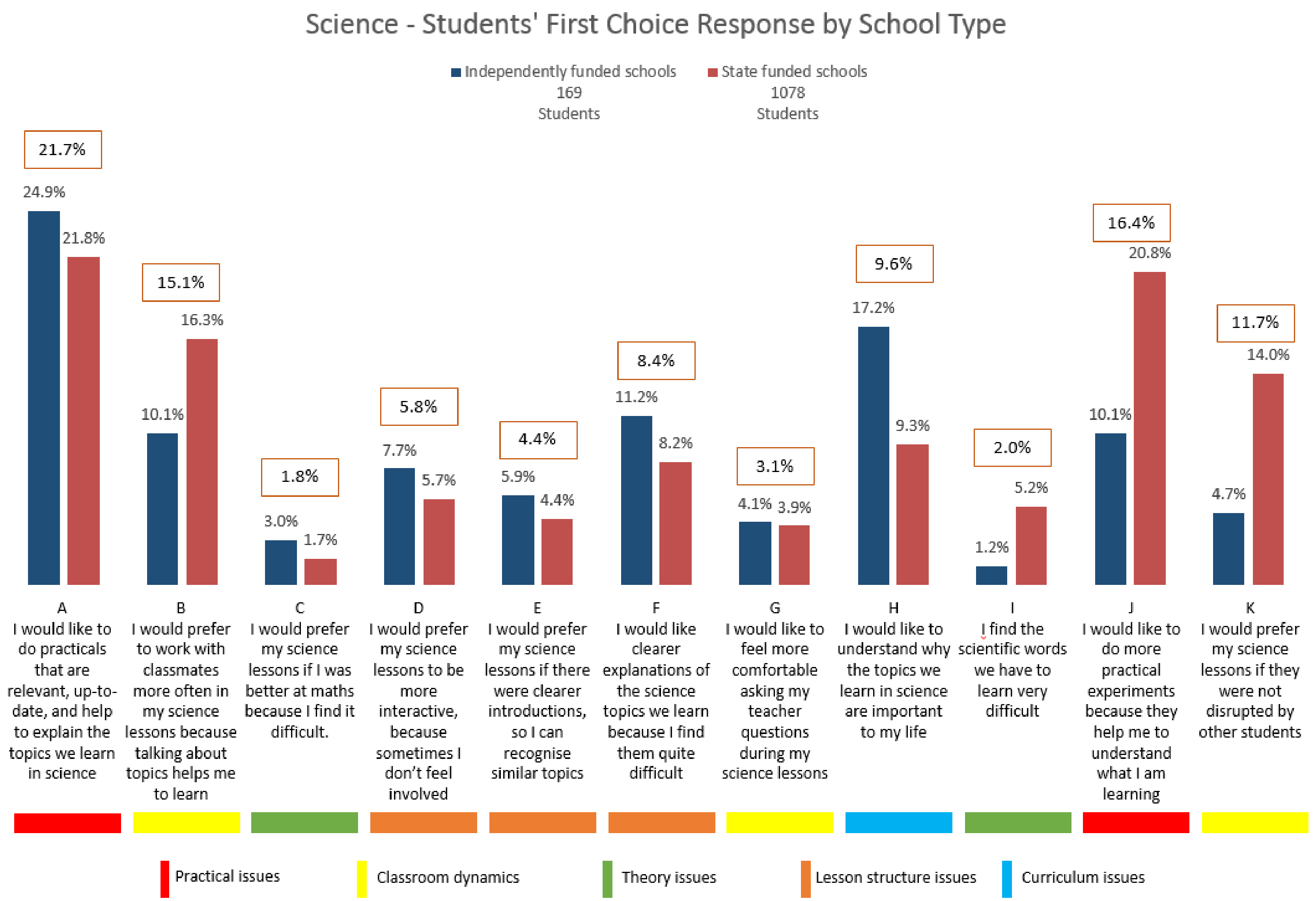

Science - Students' First Choice Response by Gender
Female 774 Students
Male 501 Students
21.7%
16.3%
30.1%
15.1%
15.5%
14.6%
1.8%
1.4%
2.4%
5.7%
6.3%
5.0%
4.4%
4.7%
4.0%
8.4%
11.6%
3.4%
3.1%
4.3%
1.2%
9.6%
9.9%
9.2%
2.0%
1.9%
2.0%
16.4%
15.9%
17.2%
11.7%
12.1%
11.0%
A I would like to do practicals that are relevant, up-to-date, and help to explain the topics we learn in science
B I would prefer to work with classmates more often in my science lessons because talking about topics helps me to learn
C I would prefer my science lessons if I was better at maths because I find it difficult.
D I would prefer my science lessons to be more interactive, because sometimes I don't feel involved
E I would prefer my science lessons if there were clearer introductions, so I can recognise similar topics
F I would like clearer explanations of the science topics we learn because I find them quite difficult
G I would like to feel more comfortable asking my teacher questions during my science lessons
H I would like to understand why the topics we learn in science are important to my life
I I find the scientific words we have to learn very difficult
J I would like to do more practical experiments because they help me to understand what I am learning
K I would prefer my science lessons if they were not disrupted by other students
Practical issues
Classroom dynamics
Theory issues
Lesson structure issues
Curriculum issues

Appendix B

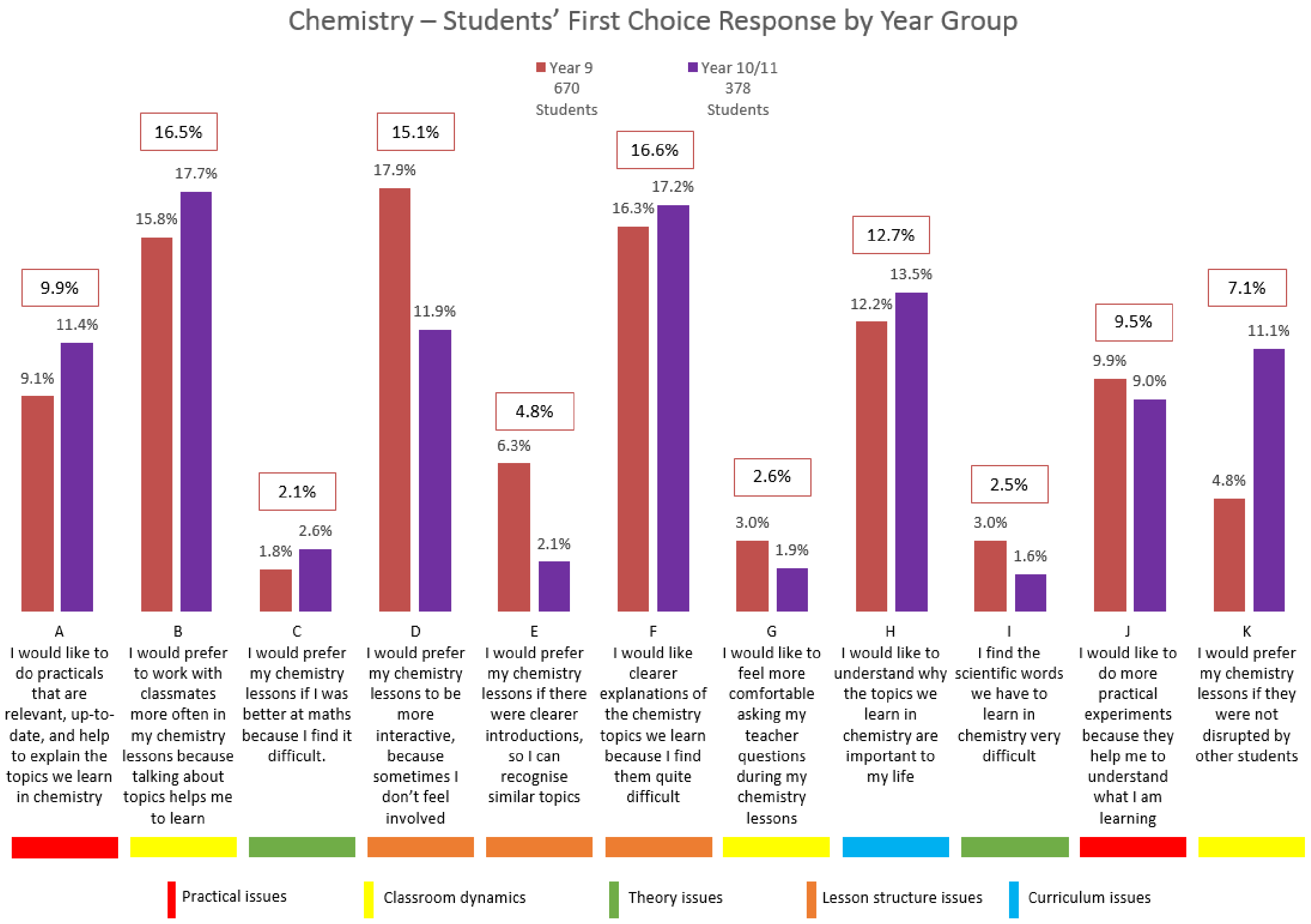

Science – Female Students' First Choice Response by Year Group
Year 7 Females 393 Students
Year 9 Females 381 Students
21.7%
17.6%
15.0%
15.1%
15.3%
15.7%
1.8%
1.0%
1.8%
5.8%
4.6%
8.1%
4.4%
2.5%
6.8%
8.4%
7.4%
16.0%
3.1%
4.8%
3.7%
9.6%
8.1%
11.8%
2.0%
2.5%
1.3%
16.4%
20.6%
11.0%
11.7%
15.5%
8.7%
A I would like to do practicals that are relevant, up-to-date, and help to explain the topics we learn in science
B I would prefer to work with classmates more often in my science lessons because talking about topics helps me to learn
C I would prefer my science lessons if I was better at maths because I find it difficult.
D I would prefer my science lessons to be more interactive, because sometimes I don't feel involved
E I would prefer my science lessons if there were clearer introductions, so I can recognise similar topics
F I would like clearer explanations of the science topics we learn because I find them quite difficult
G I would like to feel more comfortable asking my teacher questions during my science lessons
H I would like to understand why the topics we learn in science are important to my life
I I find the scientific words we have to learn very difficult
J I would like to do more practical experiments because they help me to understand what I am learning
K I would prefer my science lessons if they were not disrupted by other students
Practical issues
Classroom dynamics
Theory issues
Lesson structure issues
Curriculum issues


Science – Male Students' First Choice Response by Year Group
Year 7 Males 212 Students
Year 9 Males 289 Students
21.7%
27.8%
31.8%
15.1%
17.0%
12.8%
1.8%
1.9%
2.8%
5.8%
4.2%
5.5%
4.4%
3.8%
4.2%
8.4%
3.3%
3.5%
3.1%
1.4%
1.0%
9.6%
9.4%
9.0%
2.0%
2.8%
1.4%
16.4%
18.9%
15.9%
11.7%
9.4%
12.1%
A I would like to do practicals that are relevant, up-to-date, and help to explain the topics we learn in science
B I would prefer to work with classmates more often in my science lessons because talking about topics helps me to learn
C I would prefer my science lessons if I was better at maths because I find it difficult.
D I would prefer my science lessons to be more interactive, because sometimes I don't feel involved
E I would prefer my science lessons if there were clearer introductions, so I can recognise similar topics
F I would like clearer explanations of the science topics we learn because I find them quite difficult
G I would like to feel more comfortable asking my teacher questions during my science lessons
H I would like to understand why the topics we learn in science are important to my life
I I find the scientific words we have to learn very difficult
J I would like to do more practical experiments because they help me to understand what I am learning
K I would prefer my science lessons if they were not disrupted by other students
Practical issues
Classroom dynamics
Theory issues
Lesson structure issues
Curriculum issues

Appendix B

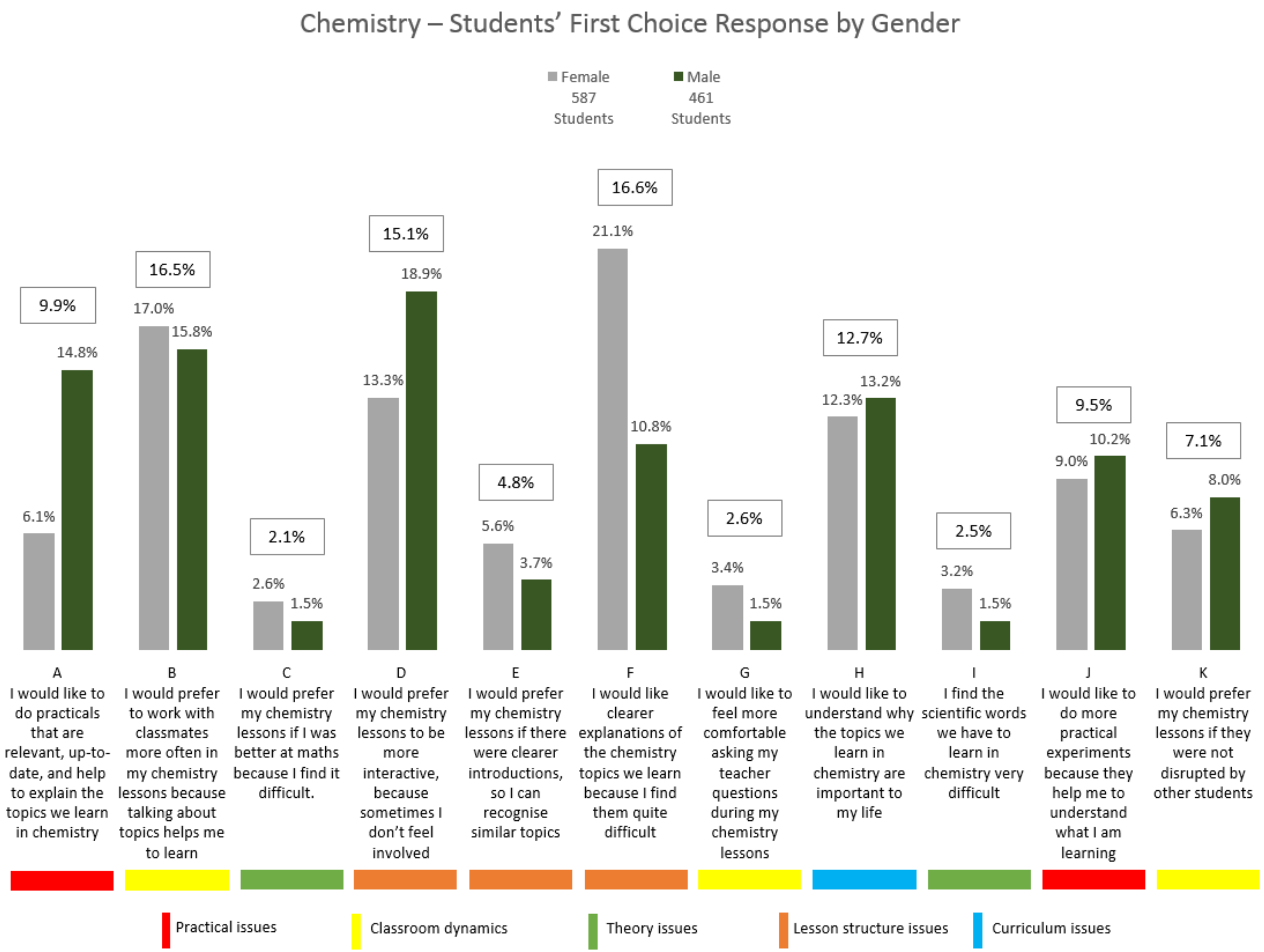


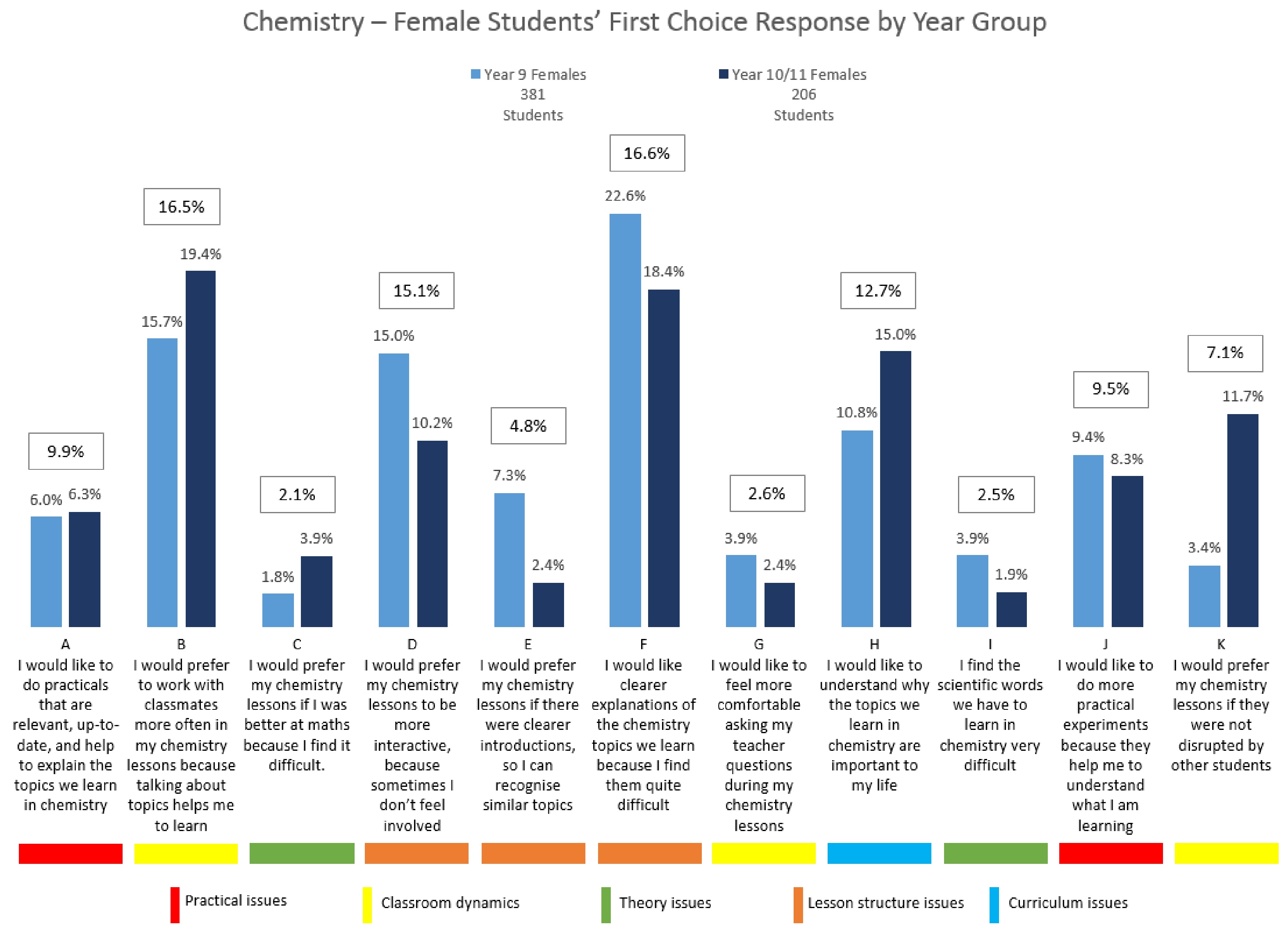
Science - Students' First Choice Response by School Type
Independently funded schools 169 Students
State funded schools 1078 Students
21.7%
24.9%
21.8%
15.1%
16.3%
10.1%
1.8%
3.0%
1.7%
5.8%
7.7%
5.7%
4.4%
5.9%
4.4%
8.4%
11.2%
8.2%
3.1%
4.1%
3.9%
9.6%
17.2%
9.3%
2.0%
1.2%
5.2%
16.4%
20.8%
10.1%
11.7%
14.0%
4.7%
A I would like to do practicals that are relevant, up-to-date, and help to explain the topics we learn in science
B I would prefer to work with classmates more often in my science lessons because talking about topics helps me to learn
C I would prefer my science lessons if I was better at maths because I find it difficult.
D I would prefer my science lessons to be more interactive, because sometimes I don't feel involved
E I would prefer my science lessons if there were clearer introductions, so I can recognise similar topics
F I would like clearer explanations of the science topics we learn because I find them quite difficult
G I would like to feel more comfortable asking my teacher questions during my science lessons
H I would like to understand why the topics we learn in science are important to my life
I I find the scientific words we have to learn very difficult
J I would like to do more practical experiments because they help me to understand what I am learning
K I would prefer my science lessons if they were not disrupted by other students
Practical issues
Classroom dynamics
Theory issues
Lesson structure issues
Curriculum issues



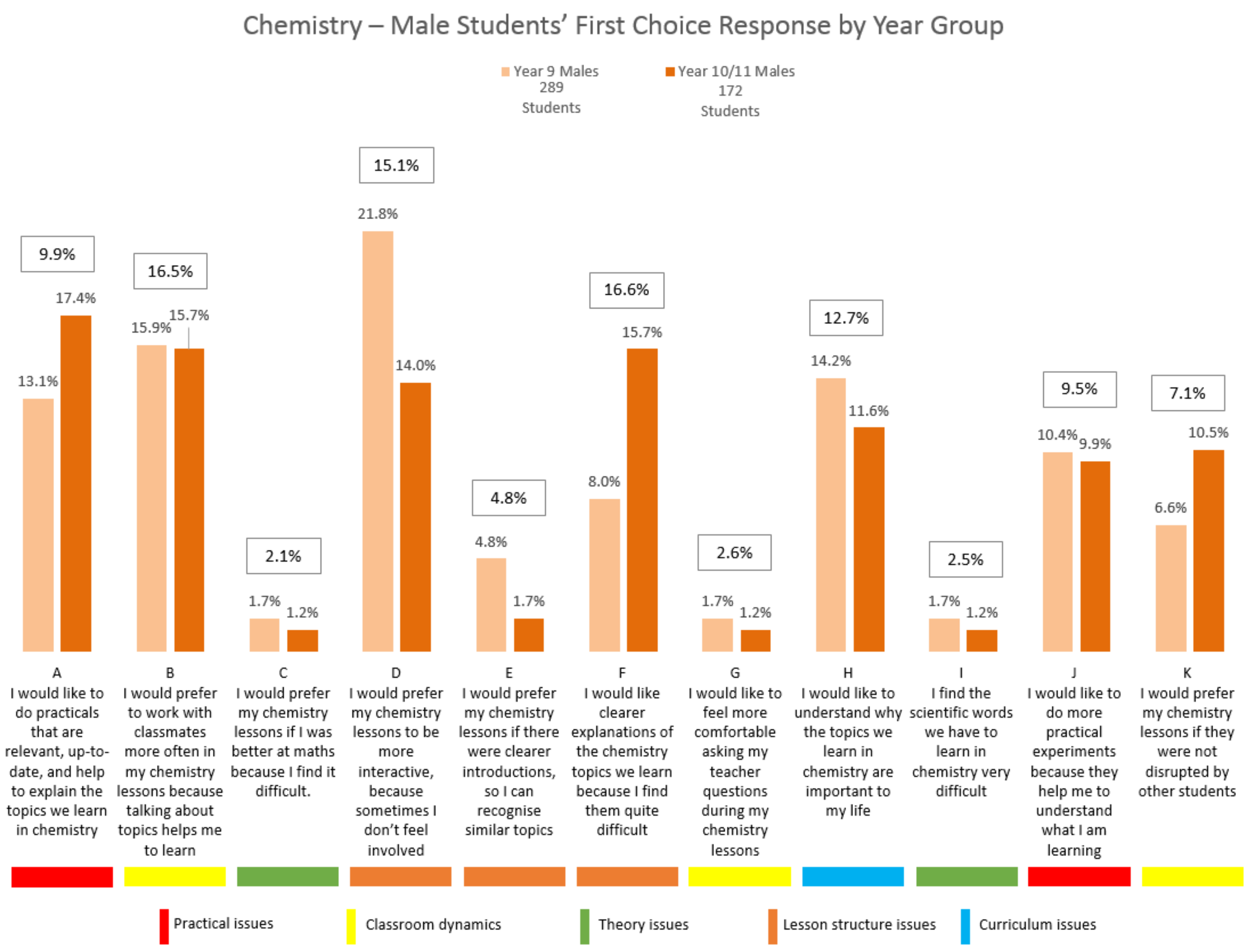
Chemistry – Students' First Choice Response by Year Group
Year 9 670 Students
Year 10/11 378 Students
A I would like to do practicals that are relevant, up-to-date, and help to explain the topics we learn in chemistry
9.9%
9.1%
11.4%
B I would prefer to work with classmates more often in my chemistry lessons because talking about topics helps me to learn
16.5%
15.8%
17.7%
C I would prefer my chemistry lessons if I was better at maths because I find it difficult.
2.1%
1.8%
2.6%
D I would prefer my chemistry lessons to be more interactive, because sometimes I don't feel involved
15.1%
17.9%
11.9%
E I would prefer my chemistry lessons if there were clearer introductions, so I can recognise similar topics
4.8%
6.3%
2.1%
F I would like clearer explanations of the chemistry topics we learn because I find them quite difficult
16.6%
16.3%
17.2%
G I would like to feel more comfortable asking my teacher questions during my chemistry lessons
2.6%
3.0%
1.9%
H I would like to understand why the topics we learn in chemistry are important to my life
12.7%
12.2%
13.5%
I I find the scientific words we have to learn in chemistry very difficult
2.5%
3.0%
1.6%
J I would like to do more practical experiments because they help me to understand what I am learning
9.5%
9.9%
9.0%
K I would prefer my chemistry lessons if they were not disrupted by other students
7.1%
4.8%
11.1%
Practical issues
Classroom dynamics
Theory issues
Lesson structure issues
Curriculum issues

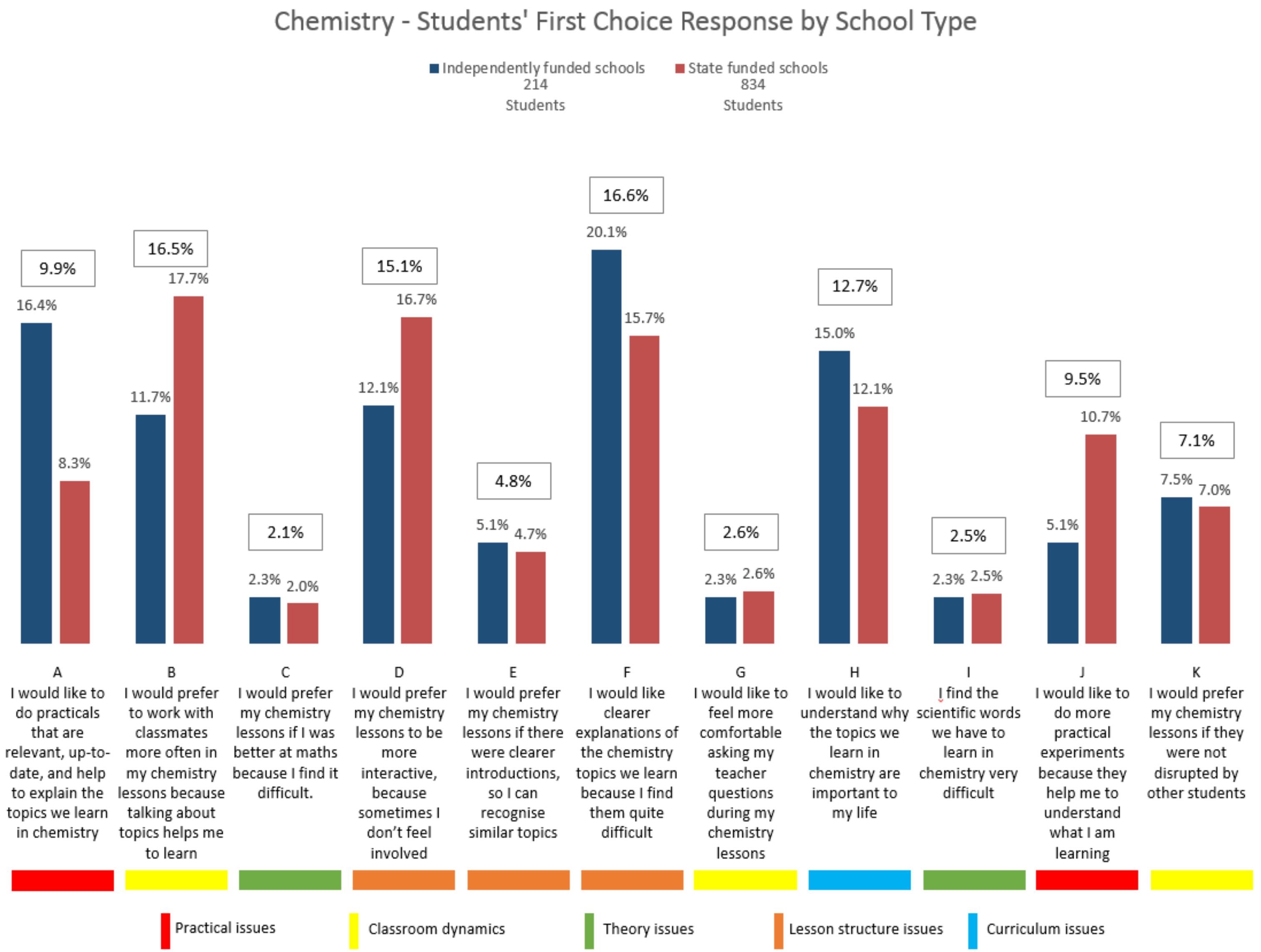
Appendix B


Chemistry – Students' First Choice Response by Gender
Female 587 Students
Male 461 Students
9.9%
6.1%
14.8%
16.5%
17.0%
15.8%
2.1%
2.6%
1.5%
15.1%
13.3%
18.9%
4.8%
5.6%
3.7%
16.6%
21.1%
10.8%
2.6%
3.4%
1.5%
12.7%
12.3%
13.2%
2.5%
3.2%
1.5%
9.5%
9.0%
10.2%
7.1%
6.3%
8.0%
A
I would like to do practicals that are relevant, up-to-date, and help to explain the topics we learn in chemistry
B
I would prefer to work with classmates more often in my chemistry lessons because talking about topics helps me to learn
C
I would prefer my chemistry lessons if I was better at maths because I find it difficult.
D
I would prefer my chemistry lessons to be more interactive, because sometimes I don't feel involved
E
I would prefer my chemistry lessons if there were clearer introductions, so I can recognise similar topics
F
I would like clearer explanations of the chemistry topics we learn because I find them quite difficult
G
I would like to feel more comfortable asking my teacher questions during my chemistry lessons
H
I would like to understand why the topics we learn in chemistry are important to my life
I
I find the scientific words we have to learn in chemistry very difficult
J
I would like to do more practical experiments because they help me to understand what I am learning
K
I would prefer my chemistry lessons if they were not disrupted by other students
Practical issues
Classroom dynamics
Theory issues
Lesson structure issues
Curriculum issues


Chemistry – Female Students' First Choice Response by Year Group
Year 9 Females 381 Students
Year 10/11 Females 206 Students
9.9%
6.0%
6.3%
16.5%
15.7%
19.4%
2.1%
1.8%
3.9%
15.1%
15.0%
10.2%
4.8%
7.3%
2.4%
16.6%
22.6%
18.4%
2.6%
3.9%
2.4%
12.7%
10.8%
15.0%
2.5%
3.9%
1.9%
9.5%
9.4%
8.3%
7.1%
3.4%
11.7%
A
I would like to do practicals that are relevant, up-to-date, and help to explain the topics we learn in chemistry
B
I would prefer to work with classmates more often in my chemistry lessons because talking about topics helps me to learn
C
I would prefer my chemistry lessons if I was better at maths because I find it difficult.
D
I would prefer my chemistry lessons to be more interactive, because sometimes I don't feel involved
E
I would prefer my chemistry lessons if there were clearer introductions, so I can recognise similar topics
F
I would like clearer explanations of the chemistry topics we learn because I find them quite difficult
G
I would like to feel more comfortable asking my teacher questions during my chemistry lessons
H
I would like to understand why the topics we learn in chemistry are important to my life
I
I find the scientific words we have to learn in chemistry very difficult
J
I would like to do more practical experiments because they help me to understand what I am learning
K
I would prefer my chemistry lessons if they were not disrupted by other students
Practical issues
Classroom dynamics
Theory issues
Lesson structure issues
Curriculum issues

Appendix B


Chemistry – Male Students' First Choice Response by Year Group
Year 9 Males 289 Students
Year 10/11 Males 172 Students
9.9%
13.1%
17.4%
A
I would like to do practicals that are relevant, up-to-date, and help to explain the topics we learn in chemistry
16.5%
15.9%
15.7%
B
I would prefer to work with classmates more often in my chemistry lessons because talking about topics helps me to learn
2.1%
1.7%
1.2%
C
I would prefer my chemistry lessons if I was better at maths because I find it difficult.
15.1%
21.8%
14.0%
D
I would prefer my chemistry lessons to be more interactive, because sometimes I don't feel involved
4.8%
4.8%
1.7%
E
I would prefer my chemistry lessons if there were clearer introductions, so I can recognise similar topics
16.6%
8.0%
15.7%
F
I would like clearer explanations of the chemistry topics we learn because I find them quite difficult
2.6%
1.7%
1.2%
G
I would like to feel more comfortable asking my teacher questions during my chemistry lessons
12.7%
14.2%
11.6%
H
I would like to understand why the topics we learn in chemistry are important to my life
2.5%
1.7%
1.2%
I
I find the scientific words we have to learn in chemistry very difficult
9.5%
10.4%
9.9%
J
I would like to do more practical experiments because they help me to understand what I am learning
7.1%
6.6%
10.5%
K
I would prefer my chemistry lessons if they were not disrupted by other students
Practical issues
Classroom dynamics
Theory issues
Lesson structure issues
Curriculum issues


Chemistry - Students' First Choice Response by School Type
Independently funded schools 214 Students
State funded schools 834 Students
9.9%
16.4%
8.3%
16.5%
11.7%
17.7%
2.1%
2.3%
2.0%
15.1%
12.1%
16.7%
4.8%
5.1%
4.7%
16.6%
20.1%
15.7%
2.6%
2.3%
2.6%
12.7%
15.0%
12.1%
2.5%
2.3%
2.5%
9.5%
5.1%
10.7%
7.1%
7.5%
7.0%
A I would like to do practicals that are relevant, up-to-date, and help to explain the topics we learn in chemistry
B I would prefer to work with classmates more often in my chemistry lessons because talking about topics helps me to learn
C I would prefer my chemistry lessons if I was better at maths because I find it difficult.
D I would prefer my chemistry lessons to be more interactive, because sometimes I don't feel involved
E I would prefer my chemistry lessons if there were clearer introductions, so I can recognise similar topics
F I would like clearer explanations of the chemistry topics we learn because I find them quite difficult
G I would like to feel more comfortable asking my teacher questions during my chemistry lessons
H I would like to understand why the topics we learn in chemistry are important to my life
I I find the scientific words we have to learn in chemistry very difficult
J I would like to do more practical experiments because they help me to understand what I am learning
K I would prefer my chemistry lessons if they were not disrupted by other students
Practical issues
Classroom dynamics
Theory issues
Lesson structure issues
Curriculum issues

Appendix C

Appendix C contains all graphs displaying the distribution of mean scores for respondents to the Attitudes towards Science Lessons scale and the Modified Attitudes towards Chemistry Lessons scale for each subscale. The graphs were used to explore how students' mean scores were distributed around the mean, and to identify whether any notable differences or unseen trends existed within with dataset.

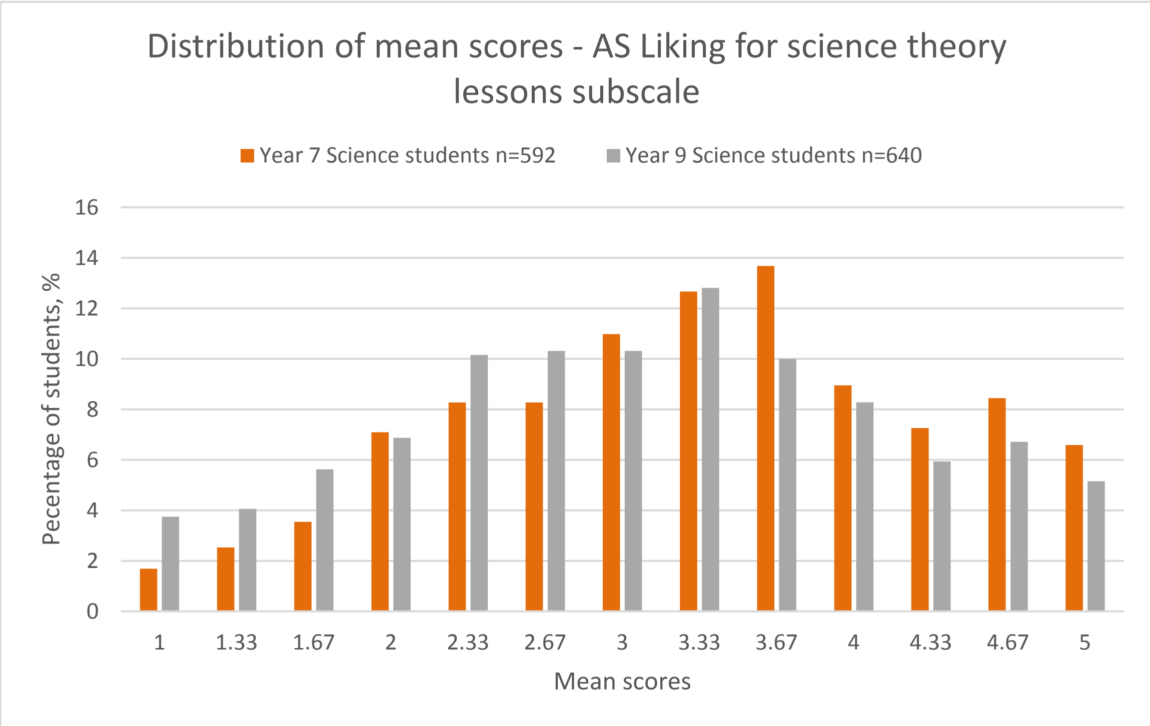


Figure 7-1 Graph showing the distribution of mean scores for the "AS – Liking for science theory lessons" subscale for all respondents to the ATCSLS. n = number of participants.

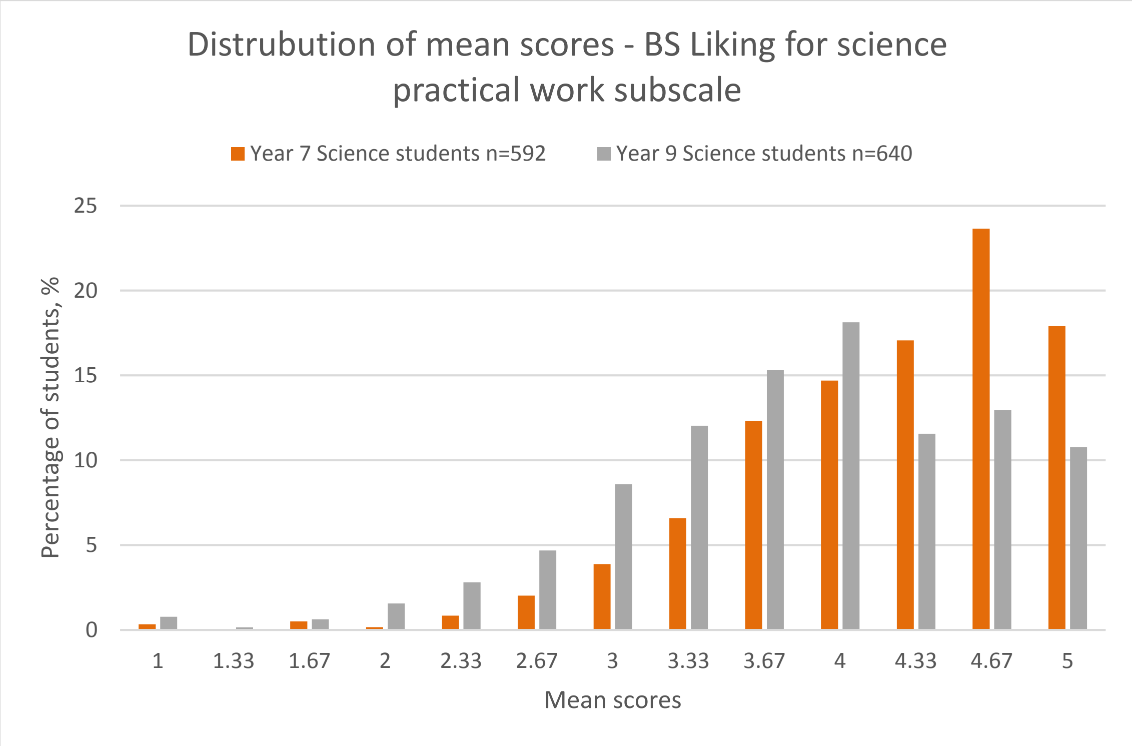


Figure 7-2 Graph showing the distribution of mean scores for the “BS – Liking for science practical work” subscale for all respondents of the ATCSLS. n = number of participants.

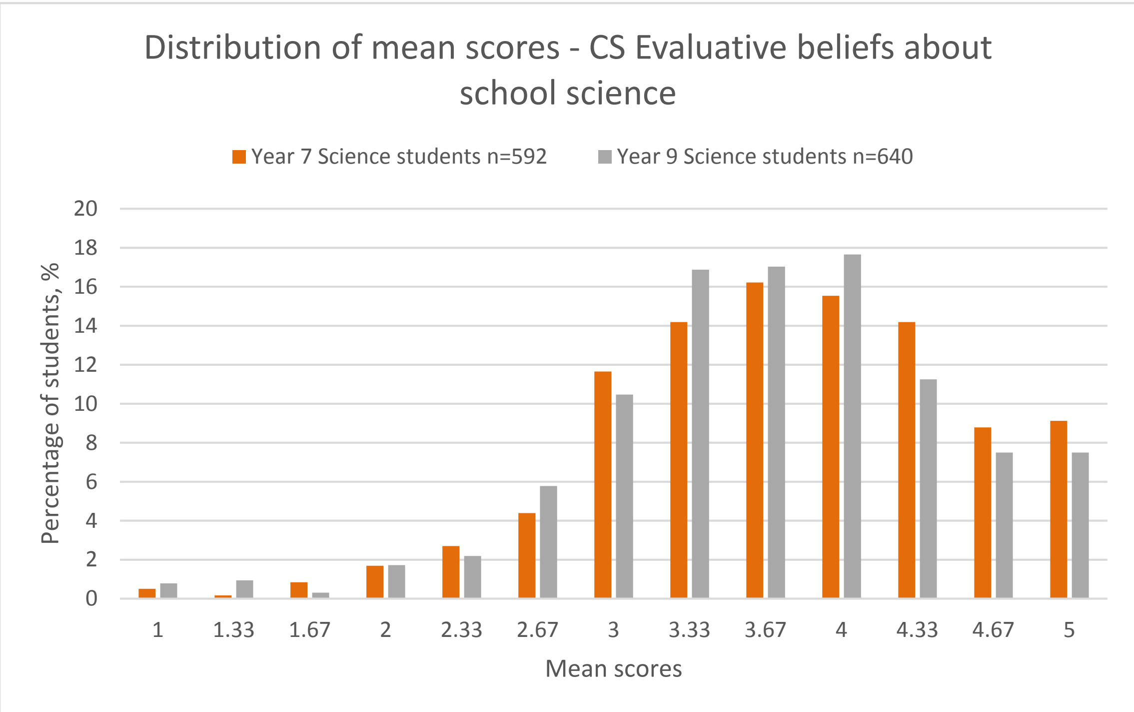


Figure 7-3 Graph showing the distribution of mean scores for the “CS – Evaluative beliefs about school science” subscale for all respondents to the ATCSLS. n = number of participants.

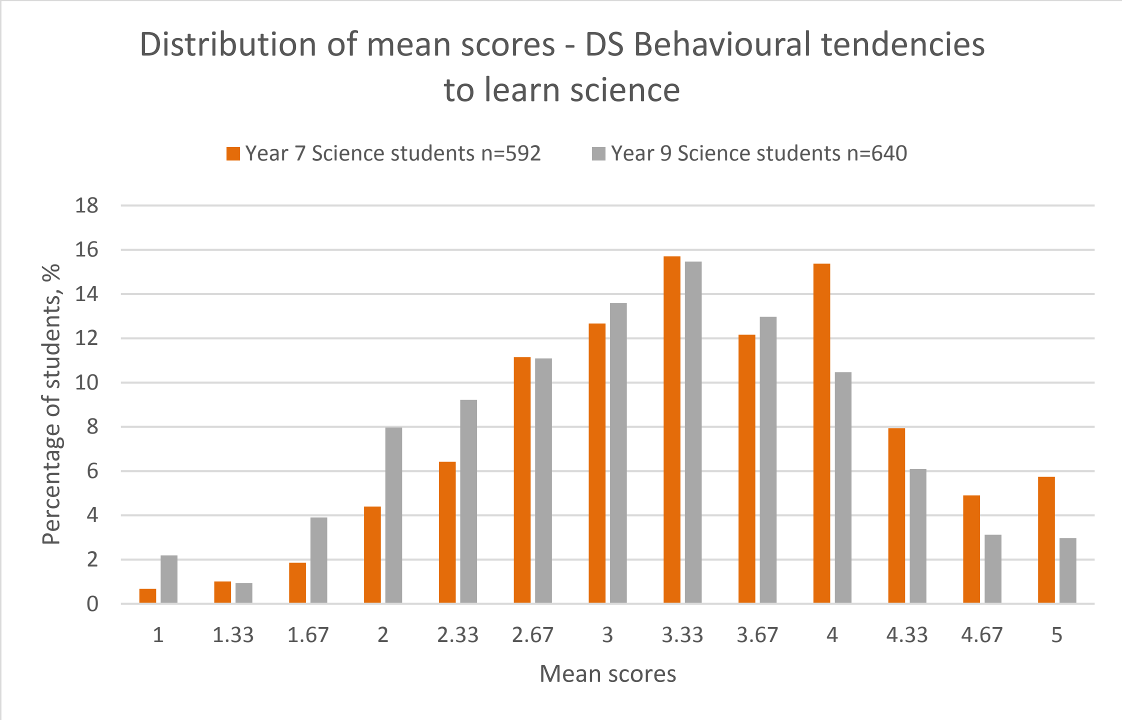


Figure 7-4 Graph showing the distribution of mean scores for the "DS – Behavioural tendencies to learn science" subscale for all respondents to the ATCSLS. n = number of participants.

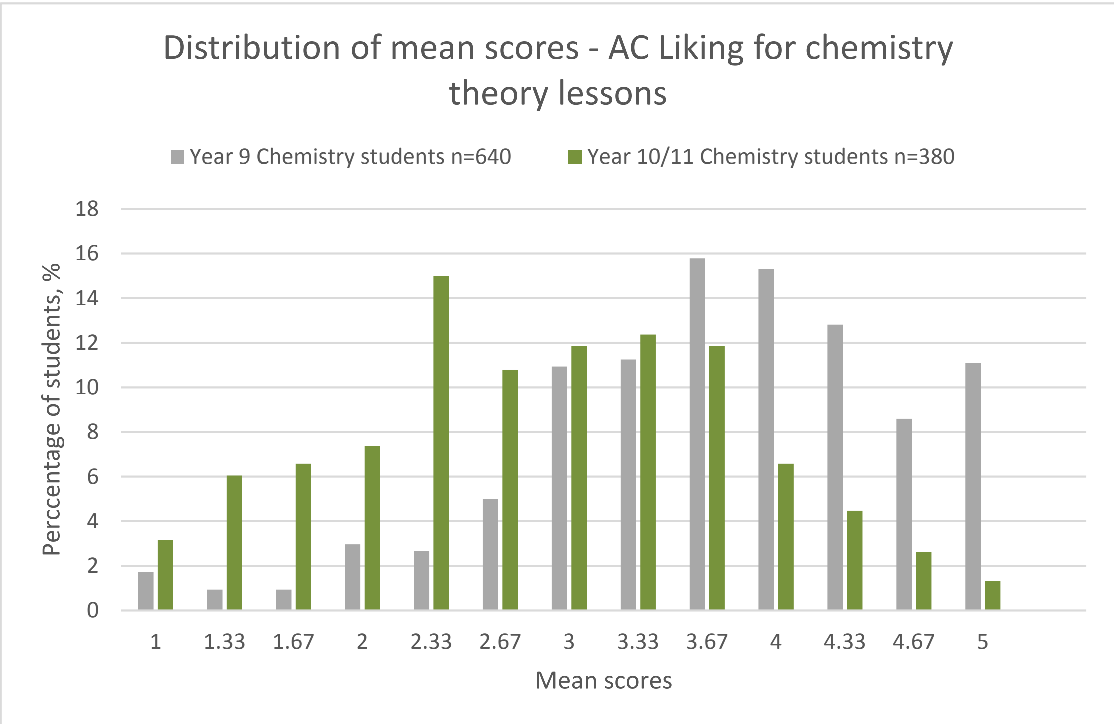


Figure 7-5 Graph showing the distribution of mean scores for the "AC – Liking for chemistry theory lessons" subscale for all respondents to the ATCSLS. n = number of participants.

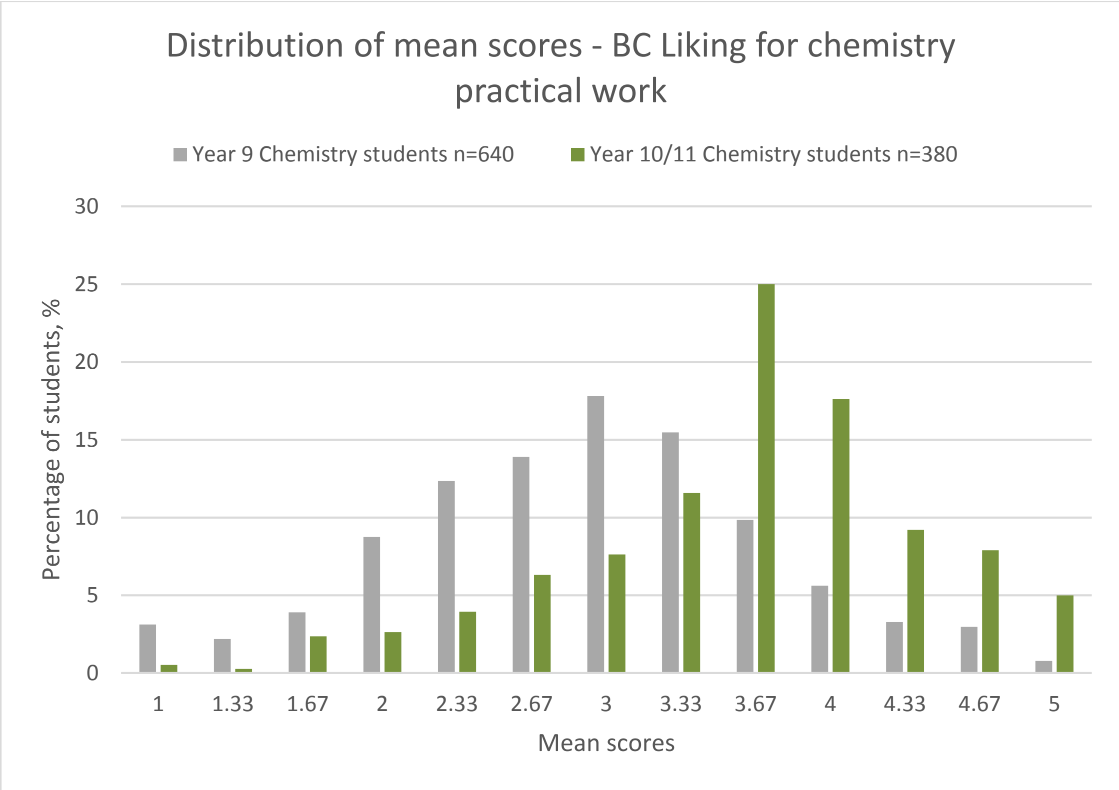


Figure 7-6 Graph showing the distribution of mean scores for the "BC – Liking for chemistry practical work" subscale for all respondents to the ATCSLS. n = number of participants.

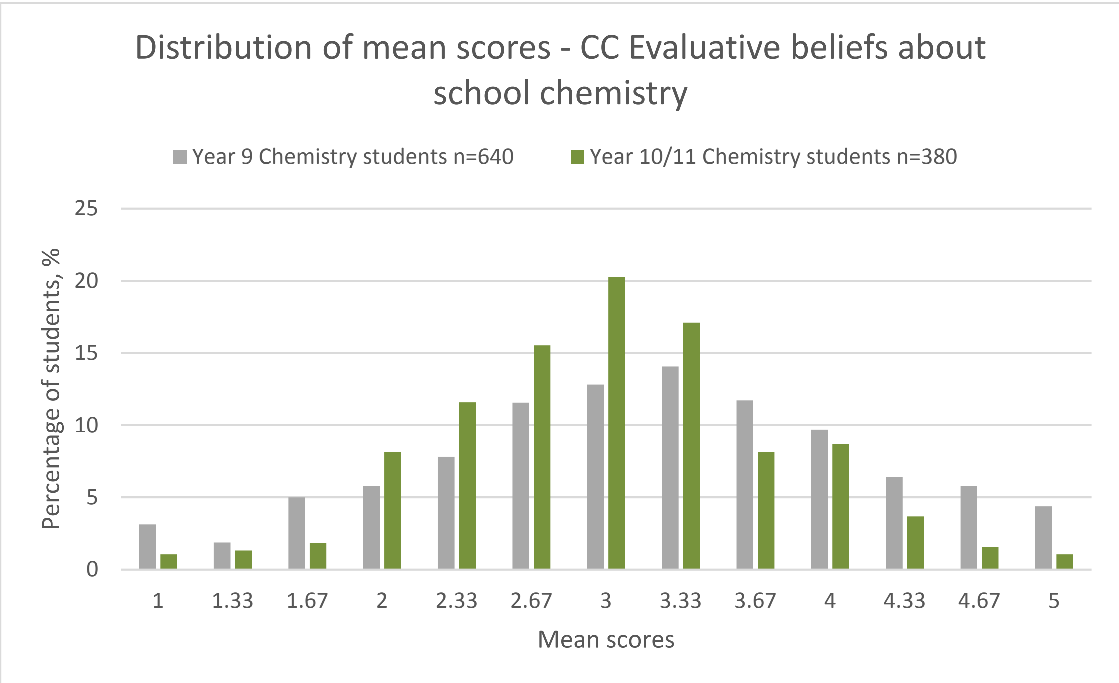


Figure 7-7 Graph showing the distribution of mean scores for the "CC – Evaluative beliefs about school chemistry" subscale for all respondents to the ATCLS. n = number of participants.

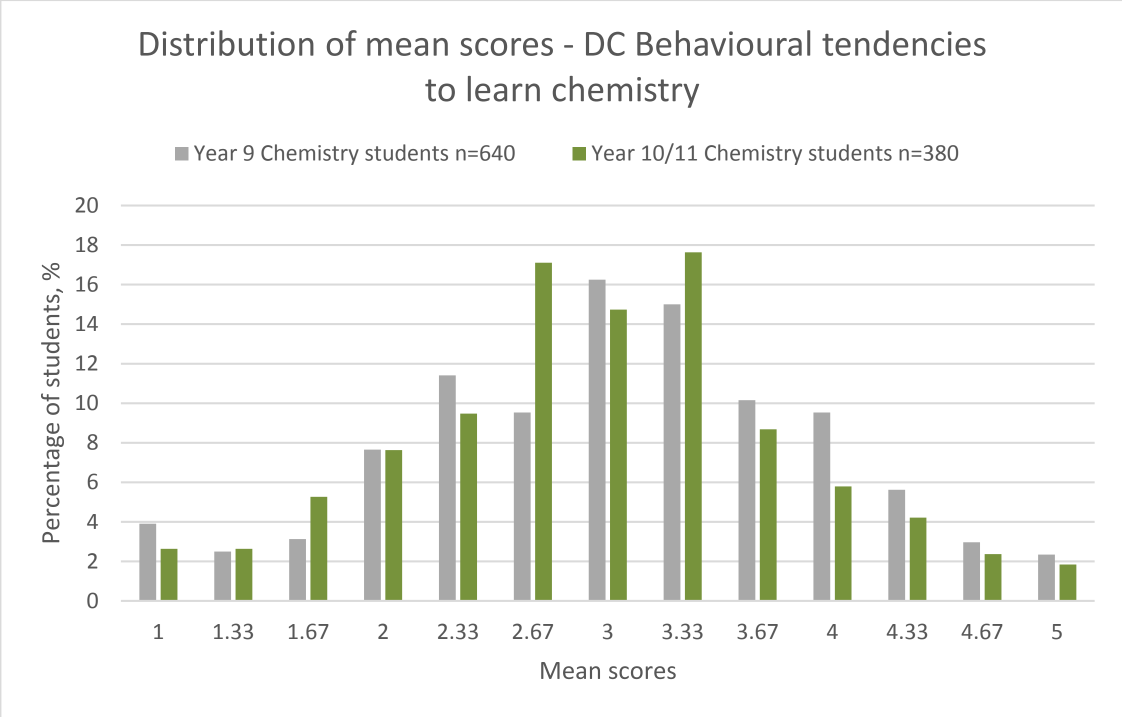


Figure 7-8 Graph showing the distribution of mean scores for the "DC – Behavioural tendencies to learn chemistry" subscale for all respondents to the ATCSLS. n = number of participants.

List of References

Aikenhead, G. S. and Ryan, A. G. (1992). "The Development of a New Instrument:"Views on science-technology-society"(VOSTS)." Science Education **76**: 477-491.

Allen, I. E. and Seaman, C. A. (2007). "Likert scales and data analyses." Quality Progress **40**: 64.

Alwin, D. F. and Krosnick, J. A. (1991). "The Reliability of Survey Attitude Measurement: The Influence of Question and Respondent Attributes." Sociological Methods & Research **20**: 139-181.

Archer, L., Osborne, J., DeWitt, J., Dillon, J., Wong, B., and Willis, B. (2013). ASPIRES: Young People's Science and Career Aspirations, Age 10-14, King's College London.

Ary, D., Jacobs, L., Sorensen, C., and Walker, D. (2013). Introduction To Research in Education, Cengage Learning.

Auerbach, C. and Silverstein, L. B. (2003). Qualitative data: An introduction to coding and analysis, NYU press.

Bardo, J., Yeager, S., and Klingsporn, M. (1982). "Preliminary Assessment of Format-Specific Central Tendency and Leniency Error Insummated Rating Scales." Perceptual and Motor Skills **54**: 227-234.

Barmby, P., Kind, P. M., and Jones, K. (2008). "Examining Changing Attitudes in Secondary School Science." International Journal of Science Education **30**: 1075-1093.

Bauer, M. W. (2008). Survey Research and the Public Understanding of Science. Handbook of Public Communication of Science and Technology. B. T. Massimiano Bucchi. London, UK, Routledge: 111-130.

Baumgartner, H. and Homburg, C. (1996). "Applications of structural equation modeling in marketing and consumer research: A review." International journal of Research in Marketing **13**: 139-161.

Beaton, A. E. (1996). Mathematics Achievement in the Middle School Years. IEA's Third International Mathematics and Science Study (TIMSS), ERIC.

Bem, D. J. (1973). "Self-perception theory."

Bennett, J., Rollnick, M., Green, G., White, M. (2001). "The development and use of an instrument to assess students' attitude to the study of chemistry." International Journal of Science Education **23**: 833-845.

Bentler, P. M. and Bonett, D. G. (1980). "Significance tests and goodness of fit in the analysis of covariance structures." Psychological Bulletin **88**: 588-606.

Bollen, K. A. (1989). "A new incremental fit index for general structural equation models." Sociological Methods & Research **17**: 303-316.

Boone, D. A. (2012). "Analyzing likert data." Journal of Extension **50**: 1-5.

Breakwell, G. M. and Beardsell, S. (1992). "Gender, parental and peer influences upon science attitudes and activities." Public Understanding of Science **1**: 183-197.

Breckler, S. J. (1984). "Empirical validation of affect, behavior, and cognition as distinct components of attitude." Journal of Personality and Social Psychology **47**: 1191.

Castell, S., Charlton, A., Clemence, M., Pettigrew, N., Pope, S., Quigley, A., Shah, J. N., and Silman, T. (2014). "Public attitudes to science 2014." London, Ipsos MORI Social Research Institute. 194.

Cheung, D. (2009). "Developing a scale to measure students' attitudes toward chemistry lessons." International Journal of Science Education **31**: 2185-2203.

Cooper, P. and McIntyre, D. (1996). Effective Teaching and Learning: Teachers' and Students' Perspectives, McGraw-Hill Education (UK).

Corp., I. (2013). IBM SPSS Statistics for Windows. Armonk, NY, IBM Corp.

Cortina, J. M. (1993). "What is coefficient alpha? An examination of theory and applications." Journal of Applied Psychology **78**: 98.

Council, I. S. (2016). "Independent Schools Council - Research." Retrieved 04/01/2016, 2016, from www.isc.co.uk/research.

Creswell, J. W. and Clark, V. L. P. (2007). "Designing and conducting mixed methods research."

De Vaus, D. A. (2004). Research Design in Social Research, Sage Publications.

DeFleur, M. L. and Westie, F. R. (1963). "Attitude as a scientific concept." Social Forces **42**: 17-31.

DeVellis, R. F. (2012). Scale Development: Theory and Applications, Sage publications.

Dewey, J. (1916). "Method in science teaching." General Science Quarterly **1**: 3-9.

Durant, J. R., Evans, G. A., and Thomas, G. P. (1992). "Public understanding of science in Britain: the role of medicine in the popular representation of science." Public Unverstanding of Sicnece **1**: 161-182.

Eagly, A. H. and Chaiken, S. (1998). "Attitude Structure and Function." The Handbook of Social Psychology **1 and 2**: 69-322.

Eagly, A. H., Mladinic, A., and Otto, S. (1994). "Cognitive and affective bases of attitudes toward social groups and social policies." Journal of Experimental Social Psychology **30**: 113-137.

Ebenezer, J. V. and Zoller, U. (1993). "Grade 10 students' perceptions of and attitudes toward science teaching and school science." Journal of Research in Science Teaching **30**: 175-186.

Education, D. o. (2013). Science programmes of study: Key Stage 3. National curriculum in England. D. o. Education.

Field, A. (2013). Discovering Statistics Using IBM SPSS Statistics - Chapter 9, Sage.

Field, A. (2013). Measures of Reliability. Discovering Statistics Using IBM SPSS Statistics**:** 706-709.

Fontana, A. and Frey, J. (1994). "The Art of Science." The Handbook of Qualitative Research: 361-376.

Francis, L. J. and Greer, J. E. (1999). "Measuring Attitude Towards Science Among Secondary School Students: the affective domain." Research in Science & Technological Education **17**: 219-226.

Fraser, B. J. (1977). "Selection and validation of attitude scales for curriculum evaluation." Science Education **61**: 317-329.

Fraser, B. J. (1981). Test of science-related attitudes. Camberwell, Victoria, Macquarie University**:** 1-18.

Freedman, M. P. (1997). "Relationship among laboratory instruction, attitude toward science, and achievement in science knowledge." Journal of Research in Science Teaching **34**: 343-357.

Freire, P. (2014). Pedagogy of hope: Reliving pedagogy of the oppressed, Bloomsbury Publishing.

Furr, R. M. (2016). Chapter 8 - Confirmatory Factor Analysis. CFA-1.

Gall, M. D., Gall, J. P., & Borg, W. R. (2003). Educational Research: An Introduction. Boston, MA, A & B Publications.

Gardner, P. L. (1975). "Attitudes to science: A review."

Gibbs, A. (1997). "Focus Groups." Social Research Update **Winter**.

Glasman, L. R. and Albarracín, D. (2006). "Forming attitudes that predict future behavior: a meta-analysis of the attitude-behavior relation." Psychological Bulletin **132**: 778.

Gliem, R. R. and Gliem, J. A. (2003). Calculating, Interpreting, and Reporting Cronbach's Alpha Reliability Coefficient for Likert-Type Scales, Midwest Research-to-Practice Conference in Adult, Continuing, and Community Education.

Harrington, D. (2008). Confirmatory Factor Analysis, Oxford University Press, USA.

Heise, D. R. (1970). "The semantic differential and attitude research." Attitude Measurement: 235-253.

Hoaglin, D. C., Mosteller, F., and Tukey, J. W. (1983). Understanding Robust and Exploratory Data Analysis, Wiley New York.

Hofstein, A., Ben-Zvi, R., Samuel, D., and Tamir, P. (1977). "Attitudes of israeli high-school students toward Chemistry and Physics: A comparative study." Science Education **61**: 259-268.

Hooper, D., Coughlan, J., and Mullen, M. (2008). "Structural equation modelling: Guidelines for determining model fit." Articles: 2.

Hoxby, C. (2000). Peer effects in the classroom: Learning from gender and race variation, National Bureau of Economic Research.

Hu, L. t. and Bentler, P. M. (1999). "Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives." Structural Equation Modeling: A Multidisciplinary Journal **6**: 1-55.

Huskinson, T. L. and Haddock, G. (2004). "Individual differences in attitude structure: Variance in the chronic reliance on affective and cognitive information." Journal of Experimental Social Psychology **40**: 82-90.

Johnson, R. B. and Onwuegbuzie, A. J. (2004). "Mixed methods research: A research paradigm whose time has come." Educational researcher **33**: 14-26.

Jovanovic, J. and King, S. S. (1998). "Boys and Girls in the Performance-Based Science classroom: Who's doing the performing?" American Educational Research Journal **35**: 477-496.

Kahle, J. B. and Lakes, M. K. (1983). "The myth of equality in science classrooms." Journal of Research in Science Teaching **20**: 131-140.

Kelly, A. (1988). "Sex Stereotypes and School Science: a three year follow-up." Educational studies **14**: 151-163.

Kind, P., K. Jones and Barmby, P. (2007). "Developing attitudes towards science measures." International Journal of Science Education **29**: 871-893.

Klopfer, L. E. (1971). Evaluation of learning in science. Handbook on Formative and Summative Evaluation of Student Learning. Bloom. New York, McGraw-Hill.

Koballa, T. R. (1988). "Attitude and related concepts in science education." Science Education **72**: 115-126.

Koballa, T. R., Glynn, S. M. (2007). Handbook of Research on Science Education, Routledge.

Krosnick, J. A., Judd, C. M., Wittenbrink, B. (2005). The Measurement of Attitudes. The Handbook of Attitudes. D. Albarracin, Johnson, B. T., Zanna, M. P., Lawrence Erlbaum Associates: 21-76.

Lightbody, P. and Durndell, A. (1996). "Gendered Career Choice: is sex-stereotyping the cause or the consequence?" Educational Studies **22**: 133-146.

Likert, R. (1932). "A technique for the measurement of attitudes." Archives of Psychology **22 140**: 55-55.

Lovelace, M. and Brickman, P. (2013). "Best Practices for Measuring Students' Attitudes toward Learning Science." CBE Life Sciences Education **12**: 606-617.

Ltd., Q. I. P. (2012). NVivo qualitative data analysis Software.

MacCallum, R. C., Widaman, K. F., Preacher, K. J., and Hong, S. (2001). "Sample size in factor analysis: The role of model error." Multivariate Behavioral Research **36**: 611-637.

McGuire, W. J. (1969). "The nature of attitudes and attitude change." The handbook of social psychology **3**: 136-314.

McNamara, C. (2006). Toolbox for Practical Data Collection Methods. Field Guide to Consulting and Organizational Development: A Collaborative and Systems Approach to Performance, Change and Learning, Authenticity Consulting, LLC 499.

Menis, J. (1989). "Attitudes towards School, Chemistry and Science among Upper Secondary Chemistry Students in the United States." Research in Science & Technological Education **7**: 183-190.

Miller, J. D., Pardo, R., and Niwa, F. (1997). Public perceptions of science and technology: A comparative study of the European Union, the United States, Japan, and Canada, Fundación BBV.

Munby, H. (1997). "Issues of validity in science attitude measurement." Journal of Research in Science Teaching **34**: 337-341.

Myers, R. E. and Fouts, J. T. (1992). "A cluster analysis of high school science classroom environments and attitude toward science." Journal of Research in Science Teaching **29**: 929-937.

Oppenheim, A. N. (2000). Questionnaire Design, Interviewing and Attitude Measurement, Bloomsbury Publishing.

Osborne, J. and Collins, S. (2000). Pupils' & Parents' Views of the School Science Curriculum, Kings College London.

Osborne, J. and Dillon, J. (2010). Good Practice In Science Teaching: What Research Has To Say, McGraw-Hill Education (UK).

Osborne, J. and Simon, S. (1996). "Primary science: past and future directions." Studies in Science Education **27**.

Osborne, J., Simon, S., and Collins, S., (2003). "Attitudes towards science: a review of the literature and its implications." International Journal of Science Education **25**: 1049-1079.

Oskamp, S. and Schultz, P. W. (2005). Attitudes and Opinions, Psychology Press.

Parkinson, J., Hendley, D., Tanner, H., and Stables, A. (1998). "Pupils' Attitudes to Science in Key Stage 3 of the National Curriculum: a study of pupils in South Wales." Research in Science & Technological Education **16**: 165-176.

Pell, T. and Jarvis, T. (2001). "Developing attitude to science scales for use with children of ages from five to eleven years." International Journal of Science Education **23**: 847-862.

Pilotte, W. J. and Gable, R. K. (1990). "The Impact of Positive and Negative Item Stems on the Validity of a Computer Anxiety Scale." Educational and Psychological Measurement **50**: 603-610.

Pintrich, P. R., Smith, D. A., García, T., and McKeachie, W. J. (1993). "Reliability and predictive validity of the Motivated Strategies for Learning Questionnaire (MSLQ)." Educational and Psychological Measurement **53**: 801-813.

Polkinghorne, D. E. (2007). "Validity Issues in Narrative Research." Qualitative Inquiry **13**: 471-486.

Professor CHEUNG Sin-pui, D. (2015). "Department of Curriculum and Instruction - Professor CHEUNG Sin-pui, Derek." Retrieved 19/11/2015, 2015.

Revilla, M. A., Saris, W. E. and Krosnick, J. A. (2014). "Choosing the Number of Categories in Agree-Disagree Scales." Sociological Methods and Research **43**: 73-97.

Richard, J. H. (1977). "Reviewed Work: Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research. by Martin Fishbein, Icek Ajzen." Contemporary Sociology **6**: 244-245.

Roberts, G. (2002). "SET for Success: Final Report of Sir Gareth Roberts Review."

Rosen, M. (2015). Good Ideas: How to Be Your Child's (and Your Own) Best Teacher, John Murray.

Royal Society of Chemistry (2015). Public attitudes to chemistry, Royal Society of Chemistry - TNS BMRB**:** 1-77.

Saldaña, J. (2012). The Coding Manual for Qualitative Researchers, Sage.

Salta, K., M. Gekos, Petsimeri, I. and Koulougliotis, D. (2012). "Discovering factors that influence the decision to pursue a chemistry-related career: A comparative analysis of the experiences of non scientist adults and chemistry teachers in Greece." Chemistry Education Research and Practice **13**: 437-446.

Salta, K. and Tzougraki, C. (2004). "Attitudes toward chemistry among 11th grade students in high schools in Greece." Science Education **88**: 535-547.

Schibeci, R. A. (1982). "Measuring student attitudes: Semantic differential or likert instruments?" Science Education **66**: 565-570.

Schibeci, R. A. and McGaw, B. (1981). "Empirical validation of the conceptual structure of a test of science-related attitudes." Educational and Psychological Measurement **41**: 1195-1201.

SCORE (2008). Practical work in Science: A Report and Proposal for a Strategic Framework. http://www.score-education.org/media/3668/report.pdf, SCORE - Science Community Representing Education.

Sharpe, R. M. (2012). Secondary school students' attitudes to practical work in school science, University of York.

Simpson, R. D. and Steve Oliver, J. (1990). "A summary of major influences on attitude toward and achievement in science among adolescent students." Science Education **74**: 1-18.

Skamp, K., Boyes, E., and Stanisstreet, M. (2013). "Beliefs and Willingness to Act About Global Warming: Where to Focus Science Pedagogy?" Science Education **97**: 191-217.

Smith, M. K. (2015) "What is Education? A Definition and Discussion."

Smith, R. M., Schumacker, R. E., and Bush, M. J. (1998). "Using item mean squares to evaluate fit to the Rasch model." J Outcome Meas **2**: 66-78.

Spector, P. E., van Katwyk, P. T., Brannick, M. T., and Peter, Y. C. (1997). "When Two Factors Don't Reflect Two Constructs: How Item Characteristics Can Produce Artifactual Factors." Journal of Management **23**: 659.

Suhr, D. and Shay, M. (2009). Guidelines for Reliability, Confirmatory and Exploratory Factor Analysis. Proc. 2009 Western Users of SAS Conf. San Jose, CA.

Tapia, M., and Marsh, G. E. (2004). "An instrument to measure mathematics attitudes. ." Academic Exchange Quarterly **8**: 16-21.

Tavakol, M. and Dennick, R. (2011). "Making sense of Cronbach's alpha." International Journal of Medical Education **2**: 53.

Tesser, A. and Schwarz, N. (2001). "The Construction of Attitudes." Blackwell Handbook of Social Psychology: Intraindividual Processes: 436.

Thomas, W. I. and Znaniecki, F. (1918). The Polish Peasant in Europe and America: Monograph of an Immigrant Group, University of Chicago Press.

Trumper, R. (2006). "Factors affecting junior high school students' interest in physics." Journal of Science Education and Technology **15**: 47-58.

Turner III, D. W. (2010). "Qualitative interview design: A practical guide for novice investigators." The Qualitative Report **15**: 754.

UCAS (2015). March Deadline Analysis: Subjects, UCAS.

van Nes, F., Abma, T., Jonsson, H., and Deeg, D. (2010). "Language differences in qualitative research: is meaning lost in translation?" European Journal of Ageing **7**: 313-316.

Weinburgh, M. (1995). "Gender differences in student attitudes toward science: A meta-analysis of the literature from 1970 to 1991." Journal of Research in Science Teaching **32**: 387-398.

West, A., Hailes, J. and Sammons, P. (1997). "Children's attitudes to the National Curriculum at Key Stage 1." British Educational Research Journal **23**: 597-613.

White, E. L. and Harrison, T. G. (2012). "UK SCHOOL STUDENTS'ATTITUDES TOWARDS SCIENCE AND POTENTIAL SCIENCE-BASED CAREERS." Acta Didactica Napocensia **5**.

Yong, A. G. and Pearce, S. (2013). "A beginner’s guide to factor analysis: Focusing on exploratory factor analysis." Tutorials in Quantitative Methods for Psychology **9**: 79-94.

Zajonc, R. B. (1980). "Feeling and thinking: Preferences need no inferences." American Psychologist **35**: 151.

Zanna, M. P. and Rempel, J. K (1988). "Attitudes: A new look at an old concept." The Social Psychology of Knowledge **81**: 315-334.