What are the challenges in progression, retention and achievement in A-level chemistry in Further Education colleges in England?

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Abstract

Choices made to study STEM subjects determine both the level of STEM skills in the population and the numbers of students with the necessary skills to continue studying STEM subjects at higher education. The aim of this research was to explore current issues around retention and achievement for A-level chemistry students in an FE college in England. Inherent in this focus was the significance of seeking out A-level chemistry students' and teachers' voices on the perspective of the challenges A-level chemistry students face.

An action research methodological approach was used to research specific school situation with the view to improve practice. Qualitative data was collected through structured questionnaire and semi-structured interviews. Four main perceived challenges from the questionnaires analysis were used to plan three action research interventions. The semi-structured interviews data were analysed using thematic analysis. Major challenges that emerged across the analysis of the questionnaires and various interviews data to varying extents included heavy maths content, stress from numerous mathematical formulae, need for maths support sessions, inadequate information for choice of A-Level Chemistry and STEM career pathway, effects of type of GCSE science offered, respondents' approach to learning, response strategy, insufficient practical experiments, and socio-economic status impact on some learners' performance.

The research study and the literature reviewed confirmed that students who take combined science route at GCSE are disadvantaged at A-level as compared to students who take separate sciences (Triple science). Having learnt the skills of using chemistry principles and concepts in answering questions, respondents were able to answer questions on time and gave detailed responses to questions when answering them than before the interventions. Implications for practice include: a provision of formulae booklet to reduce stress and load on working memory, maths support sessions to help students to develop sense of independence in learning and improvement in assessments. Socio-economic status impact on some respondents contributed to their inability to complete the two years. When addressed it could improve retention, progression and achievement in A-level chemistry. The learners' voice about their teaching and learning motivate them academically. Provision of more information for choice of A-Level Chemistry and STEM career pathway is essential.

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Chapter 1

Introduction to the Thesis

1.1 Chapter Introduction and Subject of the research work

This chapter will review the importance of science, technology, engineering and mathematics (STEM) subjects and professionals to the UK economy, analysis of entry and retention of A-Level chemistry students, and future effects of the decline in retention of A-Level chemistry students who enrol to study A-Level chemistry in England. I will give a brief account of my education and professional biography to position myself as an insider to this topic. Furthermore, I will also give a brief account of the FE educational sector in England and finally provide a structure of the thesis to give contextual background to the study.

STEM graduates are crucial to the UK economy, with research suggesting jobs were predicted to grow at double the rate of other occupations, creating 142,000 jobs between 2019 and 2023 (Giddings, 2019). According to the Migration Advisory committee (2022) the UK shortage occupation list included Pharmacists, Medical practitioners, Geochemists, Biochemists, Chemical scientists and all these professions require the study of A-level chemistry. STEM vacancies in UK are hard to fill and this is due to a shortage of applicants with the required skills and experience (UK Commission for Employment & Skills, 2022). STEM skills are important across different career paths and other aspects of life (Hoyles *et al*., 2011). Choices made to study STEM subjects including Chemistry (at A-level or through other post 16 choices) determine both the level of more general STEM skills in the population and the numbers of students with the necessary skills to continue studying STEM subjects at higher education. Entries in A level Chemistry have increased by 12.2% across the UK over the last five years (FFT Education Datalab, 2019) compared to a change of -5.8% in all A-Level entries. Furthermore, the entries in A-Levels for other STEM and some non-STEM subjects during the same period is shown in Table 1.1 below.

Table 1.1: A-Level subjects percentage entries (2015-2019)

A-Level Subjects	Percentage Entry
Biology	+9.4%
Physics	+7.4%
Mathematics	-0.9%
Psychology	+13.3%
Computing	+106.6%
Art and Design	+5.7
Design and Technology	-17.9

Source: FFT Education Datalab, 2019

However, the students' achievement rate in A-level chemistry for grade C or above has been declining for five years up to 2019 from 78.5% to 72.2% (FFT Education Datalab, 2019). This could pose a threat to the progression rate of students to higher education, since most universities requirement for a STEM course for A-Level chemistry is grade C or above (UCAS Application, 2020). Students achieving rates for grade C or above in other STEM and non-STEM A-Level subjects for five years up to 2019 were as shown in table 1.2 below.

Table 1.2: A-Level subjects Achievement rates (2015-2019)

A-Level Subjects	Achievement Rates (Grade C or above)	Percentage change
Biology	71.9% - 67.3%;	-4.6%
Physics	71.5% - 70.5%;	-1.0%
Mathematics	79.8% - 75.6%	-4.2%
Psychology	70.7% - 71.0%;	+0.3%
Computing	60.0% - 63.3%;	+3.3%
Art and Design	83.2 - 84.7%,	+1.5%
Design and Technology	68.4% - 68.2%.	-0.2%

Source: FFT Education Datalab, 2019

A level Chemistry had the highest decline in students achieving grade C or higher among both all the STEM subjects and the selected non-STEM A-levels, 78.5% to 72.2% (-6.3%).

Furthermore, McKie, (2019) indicated that the numbers of UK students applying to study chemistry at university have plunged by more than 20% over the past three years. And this fall has alarmed business leaders, who say home-grown talent is needed to run Britain's chemistry industry, which is worth more than £50bn a year to the UK economy (McKie, 2019). Turner (2020) also reported that the UK and Ireland are facing crisis in application for degrees in chemistry as there has been a drop of between 13 and 23% in application. It was further stated that this was a persistent trend, not just a blip.

Other STEM careers such as medicine, pharmacy and chemical engineering require a high grade in A-Level chemistry. A prospective applicant to medical school in UK might naturally first think about Chemistry and Biology because a large proportion of UK medical schools will ask for both (Medical School application guide, 2021). The minimum requirement for A-Level Chemistry is at least grade A by most of the medical schools (UCAS, 2020). Furthermore, almost every university requires A-Level chemistry and mostly grade B or higher for pharmacy and chemical Engineering. This is but to mention a few degree subjects with professional orientation which requires a good grade in A-Level Chemistry.

Annette (2020) reported that teachers of chemistry are among the most likely to leave the profession within the first five years after qualifying in England. She also reported that targets to train new teachers had not been met for a number of years and the story is similar in Wales, and Scotland. The report further stated that this could be a challenge for FE colleges and schools because high teacher turnover affects students attainment. One of the most important resources in schools and colleges are teachers. Great chemistry teachers could change lives. Some students are inspired by some chemistry teachers to pursue STEM careers and others also become scientifically literate after studying chemistry though they may not pursue STEM career pathways in higher education. The most effective teachers have an in-depth knowledge and understanding of the subjects that they teach (Annette, 2020). A decline in the number of students applying to study chemistry at university as reported by McKie, (2019) makes this report alarming coupled with possible challenge of getting teachers with the appropriate subject knowledge and pedagogical content knowledge for the curriculum they are expected to teach in FE colleges in future. Besides these, over twelve years report and analysis from Joint Council for Qualifications, U.K (2019) in Table 1.3 below shows that as the number of A-level chemistry students entries increases, there is also an increase in the number of students who are not able to complete the two years A-level chemistry they enrolled for.

Table 1.3. National analysis for two years progression for A-Level Chemistry

Subject	AS Level entries	A2 Level entries	Difference	Percentage change
Chemistry	18084 (2018)	59090 (2019)	+41006	+226.8%
Chemistry	32909 (2017)	54134 (2018)	+21225	+64.5%
Chemistry	73414 (2016)	52331 (2017)	-21083	-28.7%
Chemistry	87621 (2015)	51811 (2016)	-35810	-40.9%
Chemistry	88673 (2014)	52644 (2015)	-36029	-40.6%
Chemistry	85631 (2013)	53513 (2014)	-32118	-37.5%
Chemistry	82390 (2012)	51818 (2013)	-30572	-37.1%
Chemistry	79874 (2011)	49234 (2012)	-30640	-38.4%
Chemistry	62232 (2010)	48082 (2011)	-14150	-22.7%
Chemistry	58473 (2009)	44051 (2010)	-14422	-24.7%
Chemistry	54157 (2008)	42491 (2009)	-11666	-21.5%
Chemistry	52835 (2007)	41680 (2008)	-11155	-21.1%
Chemistry	50855 (2006)	40285 (2007)	-10570	-20.8%

(red)	This shows the current period when the new linear A-Level specification and exam has been introduced. First year exam is no longer compulsory and as a result most schools no longer enter their first-year students.
(blue)	This is the period when the old specification was in use and students used to do two compulsory exams, one in first year and one in second year.

Source: Joint Council for qualification, U.K (Each colour represents one specification period for the A-level chemistry exam entries. The specification is changed after some years in use).

In addition to this, I teach in the FE sector and have also noticed that though the number of A-level chemistry students' entries in the college where the research is taking place is high each year, however the number of students that complete the subject at the end of two years is low as shown in Table 1.4 below.

Table 1.4. Ten years trend of retention at College A in England

Subject	AS Level	A2 Level	Difference	Percentage change
Chemistry	50 (2020)	42 (2021)	-8	-16.0%
Chemistry	55(2019)	43(2020)	-12	-21.8%
Chemistry	68(2018)	48(2019)	-20	-29.4%
Chemistry	89(2017)	47(2018)	-42	-47.2%
Chemistry	88(2016)	52(2017)	-36	-40.9%
Chemistry	105(2015)	52(2016)	-53	-50.5%
Chemistry	99 (2014)	65(2015)	-34	-34.3%
Chemistry	111(2013)	74(2014)	-37	-33.3%
Chemistry	105(2012)	64(2013)	-41	-39.0%
Chemistry	110(2011)	54(2012)	-56	-50.9%
Chemistry	118(2010)	62(2011)	-56	-47.5%

College A, England

A quick analysis from Table 1.3 indicates that from 2010 to 2015 when the old specification was in used, 64% students nationally progressed to complete A level chemistry. In college A, the institution where the research was conducted, Table 1.4 shows that 41.3% of the students progressed to complete A level chemistry from 2010-2015. After an action plan was put in place from 2015/16 academic year to 2020 in college A, the percentage progression increased to 59.8%. This still suggested that about 40.2% students could not progress which is alarming and suggested that something must be done to improve the progression and retention of students in A level chemistry.

I have identified this gap in the achievement and progression rate of the students, and this research sought to identify the perceived challenges of the A-level chemistry students in England using college A as the research centre.

1.2 Statement of purpose

The aim of this research is to explore current issues around retention and achievement for A-level chemistry students in an FE college in England. The research is a practical action research study in an interpretive-qualitative framework involving students and teachers in one FE College in England.

1.3 Research Objectives

The study seeks to

• To explore the experiences of chemistry A-level students in an FE college and identify any problems.

• Provide better understanding of the issues and challenges faced by A-level chemistry students in FE college who applied to do chemistry and stay to complete the subject.

• Identify through structured questionnaire, implementation of action research interventions and the corresponding evaluations of each of the interventions to unravel how best to support students and encourage them to complete A-level chemistry in FE college successfully.

• Identify strategies that may help colleague chemistry teachers, educational institutions and stakeholders to improve retention and achievement rate of A-level chemistry in FE colleges in England.

1.4 Research Questions

The research questions under consideration in this research study are as follows:

1. How do learners' perceived challenges of A-level chemistry concepts influence their achievement and progression?
2. What challenges do chemistry lecturers foresee as hindrances to students' achievement and progression?
3. How does actual understanding of the chemistry concepts enhance students' achievement and progression?
4. How can practical action research intervention(s) help to solve the perceived challenges students face in A-level chemistry?

1.5 A Brief History of the FE in England

This section will give a brief history and an overview of the transformation that has taken place in the FE sector. The challenges of the professional teachers in the sector including my personal observation as a professional teacher working in the sector and the impacts of different government policies in the educational sector especially the FE are also discussed.

1.5.1 The Further Education sector

The further education colleges in England offer a broad range of education and training provision. Currently the FE colleges provisions include GCSEs, A-levels and vocational courses. They also provide higher education degree courses.

FE colleges have become a ‘bridge’ for many young people between school and work, as the colleges have sought to create a strong link between education, training and the workplace. They are mostly perceived as offering a second chance route to those who did not succeed at school (Robson, 2006; Broad, 2016). Furthermore, the FE is also viewed as a ‘remedial ground’, for all those excluded from compulsory education (Lucas, 2004), and is also used as political lever to raise the participation of young people in education (Perry and Davis, 2015). Consequently, FE has been described as working on a ‘deficit model’ (Robson, 2006; Department for Business Innovation and Skills, 2012a) and is typically seen as having a lower status than ‘’academic general education’’ (Broad, 2016). According to Coffield *et* al. (p.4, 2008), Further Education is ‘fascinating, turbulent, insecure but desperately important. The Institute for Government (2017) report indicated that there have been 28 crucial legislations in relation to the FE, vocational and skills training since the 1980s. Furthermore, there have been six different ministerial departments for education and forty-eight secretaries of state with suited responsibilities. The FE sector has survived all these various changes, however there is the believe that this instability has left the sector ineffective (Carson, 2018).

Some students see the FE as second class to schools with six-form provision with twice the number of disadvantaged 16 to 18-year-olds are in further education than in sixth form schools (Dabbous *et al*, 2020). Some of the prospective students and their parents at opening day events in my college ask questions that make you feel you teach in a second-class academic environment that may become their last result or choice if nothing works for them. However, the FE colleges provide a variety of subject combinations for students that sometimes are difficult to find in other sectors. It also provides an academic independent life style for students as a precursor to university life. This is an important skill for students if they are to succeed in higher education (HE). Despite the negative perceptions, students perform well in the FE sector. According to Department for Education (2019c) report, colleges tend to have narrower gaps in attainment between disadvantaged and non-disadvantaged students.

1.5.2 The changing context of the Further Education

Apart from being accountable to their customers for delivering the education and skills that employers and learners need, FE colleges are also accountable to government, to ensure that government's investment is directed towards training which meets the government objectives set. According to an Association of Colleges (2019) report, the Education Funding Agency (EFA) manages the budget and gives allocations to colleges and schools via a national funding formula. The government holds colleges to account for the quality, rigour and relevance of the provision through inspection and data on achievement of qualifications, and, in future, outcomes for learners. Government, in addition holds colleges to account for their financial health and control. If the quality of provision (assessed by Ofsted inspection and Minimum Standards), or financial health/control (as assessed by Skills Funding Agency audit) is found to be inadequate government will intervene swiftly and rapidly. Thus, the autonomy of colleges is limited despite the Further and Higher Education (FHE) Act in 1992 granting FE institutions their independent corporate status. The government investment in the FE sector has enabled it to introduce frequent policies and curriculum changes which mostly affect teachers' identity due to stress and high workload among other factors (Gibson, 2018). The FE sector has not much choice in how it supports its staff as so much is still directed from central government.

There have been some various studies which refer to the professionalisation of the FE sector (Avis 2005; Bathmaker and Avis 2013; Lucas, 2013). These studies examine the impact of government policy and introduction of more rigorous external quality assurance in FE sector. Lucas, Nasta and Rogers (2012) discussed the introduction of organisational standards, while others such as Forrest (2015) review effectiveness of external quality assurance agencies like Ofsted in improving standards. These studies provide a context in which FE teachers are operating.

FE colleges became incorporated in 1992 (Department for Business Innovation and Skills, 2014) and were released from local authority control. Post incorporation, standards in the FE sector were inconsistent and so began the professionalisation agenda for FE. However, it can also be argued that this agenda is yet to be finalised as there have been several iterations. These include the Further Education National Training Organisation (FENTO) Standards in 1999, Lifelong Learning United Kingdom (LLUK) Standards in 2006 and the current Education and Training Foundation's (ETF) Standards for FE Teachers and Trainers, which was published in 2014. Lucas (2007) reports that The FENTO standards and others like them encouraged a mechanistic, 'tick-box' approach, rather than a particular curriculum model, which has the greatest responsibilities for this. I share this view because no finality on the standards in the FE sector has been achieved yet since its incorporation from 1992, even though several standard agencies have been established by both previous and current governments.

Running alongside this indecisive approach to setting professional standards, the sector has experienced fluctuations in expectations of teachers' training. In 2001, new regulations were introduced which required all FE teachers to be suitably qualified to support their students. For example, FE teachers were expected to hold a Certificate of Education, a stage 3 FE teaching qualification or a qualification equivalent to a stage 3 FE teaching qualification.

This was reaffirmed in 2007 when FE teachers were expected to possess a specific teaching qualification, depending on their role. However, in 2013 the requirement to possess a teaching qualification was revoked, although the Department for Education (2016) does highlight there is a general expectation and value given to FE teachers possessing a good teaching qualification. All the aforementioned professional standards were published with a focus on teachers' standards in the FE sector.

These policies of ensuring that the FE teacher must obtain a professional certificate in order to teach in the sector in itself was good, but the teachers are not allowed to make professional decisions about planning, designing, preparing, teaching, evaluating and analysing which could make their job and learners' experience better. The FE teachers are still treated as non-professionals who must take instructions from their line managers in order to accomplish a task. However, one of the cardinal roles of a teacher is to make informed and intelligent decisions about practice to achieve various outcomes with and for students in their classes (Pezaro, 2016). More emphasis is placed on results as compared to the full development and learner experience.

1.5.3 Challenges and effects on teacher identity in FE Colleges

The Institute for Fiscal Studies (2017) reports that FE spending per student was 45% higher than secondary school spending per student in 1990. However, it was 10% lower in 2019-20. The report further reviews that spending per pupil in school was set at least 70% higher in 2020 than it was in 1990, but the FE spending was not higher than it was in 1990. This is as a result of further education spending growing more slowly than school spending. This limits the sector's competitiveness in terms of pay and investment in resources to deliver provision.

According to Weale (2018), FE sector has been hard hit with an 8% cut in budget in real terms since 2010/11 resulting in course closures, job losses and cuts to student support services. Additionally, the FE sector is expected to struggle to deliver the government reforms without extra funding. Staff pay has fallen by 25% since 2009 and most colleges are finding it difficult to recruit the professionals they require. According to Wilshaw (2014) 40% of teachers are found to leave their job within their first five years, and teachers of chemistry are among the most likely to leave the profession within the first five years after qualifying in England (Annette, 2020).

A study by Newton (2016) suggests that workload and disillusionment were the major factors that cause teachers to leave the profession but one of the most cited factors during the study that they would like to see improved about their working lives was being able to work more flexibly. Other improvement factors identified during the research were better relationships with their leadership teams and experiencing a greater sense of appreciation and value. These were noted to decrease the negative effect of high workload. This means leadership teams would be well advised to develop sustainable patterns that will be convenient for part time staff and those with caring responsibilities outside of college. She stated that if developed well, this could lead to over 84% remaining for an additional 2 years and over 34% for more than 7 years. This is an obvious fact which l have observed in my college too. In my college, the mathematics department staff turnover is the worst of us all. There has been over 90% staff turn-over in the last two years. Biology is another hard hit with over 80% staff-turnover since last academic year, 2021/22. Among the STEM courses, Chemistry seems to be one of the subjects that has most stable staff turnover for the last four years, about 30%. According to Donley *et al* (2019) high teacher turnover hinders students' performance and leads to diversion of resources from efforts to improve schools and colleges. Additionally, it could result in placement of inexperienced and less effective teachers in classrooms.

According to Education Policy Institute (2018) report, the areas outside of London had just over a third (37%) of maths teachers and just under half (45%) of chemistry teachers in the poorest schools and colleges with a relevant degree. In more affluent schools and colleges outside of London, the proportions are far higher for maths (51%) and chemistry (68%). Moreover, the proportion of teachers with a degree range between 40-50% for all schools and colleges in maths, regardless of deprivation level and it is 60% for chemistry. Thus, about 40% of teachers who are teaching chemistry are not professional chemistry teachers and this may affect their quality of teaching and the students learning experience especially practical experiment which most of the unprofessional teachers neglect because of lack of understanding and expertise. This could affect the achievement and retention rate of students who sign up to do chemistry because of lack of understanding and better learning experience. Contrarily, subjects that had a greater proportion of highly-qualified teachers were biology (78%) and English (67%). The report further stated that areas such as Portsmouth, Hampshire, Newham, Barnsley and Doncaster have the lowest proportions of teachers with a degree in shortage subjects in England.

Martin (2017) reports on a survey which covered staff at twenty-six FE colleges that 54% of teachers surveyed felt working outside of their regular teaching hours was a major challenge, while 62% said that resources issues were one of the most concerning aspects of their role.

Cattanach (2018) conducted a study about the Impact of Ofsted on teacher well-being and the following were some of the key findings:

- Many teachers generally feel a sense of inadequacy, depression and a profound feeling of letting others down where judgements are negative from Ofsted. For many the ordeal may be too much and may lead to long term sickness or staff leaving the profession. However, there is a sense of 'pure relief' when the judgement is more favourable.
- Ofsted has an unfortunate toxic impact on working climate for schools and colleges. Many teachers state that they seem to be working for the next inspection outcome as opposed to working for students. The pressure is constant – leadership

teams plan their strategic leadership objectives couched in Ofsted language. It pervades the culture of schools and colleges to such an extent that it becomes embedded in leadership practices which can cause harm.

- The work load involved in preparing for Ofsted, despite their protestations that you do not have to really prepare is vast. The relentless, tread mill of keeping up with frameworks and ensuring you have an answer for anything is exhausting.

The Education and Training Foundation (ETF), a new professional body for FE, has produced a report which suggests that staff turnover is high within the FE teaching sector at 20 per cent annually (ETF, 2014) and almost two-thirds of teachers in FE are on part-time contracts. However, this has shown a decrease as the Association of Colleges (2019) report staff turnover averaging 17% but face particular challenges recruiting and retaining Maths, Science and Engineering teachers. Other documented work has been done by Ingersoll (2002), Faber (2010) and Day (2013) to understand why teachers leave the profession. It was noted that seemingly more lucrative or attractive careers were a major factor possibly due to the stagnation of teachers' pay. This give credence to the fact that there is a growing job un-satisfaction among FE teachers which also affects their professional identity, my college not being an exception.

1.5.4 Personal Experience and Observation in the FE Sector

As a teacher who has worked in the FE sector for over seventeen years, I have witnessed quite a lot of these challenges that FE teachers routinely go through which includes excessive work load, demand for unreasonable academic results due to competition among colleges, poor salary and many more. It is common to hear colleagues discussing the stress at work and the work load which are having an effect on them in the staff room. The stress of constantly 'trying to catch up with things', never adequately attending to the growing list of responsibilities has contributed to FE teachers' sense of inadequacy and failure. I have seen colleague teachers using their lunch time to support students in many occasions. To the best of my mind and experience, FE teachers have been less valued and motivation for work is decreasing. Most FE teachers sometimes feel that they are failing the profession by not doing what they were supposed to be doing: encouraging active learning due to results-led and target-led goals by managers (Department of Education, 2018). For example, some practical experiments which could be done to make A-level chemistry more hands on are sometimes skipped for the sake of completing the specification and achieving results. This makes the subject more theoretical and denies the students more rounded experience of A-level chemistry which is meant to be a practically based subject. Furthermore, the lack of practical teaching and experience could lead to students not gaining the necessary skills and inspiration to pursue a career in the chemical sciences, either through university or following a more technical route.

Marginalisation of FE teachers appears to be related to the impact of current changes in FE. Poor workplace conditions, lack of resources, perceived lack of management support, all impact on communities of practice within FE and this has affected staff commitment and their dedication to students. It is worth noticing that workplace well-being relates to all aspects of working life. Thus, workers well-being is a major factor in determining an organisation's long-term effectiveness. In my opinion, the working environment in the FE sector is increasingly becoming a challenge for many teachers and is impacting negatively on their professional output which can affect students learning experience and achievement.

1.6 My Education and Professional Biography

My education could best be described as 'traditional'. I attended state primary school, middle school and secondary. When l entered secondary school, it was my dream to be an accountant in the future. I was looking forward to it until I attended a career and advice session organised by the assistant head mistress of my secondary school. This gave me a wider view of other careers including science. I realised that if l completed a science degree l could still become an accountant if l wanted to have a career change in future but diverting from a degree as an accountant to science would be challenging if l ever would like to do so. Such career and advice sessions in secondary schools should be encouraged to continue especially for people with similar background like me. I had no family member who had ever finished secondary school let alone doing a degree. There was no academic model in the family and as a result I had limited information and support in making academic decisions. I did science at secondary and A-level. I did Physics, Chemistry and Mathematics at A-level to ensure that my career options were wider in science.

The old educational system in Ghana between 1960 to 1997, which I used was six years primary school, four years middle school, five years ordinary level secondary school and two years six form. The number of years for university education depended on the course pursued. Entry into a secondary school required passing a common entrance examination which could be taken after second year in middle school without necessarily finishing all the four years in middle school. However, form four leaving certificate was obtained for completing the whole four years at middle school and passing a final year exam. This could be used to attend a vocational school, but not secondary school. In Ghana (1960-1997), a year of national service after A-levels was required before going to university and another one year of national service after completing a degree. I was posted to a secondary school to teach mathematics and science in lower secondary class after my A-level. My love for teaching as a career became evidently clear because the students enjoyed my teaching style and even upper secondary students would come to me for support sessions upon hearing testimonies about my teaching from the lower secondary school students.

I decided to pursue a degree in chemistry so that l could teach in secondary school or work in the chemical industry. Whiles pursing my chemistry degree, a group of undergraduates in my community, would organise vacation classes for secondary school students in the community. I taught chemistry during such sessions and the students appreciated a lot what l was teaching them. It was not a surprise that before I completed my first degree, a headteacher in one of the secondary schools approached me to come and teach in his school after completing my first degree. I joined the teaching profession right after my first degree and l have never looked back. I wrote my first book, chemistry practical made easy, in my third year of teaching (Asamoah, 2000).

During my second degree, I also applied to be a demonstrator at my department because l wanted to be part of the teaching and learning in the department. In Ghana, Master of Science is two years and as a result I became a demonstrator during my second year at the department when I was doing my research. I was an Assistant Examiner in Chemistry for the West Africa Council for four years when I was in Ghana. This enriched my teaching and made me a better teacher as l implemented the knowledge and skills acquired in my teaching.

My love for the academic field continued when I arrived in England and as a result, I pursued a degree in education to teach because I realized one cannot teach in England without a certificate in education which was not compulsory in Ghana then. I got my first job as a Chemistry lecturer at North Hertfordshire College right after my Postgraduate Certificate of Education in 2007. I left the North Hertfordshire College just after one year because I got a full time offer from another College. I have been a full-time lecturer in Chemistry in this College since 2008 and currently l am the Head of A-level Chemistry. I am an Examiner for both OCR and AQA Exam boards in Chemistry in England.

I wanted to pursue research in Professional Doctorate, Education option so that I could enhance my knowledge in this area in order to be able to do more than what I am currently doing for both my students and profession. I chose the research topic as indicated in the front sheet of this thesis, because there is a growing concern among both students and parents that A-Level Chemistry is too difficult and challenging. The number of students who drop out from the subject after one year of study at A-level is not encouraging either as indicated in section 1.1. I strongly believe that by completing this research l will enhance my quality of provision and also improve the achievement of students in A-level Chemistry. I will also be in a better position to share my knowledge and information with my colleagues in the profession which will equally improve their general understanding of practice. I have always been looking for possible means of making chemistry enjoyable and helping those who sign up for the subject to be successful in their future career with chemistry.

1.7 Structure of the Thesis

This thesis is presented in ten chapters. Chapter 2 provides a review of the literature about challenges in progression, retention and achievement in A-Level chemistry in United Kingdom. A comparison is done with other European countries in order to get a better view of the challenges to ascertain if it only pertains to England. Chapter 3 explains the methodology for my thesis and a provision is made as to why other methods were discounted. It also explains some of the main ethical challenges I came across in my research work and how they were dealt with. Chapter 4 deals with my methods for data collection and analysis, Chapter 5 deals with the findings from my first data collections, questionnaire analysis. Chapters 6, 7 and 8 are about the findings of my research work termed as analysis of the post cycles 1, 2 and 3 action research interventions. Chapter 9 is the students' voice account of A-level chemistry students who enrolled for the subject but could not complete it and analysis of two chemistry teachers' interviews. Finally, Chapter 10 deals with the discussion of the findings from my research work, placed within the contexts which have been outlined in my introduction and the conclusion of my thesis.

Chapter 2

Literature Review of the Research Study

2.0 Chapter Introduction

A literature review serves several purposes (Creswell, 2009). It gives a framework for establishing the importance of the research and provides an account of what has been published on the research topic. In this review, I intend to review some of the salient research reports that give account of the challenges FE college chemistry students face in progression, retention and achievement in England, the rest of United Kingdom and Europe.

2.1 Literature search

In this section, I would first like to describe the process used in reviewing the literature in detail. The intention is to set out the methodology of my literature search in a clear and transparent manner. The literature search strategy began with focus on key journals in education and related field namely; Chemical Education, Academia ,International Journal of Qualitative Studies in Education, Journal of Chemical Education, Chemistry Education Research and Practice, Journal of Curriculum Studies, International Journal of Research and Method in Education, Journal of Education, Chemistry Education Research and Practice, International Journal of Science Education, Irish Journal of Academic Practice, Oxford Review of Education, ResearchGate and International Journal of Research and Methods in Education.

For each of these key journals and academic social networking sites, I searched through every issue from the beginning until the time my thesis was submitted. Search engines such as EBSCOhost was thoroughly used for online journals. I made subscription to receive content updates via email from each of these journals and this kept me updated with articles as and when they were published and were made available online. This ensured that I was up to date with recent literature when I was writing my thesis. Furthermore, for all copies of these journals available online, I carried out internet searches using the following terms to ensure I had not missed any articles during my search:

retention and progression in A -chemistry

progression and retention in A-level chemistry achievement and retention in A -level chemistry

achievement in A -level chemistry

challenges in A -level chemistry

progression in A-level chemistry

retention in A-level chemistry

perceived challenges of A-level chemistry

students' perception of A-level chemistry

I then increased my search strategy in several different directions. First of all, I began to ''snowball'' search from articles I had found in my well-structured search and followed up main references from papers I had identified. This included forward and backward searching. Besides this, I also found new references by putting my search terms into Google Scholar.

Through this process I identified a total of five main pieces of literature that were relevant to my research study. Moreover, only two literatures from U.K and one from Sweden were directly dealing with post-16 or upper secondary chemistry education. All these research studies dealt only with survey questionnaires without following up with interviews of the respondents in order to get more detail information about the students' voices of the challenges in school chemistry. The search for academic research that has been done on the challenges for progression, retention and achievement for A-Level chemistry students in England has been difficult. Though much has been said (Breuer, 2002; Mckie, 2019; Turner, 2020) about the declining numbers in chemistry and its effect in the chemical industry and related chemistry profession in UK as explained in section 1.1, only few research works have been done about this issue in the six form and FE colleges in UK though this is the sector or level of education the students choose their STEM subjects before going into higher education. This could suggest that researchers might have in many occasions overlooked learner voice in their research findings as a possible means of solving the challenges in progression, retention and achievement in A-level chemistry and other STEM subjects such as Physics at post-16, which might have led to decline in number of students pursing chemistry degree in England universities. This would be explored in this research work. The five-research works have been reviewed independently to show the long-standing issues in A-level chemistry which have still not been resolved and the lack of students' voice in the various research studies. Other common themes would be discussed later in the review to show their respective effect to A-level chemistry.

2.2.1 First Review Work

As early as 2002, the issue of declining numbers in undergraduate students applying to study chemistry in UK was identified by Royal Society of Chemistry (Breuer, 2002). The report showed that the number of students applying to study chemistry courses at undergraduate had declined since 1989 to 2001, especially from 1993 to 2001 which showed 32% decline in recruitment. What was more alarming was that some universities reported the closing or merging of chemistry related departments. However, there was no recommendation for research to be conducted in the six form schools or FE colleges where students select their main A-Level subjects to study before applying to HE. This could have provided the students voice to the challenges and possible recommendations from the students' perspective. This gap in the research would be explored in my research through semi-structured interviews with students from an FE college in England. The three main challenges identified by the Royal Society of Chemistry according to Breuer (2002) were the perceived difficulty of chemistry as a subject, pessimistic public views and image of chemistry, and unattractive evident career. McKie (2019) and Turner (2020) reported that there is still a challenge in the recruitment of students to study chemistry at undergraduate as explained in chapter 1.1.

2.2.2 Chemistry is Difficult

According to Breuer (2002), the Royal Chemical Society sponsored meeting mentioned in their report that students at secondary school and undergraduates in higher education hold a general view that chemistry is difficult. There are many six formers and FE college students who move away from chemistry when choosing their career or university courses. It was further revealed that chemistry and its related courses require more attention as compared to non-science-based courses due to the variety of activities and skills involved such as literacy, numeracy and experimental skills. Chemistry is apparently viewed by students as a subject which would deny them the opportunity to be creative and not able to express their personal views during discission. This is because when the fundamentals are being taught in school, all the answers seem to be known already and as a result all students need to do is to master the knowledge and reproduce it when required. This leaves less to explore.

Most of the exciting application in chemistry and life issues, the diverse and inspiring applications still under investigation, as reported are done in higher education when students have already chosen their career pathways (Breuer, 2002). The report indicated that students get less opportunity to experience meaningful laboratory experiments in order to gain an appreciation of chemistry in schools due to pressure on time to complete the specification, demand for high achievement rate by schools and high health and safety requirements. It was proposed in the report that changes should be made in the curriculum and organisation at school level to encourage context-based teaching which may change the attitudes fundamentally. However, Kershaw (2017) reported that 29% of GCSE science students in England did less than one practical experiment in a month or never. The report which questioned around 4,081 14 to 18-year-olds, including 2000 students taking GCSE, indicated that under half (45%) said that they did at least one practical experiment once in a month. Over 22% said that even when they do a practical work, they mostly follow instructions without understanding the purpose of the experiment. It was further reported that only 36% of the GCSE students from the most deprived areas in England do practical work at least once a month compared to 54% of students from wealthiest areas. About 58% of the students wanted to do more practical experiments especially those doing single science which counts as one subject because their GCSE Chemistry is more detailed than those who do combined science and more practical experiments will inform the theory they study. It was stated in the report that lack of more practical work is unacceptable because it makes STEM subjects such as chemistry difficult to understand because chemistry is a hands-on practical subject. According to Shirazi (2017) lack of interesting science experiments in secondary school makes students feel that science is mainly theory to be learnt for examinations. Such learning experience by GCSE students could make A-level chemistry more challenging because the basic practical experiments which were meant to give them more understanding in the fundamentals were not done. There are many reasons that contribute to students' failure to engage in meaningful learning at post-16 chemistry classrooms. Nevertheless, the main hurdle lies in the students' weakness to demonstrate a good understanding of very basic concepts of chemistry from school, including practical skills, due to huge gaps in students' understanding of fundamental concepts which does not permit them to engage in in-depth learning of advance level content at post-16 (Mayhill and Brackley ,2004; Bennett *et al*, 2013).

This would be explored in my research work to find out if it is one of the challenges in the FE chemistry for progression and retention.

2.2.3 Unpopular Image of Chemistry

The word 'chemical' has gained an unpleasant feeling or implication in the U.K media (Breuer 2002). 'Chemical' usually comes about with the adjective 'dangerous', whether as a result of toxicity or some detrimental effects on the environment.

The association of the public view with danger, pollution or some other hazards is almost certain (Levinson, 1998; Breuer, 2002; Hartings and Fahy, 2011; Davies and Sanderson, 2014; Fu *et al*, 2015). It was recommended in the report (Breuer, 2002) that teachers who teach chemistry at all levels especially in schools, should try their uttermost best to thwart this unpopular image of chemistry by engaging and providing detail information to students during lessons and class discussions so that students get better understanding of chemistry in order to erode any negative image about chemistry they might have heard or had from the public. The Royal Society of Chemistry should do more to promote a positive image of chemistry, but this should be done in such a way as to avoid it appearing as a special pleading according to Breuer's report. Edwards *et al* (2016) reported that the biggest challenge for chemistry is not suspicion and negativity, but what is needed is to overcome people's neutrality, disengagement and lack of confidence. This is due to a lack of positive images. Additionally, Edwards *et al* (2016) report indicated that most people's first association with chemistry when it was mentioned was school memories, for some this meant a subject that was academic and challenging. The report further indicated that many of the respondents, 58% of women and 45% of men agreed that they did not feel confident enough to talk about chemistry. One of the respondents mentioned that the only feeling that springs to mind when chemistry is mentioned is panic because it was not enjoyable at school (Edwards *et al*, 2016).

Furthermore, Fu *et al* (2015) report showed that when respondents were asked to rank engagement or interest with chemistry, on a scale of one to ten, 43% gave a low score (1-3), 32% a moderate score (4-6) and 23% a high score (7-10). In addition to that, men were more likely than women to say that chemistry makes them feel happy (23% and 16% respectively), young adults aged 16-24 were more likely to feel bored with chemistry (18% compared with an average of 10%) and those educated to degree level were slightly more likely to feel excited (19% compared with an average of 11%). The research involved 2,104 adults aged 16 or over, UK-wide random location survey sampling. This is was collaborated by Wellcome Trust (2020) report which stated that most of year 10-13 students (68%) cited personal barriers such as lack of interest or confidence or concerns about the volume of work and perceptions of difficulty as their reasons for not offering science. The Wellcome Trust report also indicated that many students (41%) perceived science as difficult and some were put off by having a lot to remember (35%).

2.2.4 Career Prospect Options

Many people see and think about chemistry graduates as people who wear a white coat and works on a bench with glassware on it (Breuer, 2002; Fu *et al,* 2015; Edwards *et al*, 2016; Turner, 2020). Breuer's (2002) report indicated that 25% of chemists who had graduated after six months were normally in employment and working as science professionals. However, according to Royal Society of Chemistry (2022) report only 22% currently remain in employment and work as science professionals. The rest spread around a wide range of professions such as IT, Finance, Health sector and many other sectors. This shows that the broad training chemistry offers have been accepted by employers as being of great value. This should be widely publicised to six formers when they are making their subject choices and also to year 11 students that you can do chemistry as a degree but you can do whatever else afterwards. This may encourage students to select and stay on to complete chemistry at A-level and possibly choose it as a career subject in higher education. Donnelly (2021) report showed that between 2015-2019, learners at 16 pilot schools and colleges in England, who benefited from good and continuous career guidance provision became increasingly more likely to achieve their learning outcomes, compared to learners at other colleges. Additionally, teachers observed real changes in learner's engagement in class because they understood the relationship between knowledge/ skills and their future career. For those in schools, the Donnelly report indicated that the greater the career and guidance benchmarks were held, the greater the number of GCSE passes at 9-4/A*-C achieved by each learner. Making academic career decisions not only enhances students' ability to progress academically, but also increases their effective decision-making skills (Walker and Peterson, 2012; Bertoch *et al.,* 2013; Archer *et al.,* 2013; Bennett *et al*., 2013)). The Sutton Trust (2022) reported from their research work conducted in UK secondary schools that only 36% of students in UK had attended any career related programme or participated in any career related activities.

Furthermore, people have currently become more concerned with the environment and the sharp growth in living systems means that Biochemistry, Molecular biology, Environmental chemistry and Forensic science are some of the areas that excite people (Breuer, 2002; *Fu et al*, 2015; Archer *et al*, 2022). These areas all require chemistry as a fundamental subject which should be chosen and studied at six-form.

2.3.1 Second Review Work

This was a case study on effective practice conducted in New College, Durham. The aim for the case study was improving engagement, achievement, retention and student recruitment at A-level chemistry. The case study set out the strategies which were applied over two-year period between 2008/09 to 2009/10 academic years. According to Godfrey (2011) the course leader carried out a series of changes that improved the students' experience and resulted in a significant increase in achievement. These included: carrying out more clearly structured practical experiments; role play and modelling activities; use of online resources to assist learning and understanding. This was materialised using CPD opportunities available to engage with other colleagues and professionals with the help of the college.

The case study focused on delivery, resources and curriculum activities but no students' voices were included in terms of interviews or focus group. This gap has been taken up in my research work. I would interview twelve students at the end of each of my three action research interventions in order to obtain further students' voices besides the questionnaire that would be administered initially.

2.3.2 The College

Durham New College had 15,000 students enrolled onto FE courses and over 1,200 learners on HE courses in 2008, when this case study started. It received outstanding: grade 1 from Ofsted inspection in 2009 for its effectiveness of provision, capacity to improve, achievements and standards, quality of provision and the college's leadership and management. The college received recognition from Learning and Skills Improvement Service (LSIS) in March 2010 for its excellence and innovation and were awarded the prestigious 'Beacon College' status. The Ofsted inspection and the LSIS awards all happened during the duration, 2008-2010, when this case study was taking place. However, there was difficulty in recruitment and achievement in the college's A-level chemistry.

2.3.3 The Challenge

The college had approximately 300 students in the Sixth Form Centre with only one class at first year and the second year for A-level chemistry. There was only one subject specialist teacher for chemistry. The challenge was to develop inspiring course that would raise students' engagement and achievement. There was no discussion or mentioning of the subject teacher's knowledge or performance in teaching A-level chemistry, however the teacher was required to undertake self-improvement activity course which suggests there might have been an issue with his/her delivery of the subject. The chemistry teacher was asked to attend relevant CPD trainings to improve subject and pedagogical knowledge. This raises other issues which can lead to challenges in improvement and achievement in A-level chemistry: lack of relevant continuing professional development trainings for chemistry teachers, engaging activities for students during the delivery of the lesson and subject and pedagogical knowledge of the teacher. According to Wellcome Trust (2020, p. 48) teachers have reported a positive impact on teaching as a result of partaking in excellent CPD sessions, through improvements to teachers' subject and pedagogical knowledge.

This case study was teacher centred and sought to help the chemistry teacher to have self-improvement in teaching the subject as means of improving the achievement and retention of A-level chemistry students in the college. This proved successful from the results of the study which will be discussed later. There was no questionnaire, interviews or focus group discussion to get students' voice which could have added feedback from the students to enrich the research work. Some feedback from the students could have emphasised the areas of the case study which had been beneficial to them and what needed to be improved.

2.3.4 Activities Implemented

The chemistry teacher was tasked to develop a course content which was more engaging for students learning experience and new ideas of improving the student's recruitment into A-level chemistry in the college. Three key strategies were implemented. Firstly, the chemistry teacher undertook considerable high quality CPD programmes to develop new course content.

Secondly, the chemistry teacher implemented his newly acquired knowledge and experience to develop a new course content. The new course content included investigative practical experiments for A-level chemistry. The experiments were structured to attain clear learning outcomes for the A-level chemistry students and to improve their understanding. There was also the use of modelling and role play activities to provide a more varied learning experience for the A-level chemistry students and to engage them as active learners. Others included the use of online resources such as Labskills (flash-based e-learning resource) and Bestchoice (review tutorials and interactive questions) to widen students' access to appropriate learning materials, use of variety of structured assessment methods to monitor students' progress to enable early intervention and support, and the use of current research themes to contextualise the learning, improve engagement and motivate the students. Montes (2022) indicated that students who are able to access learning materials, interact and collaborate with their tutors and peers online enjoy flexible, engaging and motivating courses of study. Moreover, Osika *et al's* (2022) report suggested that learning in context can help students appreciate the relevance of disciplinary knowledge and skills, increasing their motivation and engagement. On the other hand, they indicated that learning that takes place outside the context in which knowledge and skills are to be applied can limit or reduce a student's ability to transfer and utilise that knowledge in a new environment or in the real world. Additionally, the use of lecture recordings was indicated to be positively related to students' academic performance (Zhang *et al*, 2022; Hung et al., 2018; Robertson and Flowers, 2020). Moreover, the lowest performing students were reported to have less motivation to use recorded videos and therefore other resources may be required to improve the learning experience for these students (Bezerra, 2020).

Finally, the chemistry teacher developed taster day sessions and school presentations to improve the recruitment of students into A-level chemistry in the college. These provided potential students with a more engaging learning experience to encourage them to consider A-level chemistry as one of their subjects for A-levels.

2.3.5 Achievements and Issues Raised

The recruitment onto A-level chemistry in the college increased from 15 in 2009 to 32 in 2010, but no information or data were supplied to indicate how many of them progressed to the second year. Achievement rate of the first-year students increased from 50% in 2007/2008 to 87% in 2009/2010 and the success rate increased from 43% in 2007/2008 to 67% in 2009/2010. No data in terms of achievement or success rate for the second-year group were supplied to provide the full reflection of the students learning journey in the college for the first two years when the research was undertaken.

The case study only provided a partial report of what was happening in the chemistry department in the college since no students' voice in terms of interviews or focus groups was incorporated into the research to provide further details. Furthermore, the results provided were mainly for the first-year group though the research was conducted for two years. Though retention was one of their aims for the case study nothing was reported on it at the end of the two years. However, the report has shown that a more engaging science content and activities can help to improve achievement and success rate in A-level chemistry. In addition to this, taster day sessions and school presentations can improve the recruitment of students into A-level chemistry in a college as shown in the report.

2.4.1 Third review work

Shirazi (2017) report on a research study to explore student experience of school science in England. The aim of the research was looking at student perceptions of school science experience and subsequent participation in science at further and higher education. The researcher stated that a number of research studies had been done on students' attitudes to science using large sets of national data such as the National Pupil Database but fewer studies had used students' reflections of their school experiences in establishing how school science experiences influence future choice of science at post-16 and beyond in England. The core research questions were; the reasons students decide to study science at post-16 when it is no longer compulsory, the role school science may play in a student's decision to study science further or not, and which factors or incidents are important in the students' experience of school science?

Students (ages 16-17) in sixth forms of five secondary schools in England were asked to complete a short survey questionnaire to identify their school experiences that played a role in their choice to take up science further or not. There were a total of 594 students; 273 females and 321 males.

There were two main groups; those who were doing science at A-level and those who did not take up science at A-level. Out of that population, 10% were selected for in-depth interviews to help to identify events that shaped the perceptions of school science positively for them to take science further or less positive, leading to them not taking science further.

2.4.2 Findings

The survey questionnaire grouped the participants into two students' types (scientists and non-scientists and categorised them according to trajectory type (Progressive or Regressive). An upward trajectory indicated positive experience and a downward trajectory indicated less positive experience. Thus, the shape of the trajectories indicated the story of each individual student's experience of school science. For example, engagement, attitude, enjoyment and interest. The trajectory pattern for the scientists showed that they had more progressive (P) trajectories (44%) than the non-scientists (27%) while number of non-scientists with regressive(R) trajectories (41%) was higher than scientists' regressive trajectories (22%). In addition, significance test with a Chi-square test revealed a significance difference between scientists and non-scientists with P and R graphs ($p < 0.001$). Thus, significantly more scientists got P trajectories in contrast to non-scientists and also more non-scientists got R trajectories than scientists with R trajectories (Shirazi, 2017).

Table 2.1 illustrate the experiences of both scientists and non-scientists experiences with school science as reported.

Table 2.1 Experiences of school science in each individual year at secondary school.

	Year 6 Age 10–11	Year 7 Age 11–12	Year 8 Age 12–13	Year 9 Age 13–14	Year 10 Age 14–15	Year 11 Age 15–16
Scientist N =274						
Mean	3.7	3.7	3.7	3.8	4.0	4.6
SD	1.5	1.3	1.3	1.4	1.6	1.7
Non-Scientists N = 283						
Mean	3.3	3.3	3.2	3.1	3.1	3.1
SD	1.6	1.5	1.4	1.3	1.4	1.3

Source: Shirazi, 2017

This suggested that students who had a good experience in school science mostly went ahead to study science further at post-16. It could be deduced from the analysis that a better experience of school science has an influence on whether a student would consider doing science at post-16 or not.

Other factors that influenced the participants' school science experiences and reported in the study included teacher personality and teaching method. Almost a quarter of the survey questionnaire indicated teacher influence as a high point in the influence of the participants school science experiences. A respondent stated that the science teacher explained everything very well and that got him interested. However, another respondent mentioned that he did not like the way science was taught at school because the teacher just read the PowerPoint presentations and that put him off because the students were mostly not involved.

The perception of science as being a difficult subject also had an influence on the students' experiences of school science. There was a shift from science being challenging (scientists) to science being difficult (non-scientists). It was mentioned that science involves too much information which are difficult to get your head around and that makes it difficult to understand.

2.4.3 Discussion and Conclusion

The report concluded that on average school science experience became progressively positive, interesting and enjoyable, for some students as they progressed through secondary school and went on to choose science at post-16. However, school science experience for other students was just slightly positive at secondary school and they chose not to take science at post-16. The findings underpin and enhance existing knowledge about the relationship between different experiences on students' enrolment choices which indicates that a positive experience of secondary school science may influence students' choice of science at post-16 and beyond (Lindahl, 2007; Lyons, 2006). It was also reported that school science experiment was the most common part of the school science curriculum which was commented on. A large majority of the students felt that science experiments at secondary school decreased in quality and quantity as they progressed through the years in secondary school. It was further stated that most of the students in the study felt lack of science experiments caused them to disengage from science in school. The findings also suggested that school science curriculum content should be less repetitive and exam driven. Osborne *et al* (2003) indicated that science is seen as a course of little interest and it is perceived to be a domain that is exclusive and beyond the understanding of the average student.

Shirazi (2017) also reported that the perception of science as a difficult subject was a major influential factor in a negative experiences of secondary school science. Students stressed that a lack of understanding made them less successful in science assessments and as result of attaining poor grades they were moved down sets which made them felt quite negative about school science. Shirazi (2017) recommended that school science departments should reflect on their policy of allocating supply teachers to ensure that early experience of secondary school science is not ruined by science teacher absence or frequent changes of supply teachers. It was therefore recommended that it is important to have a pool of well-qualified science teachers who can be called upon to cover for an absence in the science department and support students who need help.

2.5.1 Fourth Review

Mahdi (2014) reported on research conducted in Cardiff, UK, to explore students' attitudes towards chemistry. The aim of the study was to investigate what makes students choose or not to study chemistry as a subject. There were 70 year 12 students selected from population of 164 in Cardiff six-form schools and colleges. The correspondents were appraised in four main areas: students' perceptions toward chemistry, the concept of chemical knowledge and its understanding, application of chemical knowledge, and the effects of learning support for students using questionnaire. Despite the general perception that chemistry is a difficult subject (Mahdi, 2014), the respondents' indicated that chemistry is an interesting subject and not boring. Having help from school(teachers) was important factor that played significant role in the students' preference to study chemistry.

2.5.2 Results and analysis

The analysis of the results showed that 63.9% of the students agreed that chemistry is an interesting subject and 61.1% agreed that it involves too many chemical formulae and it is difficult to remember. Many students struggle in A-level chemistry, not because they cannot do the chemistry, but because they find the maths hard and complain about the numerous formulae which are difficult to remember (Musson, 2013; Grove, 2015; Ogan *et al.,* 2017).

Furthermore, 58.3% of the respondents agreed that chemistry is a challenging subject which confirmed the two earlier reviews (Breuer,2002; Shirazi, 2017). The report also showed that 69.4% of the respondents agreed to study A-level chemistry knowing there will be a lot of help from the teachers and the school. It was reported that 78% of the respondents had grade B to A* in their GCSE chemistry exam. This seemed to confirm the perception that chemistry is difficult and it appears the average students does not venture to offer it at post-16. Most of the correspondents (66.7%) who offered chemistry in year 12 were not planning to continue chemistry in year 13 and 64.7% of the respondents said they considered taking A-level chemistry due to career choice. This affirms the notion that some students offer chemistry at post-16 based on career options and when career options changes they may drop the subject.

However, no interviews were conducted to probe further after the questionnaire in the research to obtain the reasons for students' choice, challenges and opportunities for collaboration. This gap would be covered in my research and in addition those students who started A-level chemistry but could not complete it would also be interviewed to obtain their views to enrich my research study. Various research indicates that students who believe they have a voice are seven times more probable to be academically motivated than those who do not have such a choice (John and Lori, 2017; Quaglia Institute for School Voice and Aspiration,2016; Toshalis and Nakkula, 2012). In addition to this, it can impact the student's level of effort and persistence which are important factors that affect achievement.

2.5.4 Recommendation

The Mahdi's (2014) report recommended that chemical education should be given a greater attention in diversity of activities and skills such as numeracy and experimental work to enable students to have hands on approach to the course. It further stated that a didactic approach might prove useful in attempt to increase the popularity of the discipline amongst students, especially the topics students are anxious about. Fry *et al* (2003) reported that didactic approach is a useful teaching tool as it can provide a framework of ideas and theories but due to attention span and lack of participation it should be complemented with interaction and adults'-oriented strategies. Additionally, Walkin (2000) stated that didacticism raises a lot of limitations which involve learn by rote, note taking and possible lack of enthusiasm as the approach limits learner participation and reflection, but it is very useful especially when the subject is new to the majority of students or if the students are teacher dependent, anxious or disorganised as learners.

Furthermore, having help from teachers and school was reported by Mahdi (2014) as an important factor that play significant role in the students' preference to Chemistry. More planned support sessions should be incorporated into students' learning plan so that they could assess that to help them to achieve well. Additionally, science teachers' encouragement greatly influences students' academic performance (Dorph *et al*., 2018; Reinhold *et al*., 2018)

2.6.0 Fifth Review

2.6.1 Review of Similar Challenges in Chemistry education from Europe

In their research study, Broman and Simon (2014) set to investigate the reasons why upper secondary students decide to study chemistry at post-compulsory education level in Sweden, their point of view about school chemistry and ideas on how to improve on chemistry as a subject in upper secondary. The importance of this study as reported was due to concerns in Sweden that the number of students choosing to study chemistry at university had been low for several years though the overall university application had been increasing. The Sweden union of academics (2013) published a report which emphasised the need for more chemists as there were few chemistry students at university level. Upper secondary education in Sweden is a three-year study which should provide students with a good foundation for further studies at university or work. In order to explore what could be learned from students who had chosen to study post compulsory chemistry, the research focused on a cohort of students who were studying chemistry in the Natural Science Programme (NSP) in Sweden upper secondary schools. The study indicated that understanding the perspectives of that group of students could help to enhance the learning experiences of students who choose to study chemistry at the upper secondary school as preparation to study chemistry and its related courses at university. Furthermore, the study was also set to identify issues that could be investigated for making chemistry more interesting and relevant for the wider population of students in Sweden, which is also a concern in other European countries for students in post-compulsory education (Fensham, 2004).

According to Broman & Simon (2014) the relationship between interest and choice for chemistry at the post-compulsory schooling in Sweden remained unclear from previous studies though several issues had been identified (Christidou, 2011; Reid, 2011). There were contradictory reports on students' interests for science; some reports showed that several students find school science difficult and irrelevant and their interest gets more negative overtime as they progress (Barmby, Kind & Jones, 2008; Bennett & Hogarth, 2009; Tytler & Osborne, 2012). However, the Swedish Relevance of Science Education study (Jidesjö *et al*, 2009) indicated that many 15-year-olds seem satisfied with their school science and said science is interesting, relevant and important. According to Anderhag *et al*. (2013) the choice-interest relationship is not straightforward and therefore explaining subject choices that students may take involves understanding their interest which is linked to their perceived relevance of the subject. Furthermore, students' choice has been the issue of many previous studies in science education (Holmegaard *et al*., 2014; Anderhag *et al.,* 2013; Bøe *et al*., 2011; Archer *et al.,* 2010; Reiss *et al*., 2011; Tai *et al*., 2006).

2.6.2 Student Choice

In their investigation for the reasons for choice of a specific cohort of students offering one particular subject, Broman and Simon (2014) focused on individual factors that could influence uptake, such as the perceived usefulness for future career, enjoyment and self-confidence, as previous research had led them to believe these may impact on the connection between choice and interest (Bennett *et al*., 2013). According to Anderhag *et al* (2013) educational choice cannot solely be interpreted as enjoyment of the subject, but one has to perceive chemistry for example as a subject that one can or should do. They emphasised that the notion of choice is related to 'who you are' or who you want to be', which is referred to as identity by Bennett *et al* (2013). Other research studies (Archer *et al.,* 2010; Holmegaard *et al*., 2014; Sjøberg & Schreiner , 2010) that investigated identity from different perspectives in relation to student choice also elaborated that identity plays a pivotal role in both choice and interest in science.

2.6.3 Student Interest and Relevance of Chemistry

There are many factors that impact on students' interest in science, but the key factor for enhancing students' interest and participation in STEM subjects is teacher quality and most essential to this are the teacher's subject knowledge and pedagogy using a dialogic approach (Bøe *et al*., 2011). According to Broman and Simon (2014) the distinction between instructional and relational pedagogy provided a useful lens when examining Swedish student's perceptions of their chemistry experience. They explained instructional pedagogy as teaching methods oriented towards understanding and relates to pedagogical content knowledge, relational pedagogy stresses on how a teacher comport him/herself in regards to the relationship with the learner. This concept, relational pedagogy, according to Shirazi (2017) should be carefully looked at as frequent changes of science teachers can ruin the experience of science students as discussed in section 2.4.2. Additionally, Learning (2002) reported that instructional pedagogy can motivate students and help them focus attention, organize information for understanding and remembering, monitor and assess learning and as tools for reflecting on and assessing own learning.

Furthermore, previous research study (Hofstein & Lunetta, 2004) has found laboratory work to be a means of enhancing students' interest in science and other researchers had also highlighted students' positive engagement towards science when doing practical science experiments (Hampden-Thompson & Bennett, 2013; Toplis, 2012). Laboratory experiments in chemistry are undertaken at least once in every two weeks in Swedish upper secondary schools (Broman and Simon, 2014), though they are something teachers would like to do more often. The study also reported that students' perception of chemistry included sufficient laboratory work and could be influential in their orientation to studying chemistry in the future. This is corroborated by research reports in England (Breuer, 2002; Kershaw, 2017; Shirazi, 2017) which have been discussed earlier on in sections 2.2.2 and 2.4.3 indicating lack of adequate meaningful laboratory school experiments, which affect science students' engagement, interest, understanding and future career prospect in STEM.

The research further proposed the need for role models to improve students' interest, especially for girls. This would help them elucidate their own competencies and interest in order to make them interested in a future career in chemistry. Lack of adequate laboratory work and students' perception of chemistry as a difficult subject appeared in both England and Sweden research reports. There are themes from the Swedish study which could usefully be explored in the UK context.

2.6.4 Analysis of results

The research data was collected using survey questionnaire. There were 495 students from 19 chemistry classes at 12 schools in 19 towns and cities in Sweden who participated. The idea was to get variety of schools from smaller towns to bigger cities, from both more to less popular schools all over Sweden. The gender distribution was 265 girls (54%) and 230 boys (46%). The research analysis was mainly quantitative; however, the open questions were analysed with qualitative content analysis.

According to the results from the analysis, most of the students, 73% (362 students) were satisfied with their chemistry education at post-compulsory schooling and claimed their chemistry course to be very good or good, with only 5% (27 students) who said they found chemistry hard or very hard with their reason being that they had a bad teacher. This positive opinion means the students in Sweden post-16 education value their chemistry schooling, which suggested an interest enjoyment response (Eccles *et al.,* 1983).

The results analysed also showed that 80% of the correspondents indicated that the teacher played an important role in their study and understanding of chemistry. One respondent summed it up by indicating that chemistry was interesting and enjoyable because the chemistry teacher was very good. Students also indicated that the chemistry teacher is very important for more meaningful and engaging chemistry education. It was also reported that when the students were asked to suggest three most important changes that could improve chemistry education at the post-16 education: 58% indicated that the lessons should be more connected to everyday life, more practical work was selected as the second most important (48%) and thirdly, 28% indicated that there should be more student-centred working methods. According to Ültay and Calik (2012) connecting chemistry education to everyday life should be a component of successful learning approaches. However, Holmegaard *et al.* (2014) stated that it is difficult to measure how often connections are made to everyday life in chemistry education, since both the meaning of everyday life and the meaning of these connections are not obvious. This is because everyday life can be interpreted as something you literally meet every day in life, but it can also be something you could meet outside the chemistry classroom. Furthermore, one disapproval towards everyday life in chemistry education is the risk of losing focus on the content knowledge (Sevian and Talanquer, 2014).

2.6.5 Recommendations

The analysis from the research work showed that the students had high interest-enjoyment value of chemistry, but both positive and negative responses about chemistry education referred to the importance of the chemistry teacher, laboratory work and application of chemistry education to everyday life. To improve their chemistry learning experience, students recommended making it relevant to everyday life, more practical work and there should be more student-centred working methods. It was also recommended that for positively inclined students to maintain their value of chemistry beyond upper secondary school into choice at university level, students' own ideas on how to improve chemistry education are very important and should be taken into consideration when developing school curricula, courses and lesson plans. This would be explored in my research work since it has been a gap in all the research works reviewed in England. Though this study was carried out in Sweden, the general teaching practice in Europe bears significant resemblances to the UK model and the findings are likely to be relevant to the UK education setting.

2.7.0 Other factors

The importance and effects of other factors such as teaching methods, teaching theories, effects of maths skills on chemistry performance, language and meaningful learning have been reviewed to ascertain their effect on progression, retention and achievement of A-level chemistry students.

2.7.1 Importance and effects of teaching methods

Students' interest and achievement in chemistry have declined (Osborne & Collins, 2000; FFT Education Datalab, 2019). According to Aikenhead (2003) the reason is because 'chemistry and physics are immaterial and lack interest , mostly because their instruction is not conterminous with the world outside of school'. Laurillard, (2002) argues that the lecture method is a grossly inefficient way of engaging with academic knowledge, and 'a major problem with the lecture is that learners take up a docile, unthinking and information recipient position (McKeachie,1994), as discussed in section 2.5.4 above. Nevertheless, it provides an opportunity for a very large number of students to be exposed simultaneously to a large amount of information (Lowry, 1999).

On the other hand, Broman and Parchmann (2014) suggested that context-based learning makes chemistry content more realistic because it combines the chemistry content with familiar context for students. According to Kirman and Yigit (2017) if students are aware of the fact that what they learn will impact on their lives, that of others and the society at large, then it will positively affect their conceptual attitude, change processes and subsequently their academic performance. Other researchers such as Ulusoy and Onen (2014), and Ceyhen (2012) have also indicated that context-based learning generally affects students' interests, motivation, improving students understanding and achievements positively in chemistry.

Gutwill-Wise (2001) conducted a parallel study concerning the effectiveness of context-based teaching to that of the traditional lecture method. The results indicated that students exposed to context-based learning approach have better understanding in chemistry concepts as opposed to those who use the traditional lecture method. This may be explored further during the action research intervention if it becomes one of the issues that comes up from the initial structured questionnaire to gather information for this study.

2.7.2 Importance and effects of teaching theories

Chemistry as a subject can cause confusion and difficulty for novice learners. Much literature over the years (Bojczuk, 1982; Childs and Sheehan, 2009; Jimoh, 2005; Johnstone, 2006; Ratcliffe, 2002) have frequently identified Chemistry as a difficult subject as referred to earlier in sections 2.2.2 and 2.4.4. The various literature reviewed have laid emphasis that choosing the appropriate teaching theory should be a starting point for the planning of any lesson in order to enhance teaching and learning of students. Sheehan (2010) suggested that teaching organic chemistry may yield the best outcome using cognitivism-learning theory because organic chemistry has a high cognitive demand. However, constructivist approach works well in teaching reaction mechanism and synthesis because these topics are conceptually demanding and integrate all that the learners have learned in organic chemistry (Johnstone and Driver, 1991).

Furthermore, O'Connor (2015) argues that behaviourism is appropriate for the introductory of first year chemistry modules, laboratories and in regulatory and compliance training. However, Byers & Eilksin (2009) indicated that whilst behaviourism is helpful in understanding the simple issues associated with basic training processes, it has proved much less successful in understanding critical issues in higher level learning like problem solving, concept acquisition and creativity. McWright (2017) also argues that even the constructivism approach, which is interactive and allows students to construct knowledge, is limited in teaching some chemistry topics because some topics are very difficult. On moving from first year to final year, 'a movement from a behaviourist approach to constructivist/social constructivist model may be appropriate in order to encourage the creation of independent learners' (O'Connor, 2015). This may enhance the progression and achievement rate of FE college chemistry.

2.7.3 Language and effects

The overarching goal in chemistry education and in science education in general is to promote scientific literacy and thereby enabling students to engage as responsible citizens with science-related topics (Organisation for Economic Co-operation and Development, 2017; Roberts &

Bybee, 2014). In relation to school, language is the key to communicating knowledge and in science classes, understanding scientific language is a premise to become scientifically literate (Mönch and Markic, 2022). Another challenge students face according to various literature reviewed (Taber, 2015; Cardellini, 2018; Fleck, 2020; Taber, 2020; Rees *et al*, 2021) is that words used to teach or to test students in chemistry is a challenge for some students because they do not understand their meaning. A number of studies have described the problems of language in the learning of chemistry (Johnstone & Cassels, 1978; Cassels & Johnstone, 1983; Byrne, Johnstone & Pope, 1994; Fleck, 2020; Taber, 2020; Rees et al, 2021). Pyburn et al. (2013) and Rees *et al*. (2018) demonstrated a correlation between general language comprehension ability and general chemistry performance. For instance, when an experiment is observed, it does not only mean physical looking, but also smelling, feeling, and hearing (Mönch and Markic, 2022). Thus, pointing out these differences to students during chemistry lessons is important for them to be able to develop awareness themselves and be able to understand and use chemical language precisely during teaching and learning in school. Mönch and Markic further mentioned that the challenge that arises from the use of some specific chemical language, as well as laboratory jargon, would have to be actively addressed because in most cases they are not being used or understood appropriately by students. Consequently, it behooves on chemistry teachers to incorporate strategies for development of language comprehension and word recognition within their teaching so that students are able to develop and use chemical phenomena with understanding.

Moreover, Laszio (2011) indicated that studying chemistry includes learning the language of chemistry such as names, formulae, symbols and chemical equations. Additionally, learning this language should be done with clear understanding of the concepts used by the chemist (Talaquer, 2011). This has its own challenge; however, this difficulty is not always taken into account in chemistry teaching (Kaya & Erduran, 2013). Understanding scientific language as well as correct use of it are key competences for participating in chemistry class and essential for achievement and progression (Mönch and Markic ,2022).

Rees *et al*. (2018) also suggested that students have difficulties developing understanding of words such as salt, neutral, weak and reduction that have scientific meanings that differ from their everyday meanings, with which students are more familiar. In collaboration, Childs *et al* (2015) mentioned that students' challenges with language may also be worsened in disciplines such as chemistry in which some terms (e.g., observe, stability etc.) have different meanings in contrast to their everyday definitions.

This supports findings of previous studies, including Meyerson *et al*. (1991), Jasien (2010), Snow (2010), and Song and Carheden (2014) which all indicated that college students struggled to express and maintain the scientific explanations of these dual meaning words.

2.7.4 Teaching for Meaningful Learning of Chemistry

Several researchers have acknowledged imbalance between the eagerness of chemistry teachers and the engrossment level of their students (Johnstone, 1991, 2010; Johnstone & El-Banna, 1986; Millar, 1991; Nicolaou, 2022). This issue is enduring – it has been known about for a while and it continues. Anderson & Bodner (2008) indicated that teaching and learning are not alike. This is because meaningful learning is said to have taken place when the learner can incorporate the new knowledge in their existing cognitive structure. Furthermore, Grove & Bretz (2012) reported that learners become ignorant and indifferent towards their learning when they do not have the cognitive ability necessary to learn and comprehend the topics and have low meta-cognitive awareness, which can result in rote memorisation and meaningless learning as discussed in section 2.5.4 above. This could make the application of knowledge from one topic to another in chemistry challenging and students may lack analytical skills, which is a great learning tool in chemistry. Rote learning is not an effective way to learn information, advanced concepts and complex concepts in a way that will allow for long-term retention, and real-life application may be ignored (Taber, 2014). He further explained that a student may learn a basic concept in chemistry by rote, and even an associated definition, but if that is done without understanding then the student has not learnt the concept. Such a student is learning facts, and not learning science.

Moreover, many educational theorists (Ausubel 1963, Bloom *et al.,* 1956, Novak 2010) have emphasised the importance of the affective domain in underpinning meaningful learning. Krathwohl et al. (1973) mentioned that affective domain includes the learners' feelings, motivation and attitudes. Thus, meaningful learning requires the integration of cognitive, affective and psychomotor learning (Galloway *et al.,* 2016) as well as the constructive integration of thinking, feeling, and acting (Novak, 2010). Besides, teachers also have a special role in the teaching and learning process as they influence students' attitudes towards the study of chemistry (Yara, 2009). For instance, passionate teachers create more interactive and engaging environments where students feel free, able to take responsibilities for their own actions and then learn to construct their own informed knowledge.

Notwithstanding this, students' own attitude is also another factor that affects their performance in their study of chemistry (Hanson, 2017). Koballa & Glynn (2007) emphasised that students with positive attitudes towards chemistry are successful in the classroom as this enables them to get better understanding of the concepts and achieve well. Rodeiro (2013) reported that level 2 science route with the highest progression rate was the Triple science with 46% of the students progressing to a post-16 qualification in science, but it was mentioned that students' confidence and expectations about their achievements may also be limited if they do combined science or applied science which are perceived as less challenging routes because the depth of the content is not as much compared to Triple science.

2.7.5 Effects of maths skills on chemistry performance

Celik, (2014) stated that the concepts in chemistry learning is inseparable from mathematics. Chemistry teachers should therefore strengthen chemistry knowledge through mathematical knowledge. Teachers should adopt teaching and learning strategies that strengthen the application of mathematical knowledge in chemistry learning. Mathematics and chemistry are closely related. The study of chemistry especially at A-level and above requires mathematical thoughts and methods which provide new thoughts and methods for chemistry learning (Adigwe, 2013). Furthermore, the study of chemistry requires mathematical knowledge, thought processes, and mathematical skills (Bain *et al*, 2019). Many aspects of science are best described and illustrated by mathematical tools; mathematics is therefore the foundation of science (Russell, 2017). The lack of maths preparation hinders many students' efforts to learn chemistry, and many others to pursue science at higher level (De Berg, 2012; Musson, 2013; Russell, 2017).

Some A-level chemistry students are not able to transfer their mathematical skills to chemistry and most often have challenges in studying the maths areas in chemistry (Bain *et al*, 2019). According to Effiong *et al* (2014) the areas in chemistry that students often find them challenging mostly requires mathematical knowledge. Some chemistry teachers do not pay enough attention to the mathematical knowledge, mathematical methods and mathematical ideas involved in their teaching, and lack systematic summaries in their chemistry lessons (De Berg, 2012). Some chemistry teachers always assume that students have learned such maths skills in maths class and therefore overestimate their ability to transfer knowledge. Some students in chemistry lessons get stuck on the foundations of mathematics, and it may be better for the teachers to spend time during lessons to break through students' difficulties in relation to the mathematical areas in chemistry (Bain *et al*, 2019). It must be noted that mathematics calculation is a basic knowledge in studying chemistry (De Berg, 2012)

Grove (2015) suggested that the importance of mathematics for chemistry should not be hidden to students especially its desirability for A-level. The study indicated that students who did only GCSE mathematics and did not do A-level mathematics usually lose fluency and understanding in the mathematics ideas and skills required in chemistry over time because they were not continually reinforced. Additionally, Ogan *et al* (2017) indicated that students considering to offer A-level chemistry should take mathematics alongside chemistry to enable them to understand the connection between mathematics and chemistry. They indicated that mathematics calculations are necessary to explore the concepts in chemistry.

2.7.6 Revision Strategies for Effective Learning

Various research studies (Busch & Watson, 2022; Karpicke *et al*, 2009; Wheeler *et al,* 2003; Roediger & Karpicke, 2006) have reported that students learn better through taking a memory test. This is because taking a memory test does not only assess what a student knows, but also enhances later retention compared to repeated studying without testing. According to Karpicke *et al* (2009) testing is a powerful means of enhancing learning, not just assessing it. Their research report from two experiments indicated that even though repeated studying increased students' confidence in their ability to remember their studied material, taking a memory test produced substantially greater retention than just re-read. Additionally, the study found that, given the choice, students mostly preferred to re-read because upon completion of their revision it gives them false sense of credence and a high self-esteem (Karpicke *et al*, 2009). However, the students' exam results according to the study showed that students who did the retrieval practice tended to perform better. Todd *et al* (2021) stated that students who study chemistry and other STEM related subjects with strong cumulative elements benefit from retrieval practice because it improves their understanding.

Busch and Watson (2022) suggested that teachers should specifically teach students the benefits of retrieval practice and also help them to clearly understand precisely what retrieval practice looks like. This is because if students know how to use these study techniques and accept that they give positive results, they are probably going to use them. Additionally, Busch and Watson (2022) indicated that some good retrieval practice for students could include flashcards, mind maps and their likes. Furthermore, Rohrer (2009) stated that spacing and regular revision is important because we forget more than realise, so it is important to revisit materials regularly. Students who do this perform between 10% and 30% better than students who memorise their studies (Taylor and Rohrer, 2010).

2.8.0 Summary

The major findings included lack of adequate practical experiments during chemistry lessons which are meant among other things to help chemistry students to develop practical skills, develop specific scientific knowledge and understanding of various processes of scientific enquiries (Breuer, 2002; Kershaw, 2017; Shirazi ,2017; Broman & Simon, 2014). It was further revealed that most of the students felt that a lack of science experiments caused them to disengage in lessons. Students and teachers all reported wanting to do more practical experiments. Other findings also showed that chemistry is perceived as a difficult subject by year 11 and post-16 students (Breuer, 2002; Mahdi, 2014; Shirazi, 2017, Wellcome Trust, 2020). Chemistry is seen as a preserve for only brilliant students as one research report even showed that all the post-16 respondents involved in the research study had grade B to A* in GCSE chemistry exam (Mahdi, 2014). Chemistry is also apparently viewed by students as a subject which would deny them the opportunity to be creative and not able to express their personal views during discussion. This is because when the fundamentals are being taught in school, all the answers seem to be known already and as a result all students need to do is to master the knowledge and reproduce it when required. However, almost all the findings reported that the students agreed that chemistry is an interesting subject.

Besides these, chemistry was reported to lack a positive image in the public domain. The association of the public view with danger, pollution or some other hazards is almost certain

(Levinson, 1998; Breuer, 2002; Hartings and Fahy, 2011; Davies and Sanderson, 2014; Fu *et al*, 2015). One of the biggest challenges for chemistry according to the research findings is to overcome student's neutrality, disengagement and lack of confidence (Edwards *et al*, 2016; Fu et al, 2015; Wellcome Trust, 2020). Some students feel chemistry is a subject that is academic and challenging (Edwards *et al*, 2016; Fu *et al*, 2015). One research report Edwards *et al* (2016) indicated that many of the respondents, 58% of women and 45% of men agreed that they did not feel confident enough to talk about chemistry. Furthermore, having help from teachers and school was reported by Mahdi (2014) as an important factor that play significant role in the student's preference to Chemistry. More planned support sessions should be incorporated into students' learning plans so that they could assess that to help them to achieve well.

The research findings, especially from New College Durham, revealed that CPD for teachers should be enforced every academic year. This is because though the college had received outstanding with grade 1 from Ofsted inspection, and had also been awarded the prestigious 'Beacon College' status for excellence and innovation by the Learning and Skills Improvement Service, yet its chemistry department was struggling with progression, achievement, success rate and recruitment of students. What rather helped the chemistry department was high quality CPD programmes attended by the only specialised chemistry teacher in the college which resulted in an increase in both achievement rate and success rate. This was corroborated by the Wellcome Trust (2020) report which indicated that teachers who participated in high quality CPD reported a positive impact on their teaching as a result of improvements to their subject and pedagogical knowledge.

On the other hand, the research findings also suggested that students who had a good experience in school science mostly went ahead to study science further at post-16. To improve their chemistry learning experience, students recommended making chemistry lessons relevant to everyday life so that it could impact positively on them. It was reported that if students are aware of the fact that what they learn will impact on their lives, that of others and the society at large, then it will positively affect their conceptual attitude, change processes and subsequently their academic performance (Kirman and Yigit, 2017). Teacher personality was also reported to influence students' school science experience. Some respondents were reported to have enjoyed and performed creditably due to a good chemistry teacher they had, but others blamed their discontinuation of science on their teachers' poor teaching and learning methods.

Finally, other research findings such as teaching methods, teaching theories, chemical language and meaningful learning were reported to have effect on progression, retention and achievement of A-level chemistry students. The various literature reviewed (Byers & Eilksin, 2009; Sheehan, 2010; O'Connor, 2015; McWright, 2017) laid emphasis that choosing the appropriate teaching theory should be a starting point for the planning of any lesson in order to enhance teaching and learning of students. Other researchers (Gutwill-Wise, 2001; Laurillard, 2002; Ceyhen, 2012; Ulusoy and Onen, 2014; Broman and Parchmann, 2014) reported that choosing the suitable teaching method for a particular topic generally affects students' interests, motivation and improves students' understanding and achievement rates positively in chemistry. It was asserted that studying chemistry includes learning the language of chemistry such as names, formulae, symbols and chemical equations (Laszio, 2011) and learning this language should be done with clear understanding of the concepts used by the chemist (Talanquer, 2011). Consequently, it was indicated that it is essential that chemistry teachers incorporate strategies for development of language comprehension and word recognition within their teaching so that students are able to develop and use chemical phenomena with understanding. A correlation between general language comprehension ability and general chemistry performance was also demonstrated (Pyburn *et al.*, 2013 and Rees *et al*., 2018)

All the research studies reviewed overlooked learner voice in their research studies as one of the possible means of solving the challenges in progression, retention and achievement in A-level chemistry. This would be explored in my research study by conducting three semi-structured interviews, one after each of the three action research cycles that would be carried out.

Chapter 3

Theoretical Framework and Methodology

3.0 Introduction

The purposes of a research study determine its design which, in turn, informs the methodology (Cohen *et al,* 2018, p. 173). The choice of methodology is underpinned by the researcher's philosophical and theoretical positions regarding what knowledge is and how it can be constructed and gained (Kusi, 2012; Matthews, 2013). My proposed research is framed by my alignment to the interpretive paradigm, underpinned by a subjectivist, socially constructed ontology (Cohen *et al.*, 2011, p.116). I subscribe to the idea that people construct their social world (Becker, 1970) and the social world can only be understood from the subjective positions of the people operating within it (Beck, 1979). This perspective reflects a constructivist epistemology (Crotty, 1998). This underlying belief led me in the context of this work to seek individual perspectives through which to investigate the perceived challenges that A-level students face in progression, retention and achievement rate.

The initial section of this chapter will explain 'ways of knowing' the world in which we live by giving a critical view of the dissimilar ways of understanding human existence and the forms of knowledge that pervade it. There was interaction with A-level chemistry students via structured questionnaires and semi-structured interviews to explore their experiences, feelings and viewpoints. The students had the opportunity to tell their own stories and their voices' were used as data for the research analysis. Social reality in this context will be viewed as the result of human thinking and reality is relative to how the individual A-level chemistry student experiences it at a given time and place. Additionally, this will be followed by the philosophical school of thinking that has significantly influenced my thinking during this research study. Lastly, l will explain in detail how the theoretical framework l have developed in this chapter informs my views about the research methodology chosen for this research study (Sausa *et al,* 2017).

3.1 Philosophical Perspective – Ontology and Epistemology

It is important for a doctorate student to demonstrate his/her understanding of philosophical and theoretical issues and how they inform methodological choices and the entire research processes. This is because choice of methodology is underpinned by the researcher's philosophical and theoretical positions regarding knowledge and how it can be gained (Kusi, 2012). These positions also influence decisions regarding research approach, choice of methods and frame work for analysis. Furthermore, the research design at all stages of the research would be guided by these positions.

According to Saunders *et al.* (2007) research philosophy depends on the way the researcher thinks about the development of knowledge. The two research philosophical issues pertain to ontology and epistemology ((Gray, 2004; Sikes, 2004). Ontology is about the nature and essence of things in a social world (the nature of reality) (Cohen *et al,* 2007; Gray, 2004) which can also be explained as what exists for people to know about. Sikes (2004) suggests that there are two main ontological assumptions about reality; researchers could view social reality as external, independent, given and objectively real or socially constructed, subjectively experienced and the result of human thought revealed by way of language. According to Burrell and Morgan (1979) the realist argues that social reality has external existence and is independent of the researcher. They further mentioned that the realist believes social reality is existing 'out there' and hence can be accessed through scientific approaches, which are objective in nature. On the other hand, Burrell and Morgan (1979) indicated that nominalist school of thought argues that social reality has no external existence such that it can be objectively and easily be accessed, rather it is as the result of human thinking and is referred to as interpretive paradigm. Thus, reality is 'relative' to how individuals experience it at any given time and place. Qualitative researches are underpinned by this latter ontological viewpoint about social reality and it informs methodological decisions in an attempt to gather valid data to make valid interpretation for the creation of valid knowledge (Sikes, 2004). My data collection method was influenced by this viewpoint because I needed to speak with the A-level chemistry students to hear their views and experiences on progression, retention and achievement in A-level chemistry. I collected data through open-ended and conversational communication (semi-structured interviews) with A-level chemistry students, chemistry teachers and early leaving A-level chemistry students in this research study.

Grounded in their ontological assumptions are researchers' epistemological perspectives. According to Sikes (2004) epistemology is what constitutes knowledge and whether is it possible to know and understand and re-present.

According to Sikes (2004) epistemology is concerned with all aspects of the validity, scope and methods of acquiring knowledge such as; what constitutes a knowledge claim, how can knowledge be acquired or generated and the extent of accessing it transferability. Therefore, epistemology is important because it influences how researchers frame their research in their attempts to discover knowledge (Moon and Blackman, 2017). There are three epistemological positions (Gray, 2004) namely objectivist epistemology, subjectivist epistemology and constructivist epistemology. Objectivist epistemology argues that reality exists independently of the knower and therefore research aims to discover such truth through a scientific approach (Kusi, 2012). This point of view is linked to the realist argument presented above in this section. Kusi however, indicated that the subjectivist epistemological position accepts that participants have the ability to construct knowledge, but argues that meaning is imposed on the actors by the objects. Finally, constructivist epistemology dismisses the objectivist epistemology and argues that meaning is constructed not discovered, so subjects construct their own meaning in different ways, even in relation to the same phenomenon (Gray, 2004; Kusi, 2012). This epistemological world view is linked to the idealist ontological position presented above in this section. I subscribe to this standpoint because I am also of the view that the research participants for this study would construct their own meaning in different ways concerning the research topic so that data could be collected for analysis, discussion and conclusion.

3.2 Philosophical Perspective - Research Paradigms

Various researchers (Kuhn, 1962; Henn *et al*, 2006; Hammersley, 2013) explained paradigms as ways of looking at the world, different assumptions about what the world is like and how we can understand or know about it. There are many research paradigms, each of which has an epistemological foundation (Kusi, 2012; Ndhlovu, 2017). Creswell (2013) suggested four philosophical worldviews; post-positivism, constructivism, participatory and pragmatism. Lukenchuk (2013) identified six paradigms namely; Empirical-analytic, Pragmatic, Interpretive, Critical, Post-structuralist and Transcendental. She noted that paradigms are not exhaustive. However, the most common paradigms identified in research literature are the positivist, interpretive/constructivist (Esterberg, 2002; Henn *et al*, 2006; Scott & Usher, 1999) and critical paradigms (Cohen *et al*, 2000). For the purpose of this research study I will focus on interpretive paradigm, which informs my methodological choice in qualitative studies. This is because my research study data would be based on the feelings, experiences and viewpoints of the research participants, which is in agreement with the interpretive paradigm. However, l would briefly explain positivist paradigm (which informs quantitative studies) and critical paradigm (which informs qualitative studies).

3.2.1 Interpretive Paradigm

The premise for the interpretive paradigm is the constructivist epistemology discussed in section 3.1 above. The origin of the interpretive paradigm could be attributed to Max Weber (1864-1930), but was also influenced by well-known social theorists of the time which included Harriet Martineau (1802-1876) and Wilhem Dilthey (1833-1911). Weber (1949) argued that our understanding of the social world can be enhanced when we make an effort to comprehend it from the perspectives of the people being studied rather than explaining their behaviour through cause and effect. Moreover, the interpretive paradigm contends that social reality is created jointly through meaningful interaction between the researcher and the participants on agreement (Grbich, 2007; Rugg & Petre, 2007) in the latter's social-cultural context. The same objective reality can be experienced and understood in different ways by different people in a society and each would have individual reasons for their actions (Alharahshel & Pius, 2020; Bhattacherjee, 2012). Social reality is experienced in a number of ways and interpreted often in similar but not necessary the same manner (Kusi, 2008). He further stated that interpretive research acknowledges the feelings, experiences and viewpoints of the researched as data. This research study seeks to interact with the research participants (A-level chemistry students) in order to acknowledge their feelings and viewpoints concerning the challenges in progression, retention and achievement in A-level chemistry, which is the focus of this study. I acknowledge that the students will be the best people to explain their experiences by telling their own story. Additionally, I view social reality as socially constructed, subjectively experienced and the result of human thought as expressed through language(Sikes, 2004). This is in harmony with the interpretive paradigm and informs the reason why this is chosen as the research paradigm for this study. Moreover, Bessey (1999) indicated that data collected in qualitative study are usually richer in a language sense, than positivist data, which are objective and numerical data that can be analysed. I subscribe to this because l would use learner voice, as this appears to be missing in previous studies, through semi-structured interviews to collect data for this research study from A-level chemistry students, which would give me first-hand information, experiences and feelings from the students' point of view in their social context.

The interpretive paradigm underlines qualitative methods while the positivist paradigm emphasises what are termed as quantitative methods (collecting standardised data and using numbers and statistics for analysing them (Flick, 2018)). However, it is possible to supplement qualitative instruments such as semi-structured interviews with quantitative instruments such as structured questionnaires in qualitative research (Kusi, 2012). This is termed as mixed methods. This is corroborated by Verma and Mallick (1999) who indicated that if a researcher decides to use a qualitative approach for the investigation of a problem, there is no obligation to ignore the quantitative data that are collected or vice versa. This argument implies that you can be flexible and adaptive. Additionally, Adamson *et al* (2004) indicated that well designed and validated questionnaires produce data of immense value, and this value could be further enhanced by their use within a qualitative interview. This was used in my research study as structured questionnaire was initially used to diagnose the challenges of the A-level chemistry students in the FE college. The quantitative analysis from the structured questionnaire responses gave evidence based data to design the action research interventions. These were followed by semi-structured interviews which allowed in-depth responses, experiences, feelings and the participants' viewpoints in their social-cultural context to be collected as data, see chapters 6 to 8 for further details.

A lot of positivist researchers view interpretive research as inaccurate and biased, given the subjective nature of qualitative data collection and the process of interpretation used in such research (Nickerson, 2022). This was addressed by choosing action research methodology approach in this research study, it is grounded in the specific context with insider researchers. This will be further discussed in section 3.3.

3.2.2 Positivist and Critical Paradigms

The positivist paradigm is associated with the objectivist epistemological perspective. It contends that social reality exists out there and is independent of the observer. Cohen *et al* (2007) stated that the positivist paradigm operates on the assumption that human behaviour is essentially rule-governed. As a result, positivist researchers use methods located in the natural sciences such as chemistry and biology to discover existing truth. This was corroborated by Esterberg (2002) who indicated that the aim of the positivist researchers is to discover a set of laws that can be used to predict patterns of human behaviour. Positivist researchers employ scientific methods that have measuring qualities such as structured questionnaires to gather data. Such data can be subjected to statistical analysis. Several criticisms have been levelled against the approaches used by positivist researchers in their investigations especially when used in social science. Flick *et al* (2004) indicated that the scientific approaches employed by positivist researchers are ineffective for understanding the complexity of the interaction existing in societies and individuals. The approaches tend to have simplistic view of the human beings as matters often investigated in natural science (Muijs ,2004). He further argued that the positivist approaches claim that knowledge is based on observable evidence, however some of the theoretical explanations in some branches of science depend mainly on mathematical evidence, not necessary on the observation of tangible evidence.

Positivist paradigm was rejected for this research study because I wanted to understand the challenges of progression, retention and achievement in A-level chemistry from the perspective of the students doing A-level chemistry by having meaningful interaction with the research participants in their social-cultural context. I will be able to use their feelings, expressions and viewpoints as my research data, which is in agreement with interpretive paradigm.

On the other hand, critical paradigm adherents argue that social reality is better comprehended when researchers take into consideration the socio-political and historical values or factors which limit the actions and thoughts of individuals and groups within a society (Cohen *et al.,* 2007; Henn *et al.,* 2006). Kusi (2012) asserted that critical paradigm researchers identify the exploited and document their situations to bring about change through knowledge sharing and hence effecting changes in the society. Furthermore, critical researchers work is transformative because it seeks to change people and society (Clough and Nutbrown, 2002). Therefore, their aim is to empower the oppressed in society; emancipate the working class, women, and ethnic groups (Kusi, 2012).

Both critical and positivist paradigms could not inform my research study because l view social reality as socially constructed, subjectively experience and the result of human thought as expressed through language. I contend that social reality is created jointly through meaningful interaction between the researcher and the researched-on agreement as explained in section

3.2.1. As a result, l would be conducting semi-structured interview with the A-level chemistry students and use their verbal responses as data for my research analysis. Besides this, I do not see the A-level chemistry students as being exploited or requiring emancipation because they chose to do chemistry and education is free for any school going age students in England. However, I wanted to hear their voices with their consent and used that as my data in this research study.

3.3 Research Approach

The research questions of my research study, my viewpoint on philosophical and theoretical assumptions underlying knowledge construction as discussed in section 3.2 above enabled me to choose the appropriate research approach. I settled on qualitative research approach because there was the need to interact with the research participants (A-level chemistry students) in their socio-cultural context in order to gather data and interpret them to create knowledge. Thus, I chose qualitative research approach because it is in line with my theoretical and philosophical arguments about knowledge construction.

I propose to use practical action research methodology in this research. The purpose of the practical action research is to research specific school situation with the view to improve practice (Schmuck, 1997). This is in line with my proposed research work, as a professional FE teacher, to conduct research about the perceived challenges in progression, retention and achievement rate in A-level chemistry in an FE College where l work in England. I intend to apply three cycles of interventions, to address the research questions in this research work, which is a characteristic of action research (Moroni, 2011, McAteer, 2013). This will enable me to evaluate and reflect on the results from the data collected after each cycle to ascertain if the intervention has addressed the research questions. The figure 1 below illustrate what l intend to do during each cycle.

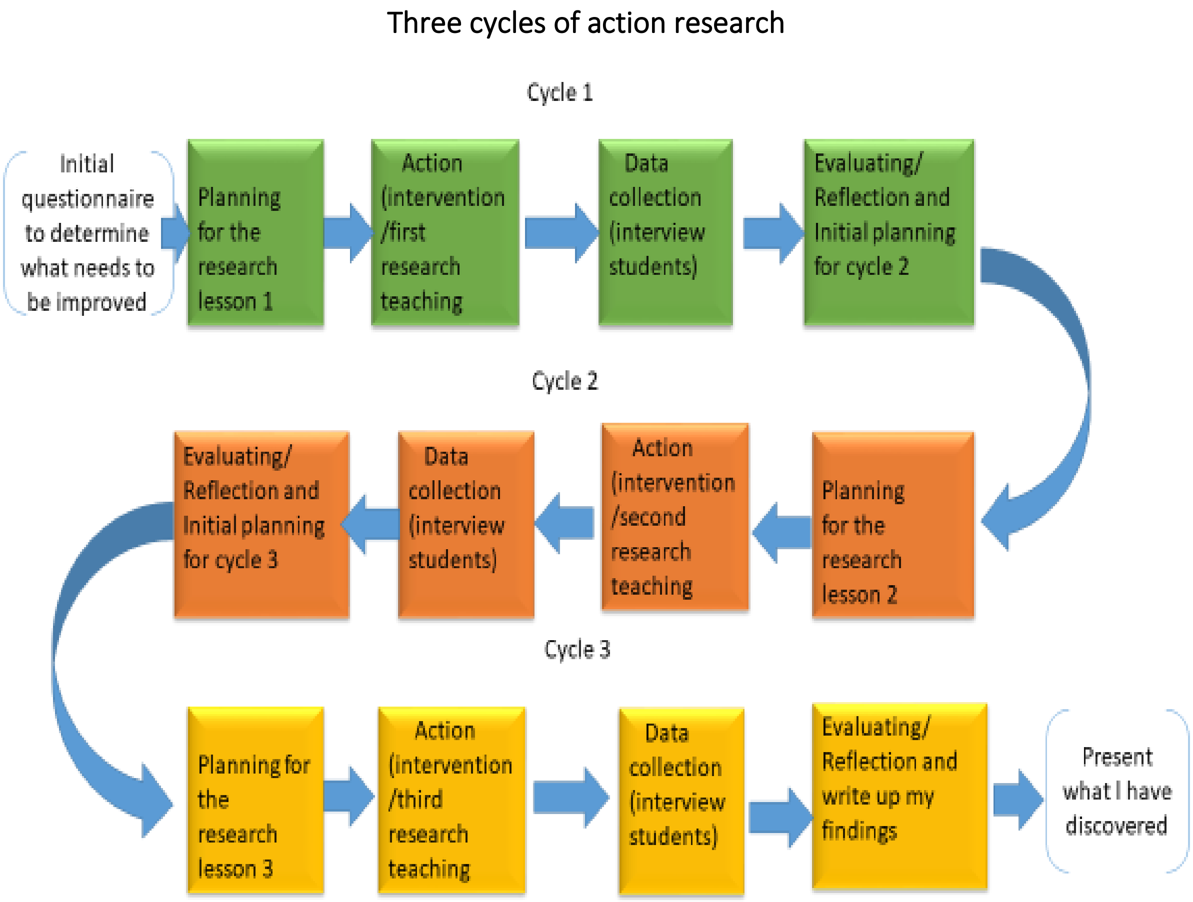


Figure 1 Three cycles of action research

This was moulded after progressive problem solving with action research by Centre for Collaborative Action Research. Figure 2 below depicts the original model.

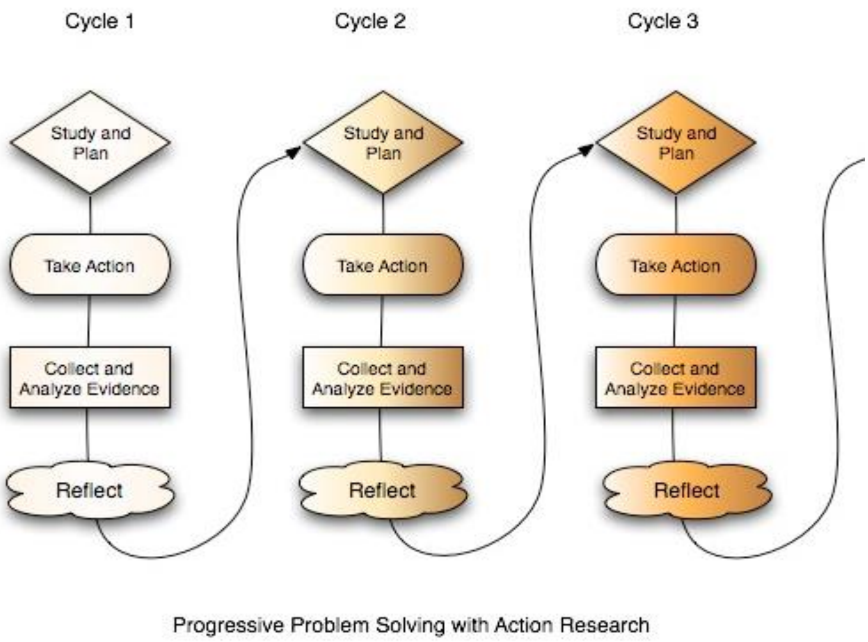


Figure 2. Source: Riel (2006)

The main aim of practical action research, is ‘to improve practice’ (Elliot, 1991, p. 49). It combines diagnosis, action and reflection (McNiff, 2010), focusing on practical issues, as stated in the research questions, that have been identified by participants and which may somehow be both problematic yet capable of being changed (Elliot, 1978, p. 355-6). Jefferson (2014) indicated that the main presumptions of action research encompass that practitioners work best on problems that they have identified themselves’, and ‘it is owned by the participants rather than external researchers’ (Kemmis and McTaggart, 1992. p. 21-22; Cohen *et al* , 2017. p. 442). Action research methodological approach suits this research study because the aim of this research is to explore current issues around progression, retention and achievement for A-level chemistry students in an FE College in England where l work as a professional teacher. Additionally, I identified that the progression and retention of A-level chemistry in the college was a challenge and decided to do research on it. I intend to interact with the research participants, A-level chemistry students, and seek their viewpoints on these issues so as to improve practice, achievement and progression in A-level chemistry in the college.
I am cognisant of the concerns with practical action research, such as the criticisms on the authenticity of practical action research (Kemmis, 2009). Pine (2008) indicated that practical action research has been accused as straying from the main characteristics of action research because it has been influenced by outsiders’ inputs and techniques. In a sense, it might happen that the research questions could be “externally formulated” and the issues raised might not be the actual sentiments and challenges of the practitioners and learners (Kemmis, 2009).

However, Schmuck (2006) argues that practical action research focuses on a specific research question with the aim of improving practice which matters in one’s workplace. I am also aware of the limitation of ‘‘generalisation’’ problem in qualitative action research. The results are relevant in the environment where the action took place, but how to make it general to a whole FE sector in England. I will therefore need to frame my findings as ‘fuzzy’ generalisations (Bassey, 1981) which may or may not apply elsewhere. Nonetheless, the research process offers a ‘replicable model’ for other FE colleges in England interested in designing their own immersive professional learning (Boss, 2020). Furthermore, given that the phenomenon is broader than just affecting my college, this gives some hope that the findings will resonate with students and lecturers elsewhere.

Another type of action research known as participatory action research was considered, but it was discounted. It has a social and community orientation and an emphasis on research that subcribes to emancipation or change in our society (Creswell, 2008). Creswell further indicated that it brings about improvement in the lives of people, families, communities and organisations. The focus of this research study is not about emancipation or seeking to bring change in a community, but is to research specific school situation with the view to improve practice which is in line with practical action research. Moreover, I intended to improve practice by listening to the voices of the students. Hence the choice of practical action research over participatory action research.

Case study was considered and discounted. This alternative appeared attractive at first, given its ability to capture and explore the complexity of phenomenon for a better understanding (Muijs, 2004). It is action-oriented and hence, the findings are useful for improving practice (Cohen *et al,* 2000). Additionally, it requires the use of multiple methods to collect data, enabling it to be validated through triangulation (Denscombe, 2003; Yin, 2003). However, it requires prolonged stay in the socio-cultural context of the participants for data collection and, therefore, 'negotiating access to such a place can be difficult' (Kusi, 2012, p. 7) or interfere with the academic plan of the FE college. Furthermore, it may be difficult to clearly define the boundaries of the case in a clear-cut fashion.

Grounded theory, another qualitative research approach, was also considered, but was discounted. It aims to develop theory inductively based on data which is systematically gathered and analysed. Kusi (2012) mentioned that a researcher using a grouded theory strategy approaches the topic with a broad general idea of the area, which is of interest to him/her, and uses the interpretation of the data to develop the theory. However, Creswell (2008) indicated that though grounded theory is a useful way to approach a topic which is of interest, there is a little indication of the causes and effects involved. Additionally, Creswell (2008) mentioned that the approach is characterised by constant comparison of data with emerging categories and theoretical sampling of different groups to maximise the similarities and differences of information. The intention of this research study was not to develop a theory and as such grounded theory strategy approach was discounted.

3.4 Summary

This chapter has illustrated that in eduational research, there is a link among a chosen ontological and epistomological position, research paradigm and approach, methods for data collection and analytical methods. This is because choices of methodology are always underpinned by the researcher's philosophical and theoretical positions regarding knowledge and how it can be gained. In managing this, the different philosophical and theoretical assumptions were discussed, some paradigms including positivism, interpretivism and critical theory and their contributions to educational research were also explained. Different views of social reality and their influence on the choice of a particular research approach such as action research, case study and grounded theory were commented. I was able to examine how l view the world through this process. Consequently, I was able to realise my own construction of knowledge and social reality.

This served as a guide for me to choose my proposed research frame, which is aligned to the interpretive paradigm, underpinned by a subjectivist, socially constructed ontology. Finally, I chose practical action research methodology as the research approach for the research study because the purpose of this research study is to research specific school situation in England with the view to improve practice. The next chapter will discuss my decisions about the choice of research methods, and will move on to develop an appropriate analytical framework for my study.

Chapter 4

Data Collection, Analytical Framework and Ethics

4.0 Introduction

This chapter discusses how data were gathered for this thesis in the field and then further explains the framework which was devised to analyse the data collected. It also explains some of the main ethical challenges I came across in my research work and how they were dealt with.

4.1 Development of Methodological framework

After adopting an interpretive theoretical framework for my research study and practical action research as the research methodology as outlined in chapter 3, the next research decision surrounding the research study was my choice of data collection methods and succeeding analytical framework. As a reminder to readers, my research aim was to explore current issues around retention and achievement for A-level chemistry students in an FE College in England, by addressing the four research questions in section 1.4. Charmaz (2006) suggests that social researchers should allow their research methods to be sharpened by the research problem. This implies that there must be a harmony between the research methods and the research questions. For instance, the research questions, theoretical framework and the stated views about social research concerning this research study were alluding to the use of methods that can collect data about social settings. Structured questionnaire and semi-structured interviews are both suitable as they can flexibly be used in the field to gather in-depth information which would be used as the data for the research. The questionnaires were used at the beginning of the research work to gather information about the FE College and the general research context to identify issues which informed the action research interventions that I needed to implement. Semi-structured interviews were used to obtain participants' perceptions of the interventions used during the practical action research, discussed in section 3.3. Detailed discussion for these two methods and the research questions they were used to address would be found in section 4.2

Additionally, it was apparent that the selected methods should also be both age appropriate and ethically acceptable to the research participants in this research study, who were post-16 students. See sections 4.2 and 4.6.2 for further details. It was therefore prudent to find a fit between my data-collection methods and my research participants. Salient issues considered included the forms of communication that would enhance in-depth information to be collected as data from the research participants and at the same time ensuring that students' academic work, completion of the chemistry specification, was not much disrupted by the research activities. These ethical issues raised will be discussed in detail in section 4.6.

As an ''insider'' researcher, I had a significant advantage over those approaching the educational sector as ''outsiders'' (Lake, 2013) and this enabled me to make practical decisions based on my knowledge of the educational sector as a teacher. This is because I was privy to intricacies in the teaching field in England and believe that this rich contextual knowledge and experience enabled me to make informed decisions about these matters, including my choice of action research as the research approach in this research study. For example, knowing when to do each action research intervention owing to my knowledge of the chemistry department's teaching outline and the specification covered. This enabled me to choose appropriate date for each of the interventions with ease. However, there were some disadvantages of being an insider researcher, see section 4.6.2.

Furthermore, I was conscious that the research methods had to suit me as a researcher. I needed to be convinced and skilful about the application of the selected data-collection methods. Besides this, l was aware that l needed time and availability of resources in order to use the methods to my best advantage. Thus, knowing the appropriate time in each school term which was best to engage the research participants (A-level chemistry students) so as to minimise the disruption in their studies due to the research study. Additionally, I needed to ensure that the research study did not interfere with my job to the disadvantage of the learners as a full-time college teacher. The research methods that were suitable and best satisfied the interest of my research questions, participants and my preferences as the researcher for this study were semi-structured interview and structured questionnaire. This will be discussed in detail in ensuing sections in this chapter.

4.2 Methods for Data Collection

The methods available to qualitative researchers are numerous but I used mixed methods and these were semi-structured interview (qualitative method) and structured questionnaire (quantitative method), which together enabled me to gather data for this research study as explained in section 3.2.1. According to Cleave (2023) structured questionnaire comprises of standardised closed questions that are worded in a specific way and requires the research participants to choose from a set of predefined answers. The closed questions used in the questionnaire were meant to prompt the respondents to engage fully in completing the questionnaire. They were also meant to motivate the respondents to reflect on their experiences and perspectives. Additionally, Cohen *et al* (2018) indicated that structured questionnaire allows a large volume of data to be gathered faster, enables patterns to be observed and comparisons to be made. In qualitative research, a structured questionnaire can be used to gather an initial data to supplement data collected through methods such as semi-structured interviews (Kusi, 2012). Thus, in a single study a researcher can employ instruments such as semi-structured interviews and structured questionnaire. This was used in this study.

The structured questionnaire was used at the beginning of the research study to gather information from the students about the FE College and the general research context to identify issues that informed the action research interventions which were implemented. These were followed by semi-structured interviews which allowed the experiences, feelings and the participants' viewpoints in their social-cultural context to be collected as data. The interviews provided more detailed data on the student experiences and feelings, which were built on from the data that had been provided by the analysis of the questionnaire responses. Thus, the questionnaire first and then followed by the semi- structured interviews. The sequence allowed me to learn from each stage of the data collection and I was able to build on the previous findings.

The blending of both quantitative and qualitative data, mixed methods, allowed a more thorough exploration of the research questions as both instruments complemented each other, see Table 4.0 in this chapter. I used the Qualtrics XM software to set the questionnaire questions. The questionnaire was sent to the research participants via a Qualtrics online link after setting the questions. The completed questionnaires were collected via Qualtrics online software from the research participants. The Qualtrics system gave me an all-in-one approach: questionnaire creation and data collection to textual analysis and data reporting. This reduced the work load for both data collection and analysis for the questionnaires.

The participants were encouraged to include their own personal generated code on the questionnaire so that they could use that for identification if they intended to withdraw during the research, detailed explanation is given in section 4.4. This was confidential and the individual participant was the only person with knowledge of what code he or she had used. A space was made available for the participants to include this special unique code on the questionnaire during its completion online via Qualtrics.

Several researchers (Morrison, 1993; Timmins, 2015; Krosnick and Presser, 2010; Dillman *et al*., 2014; Owen *et al.,* 2016) advocate the piloting of questionnaires through the involvement of experts in panels during their construction to ensure content validity, reliability and practicability. Additionally, they mentioned that the wording of questionnaires and pre-testing are paramount importance for their success. Four teachers from the science faculty acted as a panel of experts; examined the content and ensured it was relevant and comprehensive. Furthermore, the construct validity was enhanced by testing among colleagues that the questionnaire measures what it claimed. Only one change was made after testing the questionnaire among colleagues. See Appendix S which shows a summary of the change made.

I also used semi-structured interviews (Bogdan and Biklen, 1992) via purposive sampling - to obtain some degree of representativeness across the chemistry students, and my two chemistry colleagues at the college for the action research (Cohen *et al*., 2011). This method was used to obtain participants' perceptions of the interventions used during the practical action research, discussed in section 3.3. In reflecting my epistemological position outlined in chapter 3, this method "regards knowledge as generated between humans, often through conversation" (Kvale, 1996, p.14). Through semi-structured interview, I discovered the in-depth perceptions of colleagues and students - including unexpected information (Morris and Twitchen, 1990). Kusi (2012) indicated that semi-structured interviews are flexible to a greater extent, provide interviewees the opportunity to express their views, feelings and experiences freely. Thus, offering the participants the opportunity to construct their own world. This was in line with my research approach, qualitative research, because there was the need to interact with the research participants (A-level chemistry students) in their socio-cultural context in order to gather data and interpret them to create knowledge. Additionally, it was in line with my theoretical and philosophical arguments about knowledge construction as discussed in sections 3.1 and 3.2. Kusi (2012) further mentioned that semi-structured interviews also give the interviewees the freedom to divert the items/questions in the schedule to seek clarification during the interviews process, using probes. I used this technique during the interviews to obtain further clarification from the research participants. This was corroborated by Wragg (2002) who noted that the instrument permits the interviewer to ask initial questions, followed by probes meant to seek clarification of issues raised in order to expand on the interviewees' responses to ascertain their feelings and experiences.

Data collection for the second stage of the research, the progressive action-research intervention, included lesson planning (see Appendix R), research teaching (chemistry intervention lessons), student interviews and teacher reflections on impact on learning post-intervention, helping to ascertain if the research questions had been answered or not. This enabled me to unearth relevant information. This is because the research participants responded in detail about their views concerning the issues in this research study during the semi-structured interviews. Details of these can be found in chapters 6 to 9 in the thesis.
A maximum of twelve in-depth semi structured interviews were carried out at the end of each of the three action research cycles, comprising six first year and six second year students. I was of the view that twelve interviews for each of the three cycles, giving thirty-six interviews in addition to eighty-one questionnaires would give enough qualitative data for the research analysis. Two high achievers, two average achievers and two low achievers were selected from year 12 and 13, using the college's academic record data. This was to ensure that the students' voices of the various categories of achievers could be captured. Interviews lasted between 30-45 minutes and were digitally recorded with consent and partially transcribed during the interviews. The two teachers in the chemistry department and three early chemistry leavers (students who dropped chemistry) were interviewed at the end of the cycles with their consent as well. All interviews were done on an individual basis to enable me to pay full attention to each interviewee. Table 4.0 below gives a summary of the research participants, methods and the research questions the data instrument addressed.

Table 4.0 Research questions and the data instruments used to address them

Participants	Methods	Research questions the data instrument addressed
Chemistry Students	Structured questionnaires	How do learners' perceived challenges of A-level chemistry concepts influence their achievement and progression?
	Semi-structured interviews	How does actual understanding of the Chemistry concepts enhance students' achievement and progression?
	Action research interventions	How can practical action research intervention(s) help to solve the perceived challenges students face in A-level chemistry?
Chemistry lecturers	Semi-structured interviews	What challenges do chemistry lecturers foresee as hindrances to students' achievement and progression?

The interviewees were provided with detailed information on the purpose of the research, the format the interviews would take and they were also notified in advance that the interviews would be audio recorded. A written informed consent had been obtained from participants, discussed in section 4.4, and were advised of their right to withdraw from the research up to 15th June 2021 if they decided to participate in the research.

4.3 Discounted alternative methods

The ability of semi- structured interview and structured questionnaires to enable me to gather data of this nature was critical in my preference for these methods over alternatives.
For instance, were I to use observation (students and teachers), it would present acute difficulties in establishing colleagues' and students' perspectives given the high degree of inference and interpretation required (and potential bias) based entirely on watching colleagues and students (Moyles, 2002; Wilkinson, 2000). However, Bell (2008) believes that observation is helpful in establishing what people actually do or how they actually behave in

their context. There are two main types of observations namely; systematic observation and participant observation (Denscombe, 2008). Denscombe mentioned that systematic observation expects the researcher to identify events or behaviours that would be looked for during the actual observation. Thus, unexpected behaviours or events, those not included in checklist of the instrument, are often neglected or overlooked by the observer though they may be useful (Kusi, 2012).

On the other hand, participation observation allows the researcher to enter the world of the target participants without any framework guiding the actual observation. This lack of structure to guide the observation means there is tendency/ danger that the researcher could be diverted from the focus of the study, gathering unusable or irrelevant data. Cohen *et al* (2007) suggest that participation observers can assume different identities. They explained that participation observers can enter the world of the participants as cover (hidden) observers to observe the participants of their study without the participants' knowledge, raising ethical concerns such as informed consent and the participants 'privacy. However, the participation observers can be overt observers who seek the consent of the 'gatekeepers' of the setting of the study and, sometimes the participants themselves (Creswell, 2008). Consequently, the participants are normally aware that they are being observed. The approach tends to disrupt the naturalness of the setting of the study, the participants can behave in an unnatural manner, and therefore the physical and social environment may be modified positively due to their awareness of the presence of the observer. This method was discounted from being used in this research study because it would not have encouraged the use of learner voices of the participants, which was identified as a gap during the literature review in chapter 3.

On the other hand, some practical considerations of interview were anticipated and acknowledged (Gadd, 2004; Kvale, 1996), such as: interruptions or distractions during interview; interviewee fear; the risk of the researcher giving advice rather than listening; and the interviewer closing an interview too soon (Field and Morse, 1989). In addressing these, I explained to the interviewees at the beginning of every interview that there was no wrong or right response to the interview questions. They were to express their views as much as they could and their voices would be used as data for analysis in this research study. Anytime I was having an interview, I ensured that a notice was put on the door, interview in progress, so that the interviews were not distracted by other lecturers and students. The doors were not closed for safeguarding purpose. Additionally, I explained to the interviewees that they should let me

know anytime they felt uncomfortable to continue the interview or wanted me to stop the recording. However, I did not experience that from any of them during the interviews. I ensured that I listened to the interviewees and did a follow up question when I needed further clarification in order to avoid coaching them during the interviews.
Moreover, interview-based research often overlooks specific consideration of transcription, according to Bird (2005) and Kvale (1996). I incorporated an open critical reflection of the interview transcription itself (Lapadat, 2000) following the interviews in order to avoid neglect. Thus, I ensured that the transcripts reflected a verbatim depiction of the speech or voice of each interviewee by reviewing and reflecting on the data.

Furthermore, Cohen et al. (2000) locate semi-structured questionnaires between structured and open questionnaires. Additionally, they also indicated that they give a clear structure, sequence and focus, but the format is open-ended, enabling the respondents the opportunity to respond in their own terms. However, Kusi (2012) mentioned that semi-structured questionnaire is tiresome and time consuming because it has to be intensively read, grouped and coded as part of the analysis. This was corroborated by Cohen et al (2018, p. 475) that semi-structured questionnaire carries the problem of data handling due to too many answers which might not be easy to summarise, including data overload. This method was discarded.

4.4 Arrangement for Research Participants' Recruitment

An initial meeting was arranged to meet my faculty manager, who had previously agreed for my research to be conducted in the college, to show her details of my research work. These included the project outline, aims and purpose.

A detailed outline of the consent process including 'informed consent' requirements and ethical arrangements for the research participants (A-Level Chemistry teachers and students) were made known and discussed. A convenient meeting date was agreed to meet the chemistry teachers from the chemistry department. I was guided by the BERA (2018) guidelines and also the UWE ethical guidelines.

4.4.1 Meeting Chemistry Teachers

The second meeting with the faculty manager included the chemistry teachers in the chemistry department. The aims and objectives of the research were explained to the teachers and they had the opportunity to ask questions for any clarification. The teachers were informed of their right to withdraw up to 15th June 2021 if they decided to participate in the research. This was two months after the data collection from the questionnaire had been administered, after that date the data collected would have been analysed. The teachers were informed of their right to anonymity and all questionnaire data collected would also be anonymous. They were also informed that the college would be anonymous in the research and the college would only be described by its socio-economic context. Following an opportunity to ask questions about the project, consent forms for teachers, see Appendix B, were distributed to them. They were required to be signed and returned later before the questionnaire was administered online via Qualtrics. The consent form included an opportunity to be part of the semi-structured interviews as well. The same ethical processes, which would be discussed in section 4.6, were adhered to in relation to informed consent, see appendix D, for the semi-structured interviews during the action research interventions. The two chemistry teachers in the chemistry department, who have already given consent for the research to use their questionnaire data, also agreed to participate in the semi-structured interviews. Additionally, three early chemistry leavers, gave their consent to participate in the semi-structured interview. This was to obtain the feelings and experiences of students who started the subject but did not complete it as part of the data collection. Before the semi-structured interviews began, the research project was outlined again and in particular, the purpose of the semi-structured interviews in probing more deeply into the themes from the questionnaire data were emphasised.

4.4.2 Meeting Chemistry Students

Subsequently, with the help of the chemistry teachers, all the A-level chemistry students were invited and about eighty-nine chemistry students (first and second years inclusive) were recruited for the structured questionnaire. A presentation was made to the students concerning the aims and the purpose of the research. This gave the student an opportunity to learn about the research project aims and purposes. The students were given the chance to ask questions after the presentation which was face-to-face. They were informed of their right to withdraw up to 15th June, 2021, which was about two months after the questionnaire data had been collected and were ready for analysis. The students were also informed of their right to anonymity and also the questionnaire data would be anonymous. Additionally, they were informed the college would be anonymous in the research and it would only be described by its socio-economic context.

Following an opportunity to ask questions about the project, consent forms, see Appendix A, were distributed and those aged 18 and above were required to sign the consent and returned before the questionnaire was administered online via Qualtrics. Students below 18 years of age were asked to send their consent forms home for their parents to consent and also provide their own consent before their involvement in the questionnaire data collection.

Twelve students who had consented to the questionnaire had the opportunity to be part of the semi-structured interviews. The same ethical processes, which would be discussed in section 4.6, were adhered to in relation to informed consent for the interviews during the action research interventions. The twelve students who had already given consent for the research to use their questionnaire data and were willing were selected for the semi-structured interviews. Before the semi-structured interviews began, the research project was outlined again and in particular the purpose of the semi-structured interviews in probing more deeply into the themes from the questionnaire data were emphasised. Another consent form, see Appendix C, were given to semi-structured interview participants and there was additional verbal consent requested before and after the interviews. I used the college's Promonitor (a software which contains students' data, current performance records and reports) which was available to all teachers in the college to identify students for the semi-structured interviews, but with permission from the college and students consent. This included students identified as high, low and medium attaining students. A careful consideration was given to a representative mix of genders and ages in order to obtain views across gender and age. It would have been useful to consider students' career choice and pathway but in relation to complexity and convenience, these were not considered to be necessary or priority for selection. This would be mentioned in the recommendation for future research study.

4.5 Analytical framework

Analysing qualitative data manually could be laborious. However, I wanted to have a hands-on feel of the data (Creswell, 2005), but later realised that it would be too much for me and decided to use Qualtrics XM software system for the questionnaire data collection and analysis. I also used NVivo software to analyse the transcripts from the interviews conducted.

4.5.1 Structured Questionnaire

The first data collection (questionnaire) and analysis began by accepting to use the Qualtrics XM software programme which was less laborious and more efficient after reading about it and testing it, see section 4.2 for further details. The Qualtrics system gave me an all-in-one approach: questionnaire creation and data collection to textual analysis and data reporting. The structured questionnaires were analysed using focus by question framework approach. I organised the data from the questionnaire across all respondents and their answers with the aim of looking for consistencies and differences. Later in the analysis, I explored the links and relationships between responses using the Qualtrics software and then wrote my report. A detail discussion would be found in chapter 5.

4.5.2 Semi-Structured Interviews

The second data (interviews) analysis began with transcribing of each of the participants' responses word by word. All the twelve interviews from the first action research intervention were transcribed, followed by the second and the third interviews as and when the interviews were conducted. I put the transcribed responses from each action research cycle intervention into separate folders. This was a way to group responses for each cycle interviews from the participants to specific interview questions and possible range of codes needed to identify initial themes which was applicable to the aims of the research study.

The process involved reading and re-reading all the information collected from the interview response transcripts in order to get a deeper understanding of the responses (Bogdan & Biklen, 2007). The idea was to become familiar with each of the cycle interview responses which had been transcribed (Stake, 2005) and be able to assign themes which are placed as nodes. The information from each semi-structured interview transcript were entered into NVivo programme/software. I used the NVivo to code the qualitative data for each action research intervention interviews. The coded information was categorised and placed at relevant themes or nodes using thematic analysis (Atkins et al., 2008). Thus, organising the data, immersing myself in it, generating themes and coding the data, and describing them. The coded information identified which were found to be related to other themes were coded together. This process allowed unique patterns of individual interview question responses from each participant to emerge before patterns were compared to others across other participants' transcribed responses. The cross-transcript responses analysis was used for searching patterns across the twelve participants transcripts. The aim for this was to go beyond the initial impressions to explore further into the data. Thus, I created links between codes and developed patterns and themes. This enabled me to achieve more reliable and improved themes.

I clustered the semi structured interview data in this study into themes (Miles and Huberman, 1994) in order to generate meaning from the transcribed interview data. Here, I described a theme in detail, providing a rich description of it, and then presented an extract from an interview to exemplify it. Moreover, I appreciated that Interpreting and representing my data was a 'craft' that presented challenges and required careful and reflexive consideration. However, this was a time worth spending; thorough attention brought rigour to my research, and the analysis and interpretation of the data reflect my epistemological and theoretical position explained earlier. Details for each report could be found in chapter 6,7 and 8 for each of the respective action research intervention interviews conducted

4.6 Ethical issues

Ethical principles encompass issues pertaining to the research study that could have potential harm, privacy, confidentiality, and protecting the rights and interests of the research participants (Berg, 2007). This section will explain in detail ethical issues I encountered in this research study.

4.6.1 The Ethics in Educational Research

Researchers in education can draw on various texts to inform them in their pursuit of ethical practice in their work. Golby and Parrott (1999, p91) stated that 'openness and honesty' are the fundamentals of ethical practice in educational research. Furthermore, they indicated that the research participants should be fully aware of the intentions of the researcher inclusive of how the research results will be published or utilised later, see sections 4.4.1 and 4.4.2. Additionally, they also emphasize maintaining participants' confidentiality, including the important reminder that presenting findings anonymously does not guarantee unrecognisability.

According to Pring (2000, p143-5) ethical research practice in education can be divided into 'general principles' of action, and personal 'virtues' of the researcher; a proposition/perspective that again fits closely with the values of virtue ethics. Pring (2000) refers to things such as respect for individuals and their confidentiality, as well as the pursuit of the truth. He however, accepts that these principles may conflict and recommend that it is important that participants are made fully aware of these conflicts and that they are informed as fully as possible about the potential consequences of the research in which they are involved.

On the other hand, Kvale (1996) suggested that ethical issues are divided into three main aspects: securing informed consent; keeping confidentiality; and a concern for consequences of the research process. These principles need to be observed continuously throughout the research study. Lastly, the British Educational Research Association (BERA) publishes guidelines which emphasize an 'ethic of respect' (BERA, 2018) for participants, inclusive of freely informed consent to participate, openness about the research aims and outcomes, and respect for the privacy of those involved.

It is appreciative that these various sources emphasise similar principles and procedures to ensure an ethical approach to educational research. Ethical approval for the study was sought and obtained from the University of West England (Appendix P). Having reviewed some of the key texts in the field, I will move on to how I dealt with some of the specific ethical challenges in my research study.

4.6.2 Mitigation of Ethical Issues

The research was conducted in a state educational institution, FE College. The British Education Research Association (BERA) guidelines (2018), and the ethics policies and procedures both of the University of the West of England and the FE College where the research was conducted were adhered to. It is unethical to enter into an organisation or social group to collect data without permission from the 'gate-keepers' (Creswell, 2005), I therefore sought formal ethical approval from both institutions. The research was conducted in an FE College where I work and hence the anonymity and confidentiality of both the institution and the research participants were safe guarded. According to Cohen *et al*. (2007) research participants are considered anonymous when another person cannot identity the participants from the information provided. I ensured that the names and addresses, etc. of the participants and the

College where the research was conducted were not reported. Furthermore, as mentioned in section 4.2, the participants were encouraged to include their own personal generated code on the questionnaire so that they could use that for identification if they intended to withdraw during the research.

Failure to safeguard the confidentiality of the research participants leads to impairment of the trust relationship (Ferguson *et al,* 2004). I took responsibility as what information about participants needed to be changed to ensure that confidentiality was maintained (Parry and Mauthner, 2004). I also ensured that no unauthorised persons had access to the data (Gall *et al.,* 2007). Any sound recording made during interviews with both teachers and students, with their consent, were stored securely on a password-protected computer. This was stored in the university's restricted folder on the university's One-Drive with encrypted password. Any sound recordings of the research participants (teachers and students) as part of the interviews were deleted and so destroyed following the final draft being made of the report. All the signed consent forms by the research participants for both the research questionnaires and the interviews as well as notes made during the interviews were stored according to the university of West of England's code of practice. These were also destroyed following the final draft being made of the report. Thus, ensuring the protection of the research participants' confidentiality during and after the study.

A strategy of 'informed consent' was adopted, with the aim and method as well as all relevant information of the research being made clear to all participants. Failure to do this would have been unethical because the research participants needed to have all information concerning the research study in order to make an informed decision, whether to partake in the research study or not. Creswell (2008) advises researchers to provide targeted participants with an informed consent form to sign before they participate in the study. Since some of the A level students were under eighteen years of age, parents' consent in addition to that of the students were sort and their approval required before the start of the research. The participants were given the consent forms and they took them home for consideration before signing and returning the forms. They were informed about what would happen to the information obtained from them, its retention, sharing and any other use of the research data. I explained to them that the results of my study will be analysed and used for my doctoral dissertation. The anonymised results might also be used in conference papers and peer-reviewed academic papers. They were informed that research study was self-funded as stated earlier on the research information sheet (Appendix H.) and if anyone decided to take part, the individual would be helping me to explore current issues around retention and achievement for A-level chemistry students in an FE college in England. This might potentially contribute to the government's effort to not only increase the number of students who enrol to pursue A-level chemistry but also attempt to find out how to increase retention, progression and achievement rate.

I informed them that I did not foresee or anticipate any significant risk to them in taking part in this study, if anyone needed any support during or after the research study, I would be able to put such individual in touch with suitable support agencies. The participants were also informed that they had the right to withdraw from the research without giving a reason until the point at which the data was anonymised and could therefore no longer be traced back to any individual on 15th June 2021. They were assured that there would be no possibility of identification or re-identification from this point. Hard copies of the research materials would be kept according to the university of West of England's code of practice, Data Protection Act 2018 and General Data Protection Regulation requirements.

Furthermore, since the research is in my own professional context and more so in my own college, I become an insider-researcher. A researcher's positionality (whether an insider or outsider) affects the research process, especially data collection and analysis, and reporting of the findings (Kusi, 2012). The process of interviewing, which was part of my method of collecting data, presents particular ethical concerns with insider research.

Smyth and Holian (2009) mentioned the ethics of insider positionality in their writing, and stated that one of the major risks can be informants telling the researcher very personal information that they would be unlikely to divulge to an unknown, external researcher. For instance, the pre-existing social connection with the researcher results in the participants feeling comfortable in disclosing vital information that, given the chance to reflect, the participants might not have shared in a research interview. I was extremely aware of this potential pitfall during my research. However, I did not specifically warn the research participants they might tell me things that they might not want to because acutely that would have seemed rather paradoxical in an interview where the expressed purpose was to gain a deep understanding of participants' challenges in progression, achievement and progression in A-level chemistry. To account for this potential problem, I avoided asking leading question during the interview setting. Additionally, when reviewing my transcripts, I felt I had done this as I ensured that the content was mainly from the participants rather than researcher. Besides, I used open questions approach and followed them up with verbal and non-verbal prompts. I ensured respect for the research participants was maintained all the time. As a chemistry teacher and a researcher in the college, I was mindful of my possible role conflict. I continuously reviewed if this was having effect on the research process.

Floyd and Arthur (2012) describe an 'asymmetry of power' during interview. Kvale (1996) argues that the power sits with the researcher who chooses the questions, steers the discussion, and analyses the data. Munro et al. (2004), however, argue that it is the participant who chooses their answers and the level of detail given. These choices can be affected by interviewees' positions in the institution; the researcher's usual job role; the interviewees' and researcher's roles in relation to each other; or institutional politics (Munro et al., 2004). As a lecturer in the chemistry department, I was aware of the issue of power during the whole research study in the college especially during the interviews. I informed the participants from the beginning of the research study and at the beginning of every interview that l am a student researcher who was seeking their views on the research questions and objectives. This avoided the issue of perception of implicit coercion during the interviews where power relationships could have existed because of my role in the department as a chemistry lecturer. Additionally, this also ensured that the participants' responses during the interviews were not influenced by their relationship with me outside the research context as their chemistry lecturer. Furthermore, I did not allow my greater familiarity with the research participants, as a chemistry lecturer in the department, to be less probing during the interviews. However, my pre-understanding of the issues meant that the lines of questioning developed further leading to richer and detail responses from the research participants. Besides, to alleviate issues of power during interviews in this study, participants were asked to verify and contest my accounts of their interview responses, as recommended by Costly and Gibbs (2010) and were also asked to check the transcripts – albeit providing only snap-shot approval as suggested by Sikes (2006).

Mercer (2007) states that there is a 'danger of distortion' with interview answers which may occur in light of personal concerns or by the need to continue a professional relationship with the researcher after research finishes. I presented myself as a learner to the participants (the students); not as an academic or a 'highly-intelligent person' who has just come to collect data (Herod, 1999). I mitigated as much as possible the ethical concerns ingrained in insider research while recognising that ethical grey areas would remain. However, Lee (2009) suggest that it is also unethical not to conduct research, a position which I support because of the importance of progression, retention and achievement rate in A-level chemistry as have been discussed in this study.

The first interviews of the participants were done when the Covid-19 restrictions were being enforced in schools and colleges in England. The interviews were face to face and as a result, I ensured the wearing of face masks as mandatory and encouraged research participants to use face shields in addition. I also ensured that the interview room was well ventilated by opening the windows when in the room for interviews. I listed the students pre-booked for interview, date and time and ensured that the door handles were cleaned before and after interviews. I reminded participants to refrain from close contact and educated them on proper hand washing before and after the interview. I advised the participants to carry hand gel/ not touch their faces and besides that, l also provided hand sanitiser in meeting rooms. I wiped down the laptop and other devices at the beginning and end of the interview with anti-viral wipes. I kept an extra supply of surgical face masks for participants who forgot or damage their own at the interview. The interviews were not influenced by the restrictions because all the participants understood that these requirements were part of the regulations during the Covid-19 era to keep everyone safe especially during face-to-face meetings.

4.7 Summary of chapter

I have outlined my choice of data-collection and analysis methods. I also explained the link between my decisions about my methods with the theoretical framework and methodology l presented in chapter 3, which was my attempt to clarify the reason behind these choices in my research methods. Additionally, I have also dealt with ethical issues I was confronted with in this research study and how they were dealt with.

Chapter Five

Questionnaire Data Analysis

5.0 Introduction

This chapter focuses on the questionnaire analysis which is the first part of the data collection. Two methods (structured questionnaire and semi-structured interviews) were used in collecting data as discussed in section 4.2. The questionnaire data analysis is the diagnosis stage (Reconnaissance phase) of the practical action research as it combines diagnosis, action and reflection (McNiff, 2010; Elliot, 1991). A total of eighty-nine questionnaires were sent out to the research participants via Qualtrics and eighty-one responses were received, representing 91% responses. This comprised of thirty-nine second year students and forty-two first year students. The total questions in the questionnaire were forty-two, see appendix E. I was convinced that questionnaires were an effective means to collect sufficient quantity and quality of the primary data systematically (Hart, 2005), see section 4.2 for further details. Additionally, it would provide evidence-based conclusions which would support the second data collection using action research interventions and semi-structured interviews. The content of the questionnaire was student-friendly, no complex terminology (Opie, 2004). The layout of the questionnaire consisted of two main sections; decisions and factors leading to choosing A-level chemistry as a subject and the second section solicited ideas about the perceived challenges in A-level chemistry. This was to ensure that the data collected was relevant to the research.

The first section of this chapter is an overview that briefly describes the framework of the analysis. The demographic characteristics of the respondents will be discussed in the second section. The third section analyses the preferred career options by the A-Level chemistry students in the FE College, the reasons behind those decisions and adverse effects on retention and progression. The fourth section analyses respondents' perception of A-Level chemistry in relation to the type of science they did at GCSE.

The subsequent sections deal with the analysis of GCSE Maths grades respondents obtained in relation to their perception to A-Level chemistry as a subject, and analysis of probable drop in A-level chemistry by respondents in relation to their year group. These will be followed by the analysis of the effects of understanding chemistry principles and concepts on A-Level chemistry studies, the effects of numerous maths formulae and their applications in A-Level chemistry achievement and progression, the effects of recorded lessons and chemistry educational videos on students' revision and achievement. Finally, there will be analysis of how four major perceived challenges were selected and used to plan for the ensuing three action research interventions.

5.1 Analysis over view

This study is a qualitative action research using mixed methods for data collection, see section 4.2. There was no quantitative statistical analysis intended for the structured questionnaire, which was the first stage of the data collection. However, percentage rankings were used to analyse the findings from the questionnaire responses, see the next three paragraphs in this section (5.1) for further details. Statistical analysis was not used because the data analysis at this stage of the research study was only used to diagnose the challenges in A-level chemistry in the FE college, which is one of the characteristics of action research (McNiff, 2010). The evidence based findings which were identified as important from the analysis of the questionnaire responses using percentage rankings could be found in section 5.18. The results from the questionnaire analysis informed the three action research intervention cycles which were followed by semi-structured interviews to provide the interviewees the opportunity to express their views, feelings and experiences of the interventions to be collected as data for further analysis, see chapters 6 to 8. The structured questionnaire could not indicate the feelings and expressions of the respondents in their socio-cultural context which was the main focus of the research study. However, the analysis from the responses of the structured questionnaire provided evidence-based conclusions, see section 5.18, which supported the second data collection using action research interventions and semi-structured interviews.

The responses for each of the forty-two questions in the questionnaire were ranked in percentages to identify those responses which were mentioned most frequently. The responses were also cross linked or tabulated using the Qualtrics XM software which allows you to see the overall response of respondents for any two questions. Thus, the cross tabulation of the responses enabled the relationship or correlation between the questionnaire responses to be observed. Again, these were also analysed and ranked in percentages. The percentage ranking of the questionnaire responses gave indication of the most frequent responses in terms of percentages that the students indicated to be challenging in A-level chemistry. Any percentage above 45 was considered above average and anything below 45 was below average. This was considered because 45% was nearly half of the 81 respondents' responses, which gave an indication of a high level opinion expressed by the respondents. All the cross tabulation responses which were on a Likert scale were conflated except section 5.8 with Table 5.9. The Likert scales responses for 'strongly agree' and 'somewhat agree' were conflated because they both give positive opinions whereas 'strongly disagree' and 'somewhat disagree' give negative opinions. This only demonstrates the directionality feature of a Likert scale: the categories of response may be increasingly positive or increasingly negative. For example 'strongly agree' is a more positive opinion than 'somewhat agree' but they demonstrate increasing positive directionality of a Likert scale and were conflated. The cross tabulation responses in section 5.8 (Table 5.9) were on a Likert scale, but were not conflated because the options available were unique and did not demonstrate any directionality feature of a Likert scale.

Additionally, the cross tabulation responses which were not on Likert scale were not conflated because there were no positive or negative directionality features of a Likert scale. The percentages of such responses were separated during the analysis. Furthermore, the four high percentage ranking responses, which were above 45%, were selected as the major perceived challenges A-level chemistry students in the FE college faced. Further details can be found in section 5.18. and Table 15.9

Moreover, a 5% point difference or higher between groups such as Triple science (54 students) and double science (22 students), first year (42 students) and second year (39 students) and so on during the analysis was considered noticeable. This is because a 5% point difference or higher amounts to at least one student for a group of 20 students (minimum number for any main group in the chemistry department) of the A-level chemistry students in the FE college. This was considered as noticeable because in education every student matters and each student should enjoy and achieve. It was also considered noticeable because of the real-world academic impact the 5% point difference or higher would have on the A-level chemistry students in the college. This could affect their progression, retention and achievement even if it happens to be affecting only one student. Thus, the academic context and the implications of the comparison on the students were key considerations during the analysis.

5.2 Demographic Characteristics of the Respondents

The study administered questionnaires to participants from the following groups; First year A-level chemistry students and second year students. There were 42 (51.9%) first year students and 39 (48.1%) second year students.

5.2.1 Gender of the Respondents

The percentage distribution of the gender of the respondents were as follows; among the A-level chemistry students who returned their questionnaire 37 (45.7%) were males, 43(53.1%) were females and 1(1.2%) preferred not to declare gender status. This is indicated in Table 5.1 below. This was included to ascertain if gender has any effect on the perceived challenges in A-level chemistry. Additionally, 53.5% of students in the chemistry department were females and 46.5% males, which reflected the gender data of the respondents. Further discussion would be found in section 5.17 and table 5.18.3. Department for Education (2021) report indicated 49% increase in the number of women accepted into full-time STEM undergraduate courses in UK between 2010 and 2020 though in the past STEM subjects had been harder for young people to access especially girls. The potential barriers to access STEM based on gender is gradually being lifted (Department for Education,2021).

Table 5.1 Gender of respondents in relation to the year groups in A-level chemistry

	Year Groups			
		Total	First year	Second year
	Total count (Answering), n =	81	42	39
Gender	Male	37.0	19.0	18.0
		45.7%	45.2%	46.2%
	Female	43.0	22.0	21.0
		53.1%	52.4%	53.8%
	Non-binary/third gender	0.0	0.0	0.0
		0.0%	0.0%	0.0%
	Prefer not to say	1.0	1.0	0.0
		1.2%	2.4%	0.0%

Source: Field Data (2021)

5.2.2 Ethnic Origin of Respondents

Table 5.2 Ethnic origin of A-Level chemistry students in relation to their year group

	Year Groups			
		Total	First year	Second year
	Total count (Answering), n =	81	42	39
Ethnic origin	White	35.0	22.0	13.0
		43.2%	52.4%	33.3%
	Black/African/Caribbean/Black British	5.0	2.0	3.0
		6.2%	4.8%	7.7%
	Asian/Asian British	36.0	14.0	22.0
		44.4%	33.3%	56.4%
	Mixed/Multiple ethnic group	3.0	2.0	1.0
		3.7%	4.8%	2.6%
	Other ethnic group	2.0	2.0	0.0
		2.5%	4.8%	0.0%

Source: Field data (2021)

According to the ethnic origin distribution of the students who returned their questionnaire as described by Table 5.2, 35 students (43.2%) were white, 36 students (44.4%) were Asian/Asian British, 5 students (6.2%) were Black /African/Caribbean /Black British, 3 students (3.7%) were Mixed/Multiple ethnic group and 2 students (2.5%) were other ethnic group.

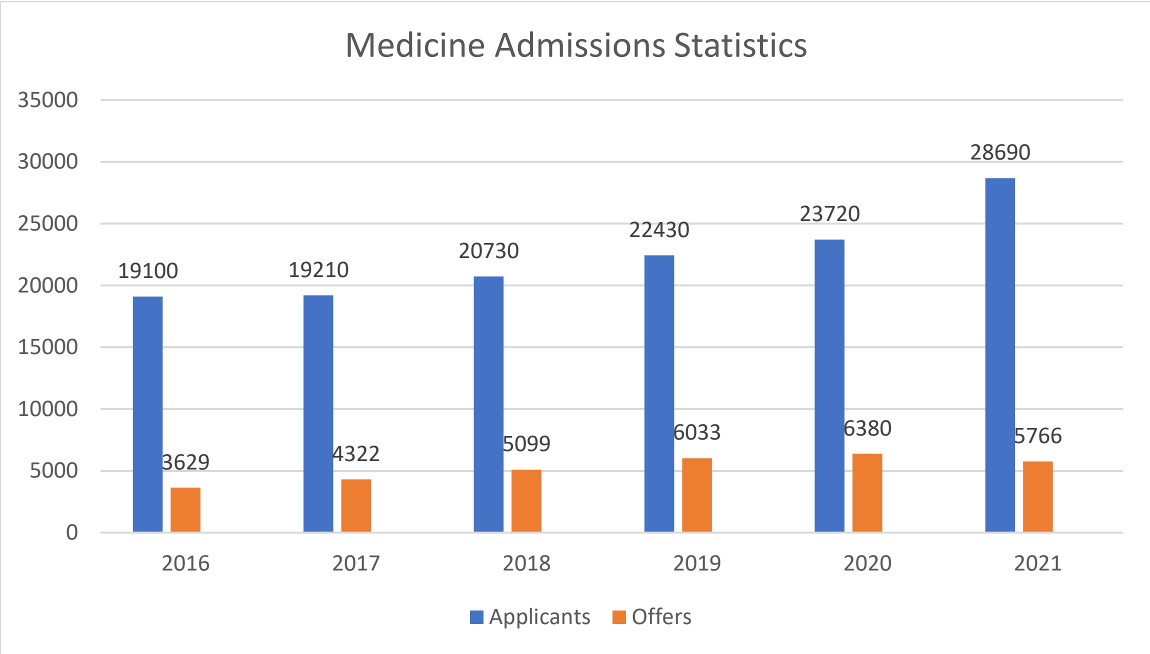
5.3 Future careers Respondents had chosen at A-level

Table 5.3 Analyses of Possible Future Careers by the A- Chemistry Students

Future Career	Frequency	Percentage
Medicine	25	30.86%
Physician Associates	2	2.47%
Engineer	7	8.64%
Physiotherapist	2	2.47%
Pharmacist	8	9.88%
Marine Biologist	1	1.23%
Forensic Scientist	3	3.70%
Environmental Scientist	1	1.23%
Biotechnologist	1	1.23%
Research Scientist	1	1.23%
Psychologist	3	3.70%
Nutritionist	1	1.23%
Microbiologist	1	1.23%
Biochemist	2	2.47%
Nursing	2	2.47%
Royal Air Force	1	1.23%
Architecture	1	1.23%
Sonographer	1	1.23%
Teacher	1	1.23%
Biomedical Scientist	3	3.70%
Mathematician	1	1.23%
Accountant	1	1.23%
Zoologist	1	1.23%
Data Security	1	1.23%
International Development	1	1.23
Not sure	9	11.10%
	Total = 81	100%

Source: Field data (2021)

Medicine is the most popular future profession or career among the chemistry students even though it is highly competitive career in UK (Medical Schools Council, 2021). This is confirmed by figure 3 below from the Medical Schools Council.



Source: Medical Schools Council (2021)

Figure 3 Medical School Admission Statistics, UK

One of the reasons why medicine is highly competitive according to the Medical Schools Council is the limited places available. For example, only 20.1% (28,690) of the applicants in 2021 had offers to study medicine. According to Table 5.3, 25 students (30.86%) of the A-Chemistry students in the FE college have Medicine as their future career. On the other hand, 8 students (9.88%) wanted to become a pharmacist. However, 9 students (11.1%) were not sure of what they wanted to do in future. This re-enforces the need for continuous career advice in secondary schools so that students are clear in their minds what exactly they want to do in future. Sometimes students who are not sure of what they want to do in future may not be focused and the motivational level of such students may be low as they may not have a goal or target to aspire to. Walker and Peterson (2012) indicated that making academic career decisions not only enhances students' ability to progress academically, but also increases their effective decision-making skills. Additionally, they mentioned that learning how to effectively make career decisions and developing suitable goals are essential life skills for every student. Furthermore, Bertoch *et al* (2013) examined students' career decision in relation to classroom performance. They found that the degree of instability in career decision by students' is directly related to their low classroom performance. They explained that students with firm career decisions are usually highly motivated and more focused. Additionally, some research reports (Archer *et al.*, 2013; Kantar, 2020) indicated that most young people and their parents seem to have limited understanding where science can lead. Many of them believe that science qualification leads mainly to careers such as a science teacher, doctor or scientist. On the other hand, the report indicated that young people who are aware of the transferability of science qualifications are more probable to aspire to STEM related career, see Table 5.3.1 below, and plan to study the corresponding subjects at post-16. This raised a critical issue as there were as many as 9 students (11.1%) involved in this research, as discussed above, who were not sure of what they wanted to do in future.

Table 5.3.1 STEM related careers

Computer and Information System	Entertainment Industry	Applied Engineering	Other Related careers
Computer programmer	Animator	3D printing engineer	Medical illustrator
Hardware Engineer	Digital content director	Robotics engineer	Curriculum developer
Network administrator	Gameplay engineer	Data engineer	Actuary
Professional hacker	Virtual world creator	Health and Safety engineer	Surveyor
Data scientist	Music data Journalist	Sale engineer	Financial analyst

Furthermore, Kantar (2020) indicated that year 10–13 students in England with some idea about what they wanted to do as a future career were twice as likely to aspire to a non-STEM career than a STEM career.

5.4 The Type of Science Respondents did at GCSE

Table 5.4 Type of science students did at GCSE in relation to year groups in A-level chemistry

	Which year group are you?			
		Total	First Year	Second Year
	Total count (Answering), n =	81	42	39
What type of chemistry did you do in GCSE?	Triple science	54.0	29.0	25.0
	Percentage count	66.7%	69.0%	64.1%
	Combined science	22.0	12.0	10.0
	Percentage count	27.2%	28.6%	25.6%
	Other science	5.0	1.0	4.0
	Percentage count	6.2%	2.4%	10.3%

Source: Field data (2021)

The analysis from Table 5.4 indicates that 54 students (66.7%) did Triple science which covers the GCSE Chemistry, Biology and Physics in more detail than combined science and the other GCSE sciences. Twenty-two students (27.2%) did combine science and 5 students (6.1%) did other science such as applied science.

According to Table 5.5 below, 72.2% who did Triple science strongly or somewhat agree that A-level chemistry is a difficult subject whereas 81.81% who did combined science strongly or somewhat agree that A-level chemistry is a difficult subject. This analysis suggests that students who did Triple science were less likely to find A-level chemistry challenging although both percentages are high. Two out of the three early chemistry leavers (A-level chemistry students who did not complete the two years), who were interviewed in chapter 9, did combined science and one did Triple science at GCSE. This gave a bit of follow up on the trend of GCSE science students who leave A-level chemistry though the data was not enough to give more information at this point.

According to Kantar (2020) one of the barriers to studying Triple science is related to some schools being selective in who studies it, rather than not offering it at all. However, uptake of Triple science sometimes is mainly due to personal factors such as confidence and lack of interest, although some students are discouraged by not meeting grade thresholds or by their teacher. Additionally, a Teach First (2022) report indicated that among the three sets classification in schools, top set students are more probable to be offered Triple science compared to middle and bottom sets students, but Triple science is mostly required by schools and further education colleges for progression in the sciences in A-levels which grants access to higher education, and career in STEM.

Rodeiro (2013) research report, which was conducted by comparing progression routes to post-16 Science qualifications, indicated that students who take separate sciences (Triple science) at GCSE do better than any other group. In addition, it was mentioned that students' confidence and expectations about their achievements may also be limited if they do combined science or applied science which are perceived as less challenging routes because the depth of the content is not as much, as compared to Triple science. Furthermore, Rodeiro (2013) reported that level 2 science route with the highest progression rate was the Triple science with 46% of the students progressing to a post-16 qualification in science. This was followed by double science with 26% of the students and fewer than 5% of the students following an applied route at level 2, progressed to science at post-16 or a higher level. This supports the notion that students who want to do STEM A- Level sciences may be faced with fewer challenges if they do Triple science at GCSE because they do cover in detail the respective science subjects at the GCSE and might help them to achieve well at A-level. This may perhaps be the reason why a high percentage (66.7%) of the research participants did Triple science at GCSE. Additionally, this suggests that those coming with double or other science may need additional support and resources at A-level so as to achieve well.

Table 5.5 Respondents' perception of A-Level chemistry in relation to the type of science they did at GCSE

		Type of chemistry done at GCSE			
			Triple science	combined science	other science
Chemistry is a difficult subject	Total Count (Answering), n =	81	54	22	5
	Strongly agree		18.0	9.0	0.0
			33.3%	40.9%	0.0%
	Somewhat agree		21.0	9.0	2.0
			38.9%	40.9%	40.0%
	Neither agree nor disagree		8.0	1.0	0.0
			14.8%	4.5%	0.0%
	Somewhat disagree		6.0	3.0	3.0
			11.1%	13.6%	60.0%
	Strongly disagree		1.0	0.0	0.0
			1.9%	0.0%	0.0%

Source: Field data, (2021)

5.5 Maths Grade Respondents obtained at GCSE

Table 5.6 Year group in relation to grades respondents obtained in GCSE Maths

	Number of students achieving respective GCSE Maths grades		
Grade in GCSE Maths	First Year (42 students)	Second Year (39 students)	Total (81 students)
5	7	4	11
6	7	11	18
7	10	10	20
8	14	11	25
9	4	3	7

Source: Field Data (2021)

From the above responses, 28 students (66.6%) from first year got grade 7-9 in GCSE Maths, 24 students (61.5%) from the second year got grade 7-9. Overall, 52 students (64.2%) of both year one and two students got grade 7-9 in GCSE Maths. This suggests that more than 50% of the A level students doing chemistry got high grades in GCSE Maths in the FE college. This suggests that apart from Triple science, as discussed in section 5.4, a good grade in GCSE maths is also necessary for achieving well in A-level chemistry. This is further supported by the analysis in section 5.6 below. It would have been useful to compare this with national data, GCSE maths grades the A-level chemistry students obtained, but this was not available.

5.6 Respondents' perception about A-level chemistry

Table 5.7 Maths grades respondents obtained in relation to their perception to A-Level chemistry as a difficult subject

	GCSE Maths grade	
A-level chemistry is difficult	Grade 5-6	
	Strongly agree	Somewhat agree
	34.5%	44.8%
	Grade 7-9	
	Strongly agree	Somewhat agree
	32.7%	36.5%

Source: Field Data (2021)

Table 5.7 above reveals that 69.2% of students who scored a grade 7-9 in GCSE maths strongly or somewhat agree that A- level chemistry is difficult. Furthermore, 79.3% of students who got a grade 5-6 in GCSE maths strongly or somewhat agree that A-level chemistry is difficult.

This suggests that the students who got grade 7-9 in GCSE maths may be less likely to suggest that A-Level chemistry is difficult. Students who get grade 5-6 may be more likely to have challenges in A-level chemistry because they are less likely to be doing A-level maths that serves as an advantage for A-level chemistry students. The maths department does not allow students with grade 5 in GCSE maths to do A-level mathematics in the FE college. Students who do A-level maths are able to apply their maths skills in chemistry to their advantage. Grove (2015) suggested that the importance of mathematics for chemistry should not be hidden to students especially its desirability for A-level. The study indicated that students who did only

GCSE mathematics and did not do A-level mathematics usually lose fluency and understanding in the mathematics ideas and skills required in chemistry over time because they were not continually reinforced. Furthermore, Ogan *et al* (2017) assert that mathematics should be taken alongside chemistry by students studying chemistry to enable them to understand the connection between mathematics and chemistry. They indicated that mathematics calculations are necessary to explore the concepts in chemistry. According to Musson (2013), many students struggle in A-level chemistry, not because they cannot do the chemistry, but because they find the maths hard.

Table 5.7.1 Maths grades respondents obtained in relation to how they enjoy A-Level chemistry

		GCSE Maths grade					
		Total	**5**	**6**	**7**	**8**	**9**
Enjoys A-level chemistry lessons	Total Count (Answering), n =	81.0	11.0	18.0	20.0	25.0	6.0
	Strongly agree	25.0	4.0	4.0	7.0	8.0	1.0
		30.9%	36.36%	22.2%	35.0%	32.0%	16.67%
	Somewhat agree	41.0	5.0	10.0	10.0	13.0	4.0
		50.6%	45.45%	55.6%	50.0%	52.0%	66.67%
	Neither agree nor disagree	12.0	2.0	3.0	2.0	4.0	0.0
		14.8%	18.18%	16.7%	10.0%	16.0%	0.0%
	Somewhat disagree	1.0	0.0	0.0	1.0	0.0	0.0
		1.2%	0.0%	0.0%	5.0%	0.0%	0.0%
	Strongly disagree	2.0	0.0	1.0	0.0	0.0	1.0
		2.5%	0.0%	5.6%	0.0%	0.0%	16.67%

Source: Field data, (2021)

The analysis from Table 5.7.1 reveals that 81.81% of the students who had grade 5 in GCSE maths and 77.8% of those who got grade 6 in GCSE maths strongly or somewhat agree that they enjoy A-level chemistry including the maths areas. The responses were very similar. Furthermore, 85% of those who got grade 7, 84% of those who got grade 8 and 83.34% of those who got grade 9 in GCSE maths strongly or somewhat agree that they enjoy A-level chemistry respectively. The general trend could be that the higher the grade in GCSE maths the more the student may enjoy A-level chemistry though all the percentages in enjoyment in A-level chemistry were all above 70% which may suggest that students were in general enjoying their lessons.

5.7 Number of Subjects Respondents do at A-Levels

Table 5.8 Number of subjects students do at A-level in relation to their year group

		How many subjects are you doing at A - level			
		Total	3	4	5
Which year are you?	Total Count (Answering), n =	81	72	9	0
	First year	42.0	39.0	3.0	0.0
			92.9%	7.1%	0.0%
	Second year	39.0	33.0	6.0	0.0
			86.6%	15.4%	0.0%

Source: Field data, (2021)

According to Table 5.8, 39 students (92.9%) of the first-year group and 33 students (86.6%) of the second-year students are doing three subjects. The students indicated that they chose three subjects at A-Level, which is the standard requirements so that they can focus on or achieve their university requirement for their future career. Most of the students who were doing four subjects at A-level stated that they would drop one subject if they needed more time to focus on achieving their university requirement. Others also indicated that they were planning to apply to a competitive university such as Oxford or Cambridge, or course which included medicine and law for example. Over 85% of the A-level chemistry students in the FE college were doing three A-levels which is the standard requirement by most universities in UK for higher education. Thus, extra workload, for students who do four subjects, did not seem to be a factor in the challenges for the chemistry students in the college.

5.8 A Probable drop in A-Level chemistry by Respondents in relation to their year group

Table 5.9 Analysis of probable drop in A-level chemistry by respondents in relation to their year group

What year are you?				
		Total	First year	Second year
Will you drop A-level chemistry if your career choice changes?	Total count (Respondents), n=	81	42	39
	Definitely yes	1.0	1.0	1.0
		1.2%	2.4%	0.0%
	Probably yes	3.0	2.0	1.0
		3.7%	4.8%	2.6%
	Might or might not	13	9.0	4.0
		16.0%	21.4%	10.3%
	Probably not	32.0	16.0	16.0
		39.5%	38.1%	41.0%
	Definitely not	32.0	14.0	18.0
		39.5%	33.3%	46.2%

Source: Field data, (2021)

When students were asked if they would drop A- Level chemistry if their career choice changes, 46.2% of the second-year students said they will definitely not as against 33.3% of the first-year group. 41.0% of the second-year students said they would probably not drop chemistry whereas 38.1% were from the first-year group. 10.3% of the second-year group said they might or might not drop chemistry but the first-year group was 21.4%. From the analysis in Table 5.9 above, it is more likely for a first year A-Level chemistry student to drop chemistry than a second-year student is. This might be because the second-year students are more convinced and have their grips on the subject than the first-year students. A-level chemistry is taught in a spiral learning format, so you build on what you learn throughout the two years. Additionally, students may improve if they spend more time and effort in their studies. The higher percentage of first year students probable to drop A-Level chemistry could also be a challenge for the progression rate in A-Level chemistry. This suggests that the first-year students would need more support and motivation to ensure that their progression and achievement are not affected.

5.9 Making a decision to choose A-Level Chemistry by respondents

Table 5.10 Making a decision to choose A-Level Chemistry in relation to year group

		What year are you?		
		Total	First year	Second year
How accurate is each of the following statement as it applies to your decision in doing A-Level chemistry? It was really not my decision alone	Total count (Respondents), n=	80	41	39
	Strongly agree2.0	2.0	2.0	0.0
		2.5%	4.9%	0.0%
	Somewhat agree	14.0	5.0	9.0
		17.5%	12.2%	23.1%
	Neither agree nor disagree	6.0	4.0	2.0
		7.5%	9.8%	5.1%
	Somewhat disagree	15.0	7.0	8.0
		18.8%	17.1%	20.5%
	Strongly disagree	43.0	23.0	20.0
		53.8%	56.1%	51.1%

Source: Field data (2021)

The research participants were also asked whether they received any career or subject choice advice before choosing A-level chemistry. According to Table 5.10, 20% of the participants strongly or somewhat agree that it was not their decision alone in choosing A-Level Chemistry as a subject. Thus, they had outside influence which could be from parents, teachers or career advisors. On other hand, this implies that 80% of the students chose A-level chemistry as a subject by themselves without any outside influence such as expert advice. Furthermore, only 17.1% of the first-year group and 23.1% of the second years respectively said they strongly or somewhat agree that it was not their decision alone in choosing A-Level chemistry as a subject.

The Sutton Trust (2022) reported from their research work conducted in UK secondary schools that only 36% of students in UK had attended any career related programme or participated in any career related activities. The report indicated that students from state schools are more likely to report not having taken part (38%) as compared to students from private schools (23%). The awareness of the Gatsby Benchmarks, the current framework for careers guidance, was found to be lower among classroom teachers in state schools (40%) though most (94%) of state school senior leaders are aware. It was also reported that around about 36% of secondary school students in UK do not feel confident in their steps in education and training, but about 56% said they felt confident. Students from state schools were reported not being confident in their next steps in education and training than those in private schools (39% compared to 29%). Additionally, 21% non-specialists were reported to deliver careers guidance in schools in most deprived areas compared to 14% from the affluent areas. This implies that there is a high probability for a non-specialist to be delivering careers guidance in deprived areas than the more affluent areas. Furthermore, over three quarters (88%) of the teachers from state school felt that their teacher training didn't prepare them to deliver careers guidance to students. Besides, over a third (37%) of senior leaders indicated that their school does not have adequate funding and resources to deliver careers advice and guidance, with 32% from state schools as compared to just 6% from private schools. Fifty-one percent of the state school teachers felt there is not enough time for teachers to provide careers advice and guidance information to students compared to 34% for private school staff (Sutton Trust, 2022).

Career advice and guidance session for students at GCSE about the workload and the suitable subject combinations based on their future career would help to prepare them for their two years at A-level which could help to prevent them from feeling overwhelmed. Some students only focus on their future career and university requirements without considering the workload involved in their subject combination. Some students on the other hand choose subjects, which they think, can easily enable them to get their university requirements without considering if they can transfer knowledge and skills from one subject to the other to enhance their achievement. Subject combination requires guidance and support so that the student can achieve well at A-Level especially in chemistry.

Furthermore, when the research participants in the FE college were asked if they considered many factors in their decision for choosing A-Level chemistry, the results analysed are as reported in Table 5.10.1 below. Thirty-one students (38.27%) strongly or somewhat agree that they considered many other factors in choosing A-Level chemistry but 41 students (50.61%) strongly or somewhat disagree that they considered many factors in choosing A-level chemistry. This further confirms the data in Table 5.10 above, suggesting that students are choosing A-level subjects including chemistry with less career advice and relevant consideration of other factors such as subject combination, workload, studies skills transfer and application.

Table 5.10.1 Analysis of respondents' responses as to whether they did consider many factors before choosing A-Level chemistry as a subject

Field	Choice count (%)	Number of students
Strongly agree	7.41	6
Somewhat agree	30.86	25
Neither agree nor disagree	11.11	9
Somewhat disagree	30.86	25
Strongly disagree	19.75	16
total	100%	81

Source: Field data (2021)

5.10 Teachers' role in teaching and learning of A-Level chemistry

Table 5.11 Teachers play a significant role during teaching and learning in relation to year groups in A-level chemistry

		What year are you?		
		Total	First year	Second year
Teachers play a significant role during the teaching and learning of process as they influence students' attitudes in relation to the study of chemistry.	Total count (respondents), n =	81	42	39
	Strongly agree2.0	58.0	30.0	28.0
		71.6%	71.4%	71.8%
	Somewhat agree	19.0	12.0	7.0
		23.5%	28.6%	17.9%
	Neither agree nor disagree	4.0	0.0	4.0
		4.9%	0.0%	10.3%
	Somewhat disagree	0.0	0.0	0.0
		0.0%	0.0%	0.0%
	Strongly disagree	0.0	0.0	0.0
		0.0%	0.0%	0.0%

Source: Field data (2021)

The research participants indicated that their chemistry teachers play a significant role in their study of A-level chemistry. Every one of them, 100% of the first-year students, strongly or somewhat agree that their teachers influence their attitudes towards the study of chemistry and 89.7% of the second-year students also strongly or somewhat agree to that as reported in Table 5.11. The percentage difference (10.3%) may be a reflection of the second years' becoming more independent and mature learners though the difference is not high but noticeable. It will therefore be prudent for FE colleges to employ teachers who are professional chemistry teachers and are experienced in teaching the subject in the sector so that the FE students could achieve well. This may also improve the students' progression. However, the high percentages from both second-year and first-year students' response may also be because they liked the teacher, felt confident learning with them or enjoyed the lessons which may not always coincide with the teacher being a chemistry specialist.

5.11 Effects of support session on decision making by students doing A-Level chemistry

Table 5.12 Effects of support session in the study of A-Level chemistry in relation to the type of science respondents did at GCSE.

		What type of chemistry did you do in GCSE?			
Knowing that there will be a lot of help offered by teachers and the college helps me to decide to stay and complete the A-level chemistry		Total	Triple science	Double science	Other science
	Total count (respondents), n =	81	54	22	5
	Strongly agree2.0	22.0	11.0	9.0	2.0
		27.2%	20.4%	40.9%	40.0%
	Somewhat agree	40.0	29.0	8.0	3.0
		49.4%	53.7%	36.4%	60.0%
	Neither agree nor disagree	14.0	11.0	3.0	0.0
		17.3%	20.4%	13.6%	0.0%
	Somewhat disagree	3.0	1.0	2.0	0.0
		3.7%	1.9%	9.1%	0.0%
	Strongly disagree	2.0	2.0	0.0	0.0
		2.5%	3.7%	0.0%	0.0%

Source: Field data (2021)

The students who did Triple science, double science and other science strongly or somewhat agree by 76.6%, 77.3% and 100% respectively that knowing there would be a lot of help offered by teachers and the college helped them to decide to stay and complete A-Level chemistry. Students who did other sciences, which are less in depth in terms of content and practical at GCSE, may require more help as compared to those who did Triple science that is more in depth of the subject content and practical. However, over 50% of all the students who did various categories of science at GCSE still indicated that help offered by teachers and the college will encourage them to stay and complete A-level chemistry according to Table 5.12.

Based on the students' responses it would appear that timetabled sessions may be useful. This is one of the significant challenges reported by the study.

5.12 Effects of understanding chemistry principles and concepts on A-Level chemistry studies

Table 5.13 It is tricky to understand chemical principles and concepts in chemistry in relation to the type of chemistry respondents did at GCSE

		What type of chemistry did you do in GCSE?			
		Total	Triple science	Double science	Other science
It is tricky to understand the chemical principles and concepts	Total count (Respondents), n =	81	54	22	5
	Strongly agree2.0	8.0	4.0	4.0	0.0
		9.9%	7.4%	18.2%	0.0%
	Somewhat agree	36.0	22.0	11.0	3.0
		44.4%	40.7%	50.0%	60.0%
	Neither agree nor disagree	18.0	13.0	5.0	0.0
		22.2%	24.1%	22.7%	0.0%
	Somewhat disagree	14.0	11.0	2.0	1.0
		17.3%	20.4%	9.1%	20.0%
	Strongly disagree	5.0	4.0	0.0	1.0
		6.2%	7.4%	0.0%	20.0%

Source: Field data (2021)

From table 5.13, 44 students out of 81 (54.3%) respondents strongly or somewhat agree that it is tricky to understand the chemistry principles and concepts. Further details for students who did the various GCSE sciences were as follows; 48.1% who did Triple science, 68.2% who did combined science and 60% who did other science respectively indicated that they strongly or somewhat agree that understanding the chemistry principles and concepts are tricky. This may indicate increased confidence for those who did Triple science with the lowest percentage in this case. However, this appeared to be one of the challenges the FE college A-Level chemistry students are facing in terms of progression and achievement. Results and analysis from Table 5.13.1 below gives a similar trend when students were asked to express their views concerning explaining and interpreting A-level chemistry principles and concepts.

Table 5.13.1 Effects of explaining and interpreting A-level chemistry principles in relation to the type of chemistry respondents studied at GCSE

		What type of chemistry did you do in GCSE?			
		Total	**Triple science**	**Double science**	**Other science**
Explaining and interpreting chemistry principles and concepts are not easy	Total count (respondents), n =	81	54	22	5
	Strongly agree	12.0	10.0	2.0	0.0
		14.8%	18.5%	9.1%	0.0%
	Somewhat agree	36.0	23.0	9.0	4.0
		44.4%	42.6%	40.9%	80.0%
	Neither agree nor disagree	19.0	13.0	6.0	0.0
		23.5%	24.1%	27.3%	0.0%
	Somewhat disagree	12.0	6.0	5.0	1.0
		14.8%	11.1%	22.7%	20.0%
	Strongly disagree	2.0	2.0	0.0	0.0
		2.5%	3.7%	0.0%	0.0%

Source: Field data (2021)

The analysis of the results from Table 5.13.1 shows that 61.1% of students who did Triple science, 50.0% of combined science students and 80% of other science students respectively strongly or somewhat agree that it is not easy to explain and interpret chemistry principles and concepts respectively. This also was an issue for all students who did the various types of sciences at GCSE including those who did Triple science because 50% or higher of all the students who did the various categories of the GCSE sciences indicated that it is not easy to explain and interpret A-level chemistry principles and concepts.

5.13 Application of chemical knowledge and understanding familiar situations in A-Level chemistry

Table 5.14 Application of chemical knowledge and understanding familiar situations in A-level chemistry in relation to the type of chemistry students did at GCSE

		What type of chemistry did you do in GCSE?			
		Total	Triple science	Combined science	Other science
To apply chemical knowledge and understand familiar situations require long hours of studying.	Total count (respondents), n =	81	54	22	5
	Strongly agree	33.0	24.0	7.0	2.0
		40.7%	44.4%	31.8%	40.0%
	Somewhat agree	28.0	16.0	11.0	1.0
		34.6%	29.6%	50.0%	20.0%
	Neither agree nor disagree	8.0	6.0	1.0	1.0
		9.9%	11.1%	4.5%	20.0%
	Somewhat disagree	11.0	7.0	3.0	1.0
		13.6%	13.0%	13.6%	20.0%
	Strongly disagree	1.0	1.0	0.0	0.0
		1.2%	1.9%	0.0%	0.0%

Source: Field data (2021)

This analysis revealed that 74% of the students who did Triple science at GCSE strongly or somewhat agree that applying chemical knowledge and understanding in familiar situations require long hours of studying. This group is supposed to be the students who got more in-depth chemistry content and practical at GCSE. Moreover, 81.8% of the students who did combined science at GCSE and 60% of those who did other sciences respectively also strongly or somewhat agree to this same question. This therefore appears to be one of the challenges A-level chemistry students have in the FE college.

5.14 Making connections between different topics in A-Level chemistry

Table 5.15 Making connections between different topics in chemistry in relation to the type of science students did at GCSE.

What type of chemistry did you do in GCSE?					
		Total	Triple science	Combined science	Other science
	Total count (respondents), n =	81	54	22	5
It is difficult to make connections between different topics in chemistry	Strongly agree	3.0	2.0	1.0	0.0
		3.7%	3.7%	4.5%	0.0%
	Somewhat agree	20.0	11.0	7.0	2.0
		24.7%	20.4%	31.8%	40.0%
	Neither agree nor disagree	15.0	11.0	4.0	0.0
		18.5%	20.4%	18.2%	0.0%
	Somewhat disagree	30.0	22.0	8.0	0.0
		37.0%	40.7%	36.4%	0.0%
	Strongly disagree	13.0	8.0	2.0	3.0
		16.0%	14.8%	9.1%	60.0%

Source: Field data (2021)

According to the analysis from Table 5.15, 24.1% of the students who did Triple science strongly or somewhat agree that it is difficult to make connections between different topics in chemistry. 36.3% of the students who did double science and 40% of those who did other science respectively also strongly or somewhat agree that it is difficult to make connections between different topics in chemistry. The above analysis suggested that majority of the students did not find linking of topics difficult. This is because all the percentages for the students who did the various categories of sciences were below the 45% average or above, which was considered to be noticeable. However, it is evident again that students who do Triple science at GCSE may perform better than those who do combined science and other science at GCSE as shown by these results and analysis as well. This supports Rodeiro (2013) who indicated that students who take combined science route at GCSE are disadvantaged at A-level because the research showed that students who take separate sciences (Triple science) achieve higher grades.

Table 5.15.1 Enjoys A-level chemistry lessons in relation to the type of GCSE chemistry respondent offered

		what type of chemistry did you do in GCSE?			
		Total	Triple science	combined science	Other science
I enjoy A-level chemistry lessons	Total Count (Answering), n =	81.0	54.0	22.0	5.0
	Strongly agree	25.0	19.0	4.0	2.0
		30.9%	35.2%	18.2%	40.0%
	Somewhat agree	41.0	25.0	13.0	3.0
		50.6%	46.3%	59.1%	60.0%
	Neither agree nor disagree	12.0	7.0	5.0	0.0
		14.8%	13.0%	22.7%	0.0%
	Somewhat disagree	1.0	1.0	0.0	0.0
	Strongly disagree	2.0	2.0	0.0	0.0
		2.5%	3.7%	0.0%	0.0%

Source: Field data (2021)

From Table 5.15.1, 81.5% of the respondents who did Triple science strongly or somewhat agree that they enjoy A-level chemistry lessons compared to 77.3% of the respondents who did combined science at GCSE though both percentage values are high.

5.15 Having the opportunity to listen to a recorded chemistry lesson enables me to recap and perform better in assessment.

Table 5.16 Having the opportunity to listen to a recorded chemistry lesson enables me to recap and perform better in assessment in relation to the type of science student did at GCSE

		What type of chemistry did you do in GCSE?			
		Total	Triple science	Combined science	Other science
	Total count (respondents), n =	**81**	**54**	**22**	**5**
Having the opportunity to listen to a recorded chemistry lesson enables me to recap and perform better in assessment	Strongly agree	40.0	29.0	9.0	2.0
		49.4%	53.7%	40.9%	40.0%
	Somewhat agree	20.0	12.0	7.0	1.0
		24.7%	22.2%	31.8%	20.0%
	Neither agree nor disagree	11.0	4.0	5.0	2.0
		13.6%	7.4%	22.7%	40.0%
	Somewhat disagree	6.0	5.0	1.0	0.0
		7.4%	9.3%	4.5%	0.0%
	Strongly disagree	4.0	4.0	0.0	0.0
		4.9%	7.4%	0.0%	0.0%

Source: Field data (2021)

Analysis from Table 5.16 above indicated that 74.1% of the correspondents strongly or somewhat agree that having the opportunity to listen to a recorded chemistry lesson enables them to recap and perform better in assessments. All students who did the various categories of sciences in GCSE had the following percentages in favour of recorded lessons as being important and enhancing their performance in assessments; 75.9% of Triple science students, 72.7% combined science students and 60% other science students respectively strongly or somewhat agree. Recording of lessons was not done in this FE college where the questionnaire was administered before Covid-19 national locked down in UK in 2020 and 2021. The high percentages from the analysis suggests that the recorded lessons were valuable to the students and they might have used them as a means of having access to first-hand information if they were absent from college, to clarify anything they do not understand, opportunity to refresh on a completed topic or module and to review difficult topics and materials. The data clearly indicates that recording lessons and making them available for students is a valuable service that students appreciate — one that may actually help improve students' performance and progression.

5.16 The effects of Chemistry educational videos on students' revision and performance in assessment

Table 5.17 The effects of Chemistry educational videos on students' revision and performance in assessment in relation to the type of science respondents did at GCSE

What type of chemistry did you do in GCSE?					
		Total	Triple science	Combined science	Other science
	Total count (respondents), n =	**81**	**54**	**22**	**5**
Chemistry educational videos enable me to have a meaningful revision and perform better in assessment	Strongly agree	38.0	27.0	9.0	2.0
		46.9%	50.0%	40.9%	40.0%
	Somewhat agree	29.0	19.0	9.0	1.0
		35.8%	35.2%	40.9%	20.0%
	Neither agree nor disagree	11.0	5.0	4.0	2.0
		13.6%	9.3%	18.2%	40.0%
	Somewhat disagree	2.0	2.0	0.0	0.0
		2.5%	3.7%	0.0%	0.0%
	Strongly disagree	1.0	1.0	0.0	0.0
		1.2%	1.9%	0.0%	0.0%

Source: Field data (2021)

According to Table 5.17, 82.7% of the students in overall strongly or somewhat agree that chemistry educational videos enable them to have meaningful revision and perform better in assessments. This suggests that students' progression and achievements in A-Level chemistry could be improved by provision of educational videos that have been designed to cover their A-Level chemistry specification. Most of the respondents indicated that they would appreciate if the educational videos were selected by their teachers and uploaded into their virtual learning environment in their college website. This could save them time and guarantee that the resources are reliable and appropriate for their teaching and learning. Audio-visual contents could promote dynamism in classes (moving the emphasis from teaching to learning), helping topics comprehension, making content more attractive and reducing absenteeism in classrooms, as many students would enjoy the subject and this could potentially increase achievement and progression.

Table 5.17.1 The effects of Chemistry educational videos on students' revision and performance in assessment in relation to gender

		Gender				
		Total	Male	Female	Non-binary	Prefer not to say
Chemistry educational videos enable me to have a meaningful revision and perform better in assessment	Total count (respondents), n =	81	37	43	0	1
	Strongly agree	38.0	14.0	23.0	0.0	1.0
		46.9%	37.8%	53.5%	0.0%	100%
	Somewhat agree	29.0	15.0	14.0	0.0	0.0
		35.8%	40.5%	32.6%	0.0%	0.0%
	Neither agree nor disagree	11.0	6.0	5.0	0.0	0.0
		13.6%	16.2%	11.6%	0.0%	0.0%
	Somewhat disagree	2.0	1.0	1.0	0.0	0.0
		2.5%	2.7%	2.3%	0.0%	0.0%
	Strongly disagree	1.0	1.0	0.0	0.0	0.0
		1.2%	2.7%	0.0%	0.0%	0.0%

Source: Field data (2021)

The proportion of female correspondents who strongly or somewhat agree that chemistry educational videos enable them to have a meaningful revision and perform better in assessments was 86.1% as compared to 78.3% who were males. In terms of those who decided not to declare their gender, 100% strongly or somewhat agree and this was only one respondent. This data reveals that female students may be more likely to use the educational videos though there is high percentage from both male and female students. The gender analysis was included to discover or learn if educational video was a learning need for a particular gender in the FE college. Educational videos are appreciated by students and their use need to be supervised by teachers so that students get the best out of them. This is supported by the analysis from Table 5.17.1 above.

5.17 The effects of numerous maths formulae and their applications in A-Level Chemistry on achievement and progression

Table 5.18.1 Effects of numerous maths formulae and their applications in A-Level Chemistry in relation to year group

		Which year are you?		
		Total	First year	Second year
There are too many mathematical formulae that are difficult to remember in chemistry	Total count(respondents), n =	81	42	39
	Strongly agree	8.0	6.0	2.0
		9.9%	14.3%	5.1%
	Somewhat agree	30.0	18.0	12.0
		37.0%	42.9%	30.8%
	Neither agree nor disagree	15.0	8.0	7.0
		18.5%	19.0%	17.9%
	Somewhat disagree	19.0	8.0	11.0
		23.5%	19.0%	28.2%
	Strongly disagree	9.0	2.0	7.0
		11.1%	4.8%	17.9%

Source: Field data, 2021

From Table 5.18.1, thirty-eight students (46.9%) strongly or somewhat agree that there are more mathematical formulae that are difficult to remember in chemistry. This comprises of 24

(57.2%) first year students and 14 (35.9%) second year students. The higher percentage of first year students suggests that they may require maths support sessions so that they do not drop A-Level chemistry during their progression from year one to year two because there are a lot of both mathematical formulae and content in A-level chemistry. Furthermore, the second years' lower percentage could be due to prolonged memorisation of the numerous mathematical formulae in chemistry.

Table 5.18.2 Effects of numerous maths formulae and their applications in A-Level Chemistry in relation to the type of science the respondents did at GCSE

	What type of science did you do in GCSE?				
		Total	Triple science	Combined science	Other science
There are too many mathematical formulae that are difficult to remember in chemistry	Total count (respondents), n =	81	54	22	5
	Strongly agree	8.0	7.0	1.0	0.0
		9.9%	13.0%	4.5%	0.0%
	Somewhat agree	30.0	17.0	11.0	2.0
		37.0%	31.5%	50.0%	40.0%
	Neither agree nor disagree	15.0	10.0	4.0	1.0
		18.5%	18.5%	18.2%	20.0%
	Somewhat disagree	19.0	14.0	4.0	1.0
		23.5%	25.9%	18.2%	20.0%
	Strongly disagree	9.0	6.0	2.0	1.0
		11.1%	11.1%	9.1%	20.0%

Source: Field Data (2021)

The number of students who did Triple science at GCSE among the respondents were 54 and 44.5% of them strongly or somewhat agree that there are too many mathematical formulae that are difficult to remember in A-level chemistry. Among those who did combined science at GCSE, 54.5% strongly or somewhat agree that there are too many mathematical formulae that are difficult to remember in chemistry. However, 40% of the students who did other science strongly or somewhat agree with that same question. According to Table 5.18.2 above, thirty-eight (46.9%) of the overall students who did the various science at GCSE strongly or somewhat agree that there are too many mathematical formulae that are difficult to remember in A- level chemistry. This may be one of the perceived challenges A-level chemistry students are facing in the FE college since nearly half of the respondents strongly or somewhat agreed that there are too many mathematical formulae that are difficult to remember in chemistry.

Table 5.18.3 Effects of numerous maths formulae and their applications in A-Level Chemistry in relation to gender.

		Gender				
		Total	Male	Female	Non-binary /third gender	Prefer not to say
There are too many mathematical formulae that are difficult to remember in chemistry	Total count (respondents), n =	81	37	43	0	1
	Strongly agree	8.0	1.0	6.0	0.0	1.0
		9.9%	2.7%	14.0%	0.0%	100.0%
	Somewhat agree	30.0	15.0	15.0	0.0	0.0
		37.0%	40.5%	34.9%	0.0%	0.0%
	Neither agree nor disagree	15.0	8.0	7.0	0.0	0.0
		18.5%	21.6%	16.3%	0.0%	0.0%
	Somewhat disagree	19.0	7.0	12.0	0.0	0.0
		23.5%	18.9%	27.9%	0.0%	0.0%
	Strongly disagree	9.0	6.0	3.0	0.0	0.0
		11.1%	16.2%	7.0%	0.0%	0.0%

Source: Field data, (2021)

According to the analysis from Table 5.18.3, 43.2% male students strongly or somewhat agreed that there are too many mathematical formulae that are difficult to remember in A-Level chemistry. However, 48.9% female students strongly or somewhat agreed that there are too many mathematical formulae that are difficult to remember in A-Level chemistry. Thus, there was higher percentage of female A-level chemistry students indicating that there are too many mathematical formulae that are difficult to remember in A-level chemistry. This might be because there is higher percentage of female respondents (53.1%) for the research compared to 45.7% males. However, there is nearly 50% across both genders of the students who expressed the same opinion. This appears to be one of the challenges the A-Level chemistry students in the FE college encounter and may be a hindrance to their achievement and progression.

5.17.1 Data Analysis in Terms of Gender

The chemistry department cohort consisted of about 53.5% females and 46.5% males and among the A-level chemistry students who returned their questionnaire 37 (45.7%) were males and 43(53.1%) were females. This implied that there was a true representation of females in the research participants. There was 7.8% point difference for the analysis in session 5.16 (Table 5.17.1) and also 5.7% point difference for the analysis in session 5.17 (Table 5.18.3). These were all noticeable because they were above the 5% point difference considered as noticeable when compare groups during the analysis.

5.18 Summary of Questionnaire Analysis -Evidence Based Conclusions

Table 5.19 Summary analysis of four major perceived challenges and three benefits

	There are too many mathematical formulae that are difficult to remember in chemistry	To apply chemical knowledge and understand familiar situations require long hours of studying.	Explaining and interpreting chemistry principles and concepts are not easy	It is tricky to understan d the chemical principles and concepts	Knowing that there will be a lot of help offered by teachers and the college helps me to decide to stay and complete the A-level chemistry	Teachers play a significant role during the teaching and learning of process as they influence students' attitudes in relation to the study of chemistry.	Having the opportunity to listen to a recorded chemistry lesson enables me to recap and perform better in assessment
Total count (respondents)	81	81	81	81	81	81	81
Strongly agree	8.0	33.0	12.0	8.0	22.0	58.0	40.0
	9.9%	40.7%	14.8%	9.9%	27.2%	71.6%	49.4%
Somewhat agree	30.0	28.0	36.0	36.0	40.0	19.0	20.0
	37.0%	34.6%	44.4%	44.4%	49.4%	23.5%	24.7%
Neither agree nor disagree	15.0	8.0	19.0	18.0	14.0	4.0	11.0
	18.5%	9.9%	23.5%	22.2%	17.3%	4.9%	13.6%
Somewhat disagree	19.0	11.0	12.0	14.0	3.0	0.0	6.0
	23.5%	13.6%	14.8%	17.3%	3.7%	0.0%	7.4%
Strongly disagree	9.0	1.0	2.0	5.0	2.0	0.0	4.0
	11.1%	1.2%	2.5%	6.2%	2.5%	0.0%	4.9%

Source: Questionnaire field data, (2021)

The four major perceived challenges in A-level chemistry in the FE college were selected after all the responses to each question were ranked in terms of percentages. This was further enhanced by cross linking the questions using the Qualtrics software and ranking them in percentages as well. The four most ranked percentage responses were therefore selected. These were as follows;

1. There are too many mathematical formulae that are difficult to remember in chemistry.
2. The application of chemical knowledge and understanding familiar situations require long hours of studying.
3. Explaining and interpreting chemistry principles and concepts are not easy.
4. It is tricky to understand the chemical principles and concepts.

These were directly linked with the research questions. However, some of the responses from the questionnaire including the remaining three from Table 5.19 above have been analysed and will be used for recommendation in chapter 10. For example, 95.1% of the respondents strongly or somewhat agree that teachers play a significant role during the teaching and learning process as they influence students' attitudes towards the study of chemistry. This supports a research report by Annette (2020) that great chemistry teachers could change lives and the most effective teachers have an in-depth knowledge and understanding of the subjects that they teach. Students have no control of chemistry teachers' recruitment in the college or the selection of a chemistry teacher to teach a particular group or year. This is a responsibility of the management so they need to know the students' voice so that they could make informed decision during recruitment. Furthermore, 74.1% of the chemistry students in the FE college who took part in the research study indicated that having the opportunity to listen to a recorded chemistry lesson enables them to recap and perform better in assessment. This is supported by Zhang *et al* (2022) who indicated that the usage of lecture recordings is positively related to academic performance. Their results also indicated that the lowest performing students have less motivation to use recorded videos and therefore other resources may be required to improve the learning experience for these students. In another study, the research participants indicated that their interaction with recorded video lesson content were similar with face-to-face (Hung et al., 2018). However, Bezerra (2020) reported that students who depend only on recorded video content might have challenges such as lack of interaction and motivation. Robertson and Flowers (2020) suggested that the combination of video content, PowerPoint slides and face-to-face are effective studying approaches. These research findings support the essence of including these analyses from the questionnaire responses in the recommendations in chapter 10. These are not necessarily challenges that the chemistry students in the FE college were facing, but resources and findings that could also improve progression, retention and achievement in A-level chemistry in the college.

5.19 Action Research Plan

The four selected major perceived challenges from the questionnaire analysis were used to plan the three action research interventions (McNiff, 2010; Elliot, 1991). The three action research cycle interventions were planned to follow the order below;

Cycle 1

The researcher planned and taught four lessons that helped students to understand how to use the various formulae involved in A-level chemistry. A designed mathematical formulae booklet, which contained all the mathematical formulae used in A-level chemistry, see appendix Q, was provided for the students to use in activities during the lessons. There is no such mathematical formulae booklet in use for A-level chemistry, but this has been the practice in A-level physics and A-level mathematics. The four lessons were followed by the first semi-structured interviews of the twelve participants who agreed to participate in the semi-structured interviews.

Cycle 2

The researcher planned and taught three lessons to enhance how students could apply A-level chemistry concepts and principles including rules and their exceptions which are supposed to be used for answering both practical and theory questions. The cycle two was planned to follow cycle one because it was intended that if the students understood how to use the basic mathematics required in A-Level chemistry, they might be able to apply them thoroughly if the concepts and principles required to answer a particular question involved mathematics and the use of mathematical formulae. The three lessons were followed by the second semi-structured interviews by the same twelve research participants.

Cycle 3

The researcher planned and taught four lessons about how to select, organise and present chemical information clearly and logically. This also included how to make connections between different topics in A-level chemistry. Cycle three was designed to follow cycles 1 and 2 because it was hoped that if students know their basic mathematical requirement needed in A-Level chemistry and how to apply A-level chemistry concepts and principles including those that involve mathematics, it might enable them to select, organise and present chemical information more clearly and logically. The four lessons were followed by the third semi-structured interviews by the same twelve research participants who were involved in the previous two semi-structured interviews.

The rationale behind the cycles order was that cycle 1 would feed into cycle 2, and cycle 2 would feed into cycle 3.

5.20 Design for Action Research Interventions

Three cycles of action research interventions were conducted in the form of teaching lessons for the continuous A-level chemistry students, including the students who were involved in the semi-structured interviews. The twelve research participants, who consented for the semi-structured interviews, were interviewed after each of the three cycles of interventions. The designs for the teaching lessons during the three action research interventions will be further explained in the ensuing paragraphs.

Intervention one

Intervention one involved four teaching lessons spread over two weeks and each lesson covered a period of two hours. The lessons aimed to support the A-level chemistry students in the FE college to learn how to apply the numerous mathematical formulae involved in A-level chemistry in a more effective way when answering questions. This is because one of the main questionnaire findings was that there are too many mathematical formulae that are difficult to remember in A-level chemistry. During the lessons I chose topics which involved maths areas in A level chemistry including acids, bases and buffer, energy changes, equilibrium, moles and titration. I explained the basic fundamentals of maths application involved in each of the topics during the lessons with emphasis on how to correctly apply the formulae involved. During each lesson students were taught to use the data supplied in a question as a guide to choose the correct formular required for each calculation. The students were given the chemistry formulae booklet prepared by the researcher to work with during completion of tasks set for each lesson. This was to allow the researcher to find out if the formulae booklet will enhance learning and could alleviate the challenge mentioned by the students in their responses from the questionnaire analysis, that there are too many difficult mathematical formulae in A-level chemistry.

Printed worksheets with questions involving the topics taught for each lesson were given to students to complete in groups of three as their first task. This was to encourage peer learning. Marking schemes were given to students to self-mark their work in class at the end of each task period. This was to enable students to identify their own mistakes as part of the learning skills and to do their corrections. The first task for each lesson were followed by whole class discussion of the task completed. The students had the opportunity to ask questions to clarify anything they needed further clarification.

The second worksheet for each lesson were completed independently by the students. The researcher went around during the task period to support students who needed help or clarification. Students were encouraged to voluntarily provide explanations and answers for the questions during a whole class discussion after the second task. The students were given marking scheme after the class discussion to do any corrections in their work. Each lesson was ended with a recap. The students were given homework at the end of each lesson for completion and submitted to the researcher for marking. Students were given written feedback by the researcher after marking the homework.

Intervention Two

Three intervention lessons were done during the second intervention cycle to explain how to use the principles and concepts in A-level chemistry. The intervention two covered a period of two weeks and each lesson was two hours. The topics used during the lessons were redox reactions, addition reactions of alkenes and transition metals. The three lessons for intervention two covered one topic each from the three topics mentioned above. The lessons for each topic were taught with an emphasis on showing students the principles and concepts involved in the topics and how to explain them when answering questions. This is because explaining and interpreting chemistry principles and concepts was one of the main challenges from the questionnaire findings, see section 5.18 for further details. Students were made aware that revision of notes written during the lessons and all other chemistry lessons should be based on the principles and concepts involved. This was to discourage rote learning. Examples of how to use principles and concepts to answer questions were illustrated in class during each of the three lessons by the researcher, using past paper questions. These involved firstly identifying the commanding words in the question and what principles and concepts that could be used to answer them. Students worked in groups of three to complete the first worksheet for each lesson and were given a marking scheme to self-mark their work. This was followed by whole class discussion which was led by the researcher to emphasise the principles and concepts involved in the questions. The students then worked independently to complete the second worksheet for each lesson . The researcher went round the class to check students' work and offered support when needed during each lesson. Students once again self-marked their work using the marking scheme provided.

The students were put in groups for the first task to encourage sharing of ideas among themselves so that they could be encouraged and be more confident to do the second task independently. Students were given homework to be completed and handed them in for marking by the researcher after each lesson. Written feedback of the students' homework sheets were given to them which enabled them to reflect on each homework done.

Additionally, grade boundary descriptors were used during the third lesson of the second intervention to show students how to move from a lower grade to a higher one. Grade boundary descriptors emphasise the principles and concepts and the relevant knowledge to be acquired by students in order to achieve a specific grade. The grade boundary descriptors are designed by the Joint Council for qualifications, a membership organisation comprising the eight largest providers of qualifications in the UK (Joint council for qualifications, U.K, 2021).

Intervention Three

Students were taught how to select, organise and present chemical information logically during the third intervention as this was among the main challenges of the findings from the questionnaire analysis. Intervention three involved four teaching lessons over two and half weeks. Each lesson covered a period of two hours. During the first part of each lesson, questions were selected from A-level chemistry past papers and used to teach students how to select, organise and present chemical information logically. These involved how to select the required principles, which sometimes involved connecting different topics, organised the information based on the commanding words in the question and finally, presenting the information logically so as to gain the highest possible marks. The chief examiner's report, from the exam board used by the college, for the selected questions were later discussed with the students to show them the errors previous candidates made when answering those questions under exam conditions as a guide to help the students to avoid such mistakes.

Students were given similar questions to complete in class during each lesson after the whole class discussion which were led by the researcher. Firstly in groups of three and then independently for the second task during each of the lessons. They self-marked each task using the marking scheme. The researcher led a whole class discussion after each task was completed during each lesson. These included questions and answers which enabled the students to clarify their minds on anything they needed further clarification. The chief examiner's reports were used after each task to point out common errors previous students made when answering those questions. Students were given homework to be completed after each lesson. They were given feedback on each of their marked homework which enabled them to reflect on each homework completed.

5.21 Summary

The analysis of the forty-two responses from the questionnaire were done and this revealed some perceived challenges in A-level chemistry faced by the A-level chemistry students in the FE college. The questionnaire analysis was done using Qualtrics software for each response and also the questions were cross linked to allow the overall response of respondents for any two questions. All the analysed responses were ranked in percentages and four of the highest percentage responses were selected as the most perceived challenges in A-level chemistry in the FE college. These were used to plan for the three-action research intervention which were followed by three semi-structured interviews to collect the second data from the research participants. The action research plan and the design of the three action research interventions were outlined and discussed.

The next three chapters will be the analysis of the three semi-structured interviews which were picking up on students' voices in relation to the action research interventions. Chapters six, seven and eight will be the analysis of the first, second and third interviews respectively.

Chapter 6

Analysis of interviews

6.1 Introduction

This chapter contains analysis of the first of the three semi-structured interviews conducted for this study. This was conducted after the first action research intervention, see section 5.18. Twelve participants were interviewed at the end of each of the three action research interventions during the research. The same participants were interviewed after each action research intervention in order to maintain continuity and to enhance review from the previous interventions. Participants expressed their views as to what needed to be done to improve the progression, achievement and retention of the A-level chemistry students who have applied to do the subject.

The research data was obtained from A-level chemistry students in an FE college in England who entered A level during the initial stages of Covid-19 pandemic in September, 2020. This cohort did not sit for the May 2020 external GCSE exam because it was cancelled by the government. The government locked the entire country down in March 2020 due to the Covid-19 pandemic. Schools and colleges in England switched to online or virtual learning. The final year students from year eleven and year thirteen were given teacher assessed grades (TAG) as their final grades to continue their education. In view of this, this cohort did not get the opportunity to experience how to prepare for external exam and neither did they get the experience of writing final external GCSE exams. They entered A-levels with teacher assessed grades in September 2020. This interview data analysis is the students' voice obtained from the cohort as a result of two years research conducted with them. Table 6.0 below is a summary of the themes from the analysis of post cycle student interviews when the three action research interventions were conducted.

Table 6.0 Themes and corresponding action research cycles

Themes	Title	Action Research Cycles
Theme A	Experience of Enabled Learning	Cycle 1
Theme B	Independence in Learning	Cycle 1
Theme C	Learning Resources	Cycle 1
Theme D	Time Factor	Cycle 1
Theme E	Motivation for Learning	Cycle 1
Theme F	Systematic Approach to Learning	Cycle 2
Theme G	Significance of Change	Cycle 2
Theme H	Response Strategy	Cycle 3
Theme I	Sense of Satisfaction	Cycle 3

6.2 Analysis of Post Cycle 1 Student Interviews

6.2.1 Background information

The first intervention, which was over two weeks, involved four sessions of A-level chemistry lessons. These intervention lessons focused on supporting students to understand the mathematics in A-level chemistry. The lessons also aimed to support students in learning when and how to apply the numerous mathematical formulae involved in A-level chemistry and in answering questions in a more effective way. A mathematical formulae booklet, which contained all the mathematical formulae in A-level chemistry, was used as part of the teaching and learning resources material. This was originated by me since there is no such formulae booklet for A-level chemistry at the moment. See appendix Q. Each lesson covered a period of two hours. See appendix R for a lesson plan.

Students who agreed to participate in the post cycle 1 interview were allowed to a book convenient time and day that would suit them over a period of two weeks, after the intervention, for each of the twelve interviewees to be interviewed. The interviews were face-to-face in the college campus and in a room which was accessible to other lecturers. The interviewees were told in advance that the interviews would be recorded, which they consented to. Two interviewees who missed their interview appointments were allowed to book another time. All interviews were conducted during college time and it was ensured that the interviews did not interfere with the students' lessons. Almost all the students used their free lesson time on their time table to book their interview appointment which made it more convenient for them. The twelve interviewees have been given pseudonym names such as CSR-1 to CSR-12. The CSR means Chemistry students for research. This would be used in quotations by the interviewees.

6.3 Cycle One: Theme A – Experience of Enabled Learning

The mathematics in A-level chemistry is a concern and a challenge for about 70% of the A-level chemistry students who do not do A-level maths as part of their A-level subjects, see chapter 5.7. The rest who do A-level mathematics were often fine with the application of their mathematical knowledge in the maths areas in chemistry. The interviewees expressed concerns that the mathematics in A-level chemistry serves as a hindrance to their progression and achievement rate. Therefore, they suggested during the interviews that a maths support session, which is solely about the mathematics in A-level chemistry would be beneficial to them. Below are some of the expressed views by the interviewees;

> *Definitely, because the maths in chemistry is not easy at all. It is really difficult especially when a question involves maths and you have no clue of what to do in a test. It makes you feel helpless* (CSR-3).

> *Yes, it will be useful because it will focus on the application of maths in chemistry which will have a more direct target to make the maths in chemistry easier* (CSR-10).

> *Yea, it will be really helpful because l don't understand most of the maths questions in chemistry. It will make it easier when l am revising after attending the support session* (CSR-11).

> *Yes, I want a chemistry support class that will focus more on the maths in chemistry* (CSR-4)

Even those who do A-level mathematics in addition to A-level chemistry indicated that a maths support session will be beneficial. They supported the set-up of such a session.

> *l don't think it will be bad idea. It will be quite a useful thing for some students since there are a lot of maths in chemistry more than you probably think* (CSR-8).

I don't think it is necessary for me but for other students who struggle with maths, they will find it useful. I am comfortable with my maths (CSR-7).

The interviewees asserted that the maths support sessions would have a positive effect on their revision and achievement. For example, it would help them to develop the sense of independence in learning. This assertion was made after they had attended the first intervention sessions which provided such opportunity.

It helped me to know how to systematically approach maths questions in chemistry. Hopefully it would help me to achieve better in chemistry (CSR-2).

It has helped me to work on more maths questions at home since I got more understanding during the sessions. I am now able to do more practice at home which would help me to do better in assessments (CSR-5).

It would help me to achieve better as l now know how to breakdown a maths question and figure it out. I would be able to work maths question better (CSR-6).

In terms of achievement, l will do better because I am more likely to know what l am doing during revision and understand the topics better. It has become easier to study and understand the notes than before (CSR-8).

The respondents, every one of them, further stated that they would prefer that when the maths support session is set up it should be led by a chemistry teacher as compared to a maths teacher. They argued that a chemistry teacher would find it easier to do the application of the maths in chemistry during the sessions and that would make it more beneficial to them.

A chemistry lecturer because they will be able to use the maths in chemistry better. A maths lecturer will look at the question and may not know what the chemistry content is asking but a chemistry lecturer can do it better (CSR-12).

A chemistry lecturer because he will be able to apply the maths in chemistry and make it easier so that it does not become complicated (CSR-11).

A chemistry lecturer because you need to understand the chemistry concept in order to apply the maths so that it will make more sense to the students (CSR-8)

I think a chemistry lecturer because he is going to teach maths in chemistry so that he can tailor it around the application in chemistry. Moreover, a chemistry teacher will know how to apply the maths in chemistry but not just necessarily teaching the maths (CSR-7).

I would say chemistry teacher because someone who knows and understands chemistry will help you to understand the maths in chemistry and the corresponding application (CSR-5).

6.4 Cycle One: Theme B – Independence in Learning

All the interviewees expressed their views on the format for the set up for the maths support session. There were two main options that they suggested. Some of them were of the view that students should be allowed to drop in when they have a need for the extra support for maths in chemistry with their questions within the allocated time set by the college.

It will be better for people to drop in so that they are more confident about what they want. In this way, they come with their own questions that they need help with. This would also motivate them to go home and practice what they requested help for (CSR-1).

I think a drop-in will be beneficial for me because the teacher can help me to understand what l need help with instead of teaching something general which has been listed and everybody comes for help. It might be a particular area in a topic that l need help with and so l do not need to be in a group session (CSR-7).

However, others were of the view that it should be teacher led with topics advertised so that students could pick and choose when they want to be there.

I think it should be time tabled with listed topics so that we know what is coming up in the session. This would enable you to choose when you want to go for a support session and would help you to plan your revision as well (CSR-3).

I think a group session with listed topics would be beneficial so that you could get someone to work with as well. This would also encourage peer learning (CSR-9).

Probably a time tabled with listed topics so that the teacher would be able to get students with the same challenge together. That would make it easier for the teacher to support and do more within a short time (CSR-12).

Furthermore, there was one interviewee who suggested that the college should find a way of implementing the two options because either of them has a unique benefit for students.

I think there should be both group session and a drop-in. You get more attention for your individual needs in a drop-in or one to one session but group session also helps you to get people who are in the same need as you and study with so that you can learn from each other. I think the college should find a way of setting up both drop-in and group support sessions so that students can choose what they want to attend at any time (CSR-8)

6.5 Cycle One: Theme C - Learning Resources

The resource materials used during the first action research included a mathematical formulae booklet, Appendix Q, which contains all the mathematical formulae required in A-level chemistry. A similar formulae booklet is allowed in A-level maths and physics exam but no such booklet is in use for A-level chemistry at the moment. This was used to ascertain how useful and helpful it would be for A-level chemistry students in their progression, retention and achievement. The interviewees, every one of them including those who do A-level mathematics, commented that the formulae booklet was very useful.

I think it was really helpful because I did not have to memorise all the formulae and could have a look at them at one go from the booklet. Using the formulae booklet helped me to answer all the tricky questions. (CSR-1).

I think it was quite helpful because the formulae were readily available in the booklet and you can look for them and use them to get all available marks even the one-mark questions. Even if you don't understand the question, you can get the data from the question and look at the formulae to see which one will be appropriate to use (CSR-6)

I thought it was useful because you have all the formulae in one place instead of having to recall them from memory. There are some of them l struggle to remember so it was good to have them in one place (CSR-8).

Besides the formulae booklet being useful and making available the correct formulae for the students to work with, the interviewees also explained that if this formulae booklet was to be provided in the exam it would improve their achievement in A-level chemistry. They argued as follows;

It will help me to fully answer the maths in chemistry questions because sometimes when you forget the formula you are not able to complete the question. If l drop a mark for not being able to answer a question fully, it affects my achievement (CSR-1).

Yea, I think it will help me to get a good grade in the exam because l will spend most of my time understanding how to use the formulae and how it is effectively applied in answering questions during revision instead of spending time to learn the numerous formulae only to recall and use it (CSR-2).

I think that will be a good idea because it would make it easier to plan before the exam knowing that the formulae booklet will be provided. I can focus on how to use the formulae to solve questions and also having more time to revise other areas of the specification which would improve my achievement. There are a lot of formulae to learn and you are expected to recall them correctly in the exam. That takes a lot of revision time (CSR-4).

It will help me to use the correct formulae and as a result l will get most of the calculation right which has been my challenge since it has been difficult for me to recall the various formulae during exam. It will make the maths in chemistry less stressful since I will not need to learn all these formulae and will help me to focus on other areas that I need to understand better (CSR-6).

I think it will be useful to have the formulae booklet because not only do you have to learn the content but also the formulae. Even if not all of them could be provided, some of them should be provided because there are a lot. One thing l struggle with in chemistry is remembering the formulae equations and having the formulae booklet *would help a lot. This would help me to answer more of the maths questions in chemistry in the exam which would improve my achievement (CSR-8).*

The interviewees highlighted the habit of memorisation which has become part of their learning due to the numerous mathematical formulae that they need to recall in the exam.

At the moment, I have a lot of flash cards full of mathematical formulae to enhance my revision. I spend a lot of time memorising the mathematical formulae instead of learning the other content. I worry that if there is a maths question, I would do bad because l would not be able to remember the formula correctly and may end up leaving the question undone. (CSR-2).

I have no choice but to memorise the mathematical formulae during the revision. There are a lot of them too and it worries me because if l do not get it right in the exam, l cannot do the question correctly (CSR-5).

However, one respondent said she does not necessarily need the formulae booklet because she could remember the mathematical formulae during both exam and internal assessments as she is used to them, but if it is available in exam, she could use it to check her work to ensure that whatever she has done is alright.

I don't think it will be of much help to me because l am used to the mathematical formulae in chemistry and l don't find that to be a challenge. However, if it is provided in the exam, I can use it to double check my work just in case I misquote any of them in my hurry to do the work (CSR-7).

Additionally, the interviewees expressed concern about the stress they have due to the numerous mathematical formulae in A-level chemistry which they need to recall in the exam correctly in order to use them. They equally mentioned that the lack of support for maths in A-level chemistry is another source of stress.

The provision for a formulae booklet would be great because I would not have to remember all the formulae equations from the top of my head. This will take a lot of pressure from me and I would get more time to study the other content in detail and revision would become less stressful (CSR-9).

If l am provided with the formulae booklet and an opportunity to attend a support session, I would do better because that will take away the stress of memorising the formulae and my revision would be better because I would have the support l need in maths when the need arises and there would be no need to be stressful about getting formulae equations correct because the formulae booklet would take care of that (CSR-2)

Right now, l spend a lot of time memorising the formulae, but if a formulae booklet is provided in the exam, it would take the away that worry. The support sessions will make me feel more confident and less stress out because when l need help l can go there for the support l need. I will find revision more enjoyable and obviously it would motivate me to stay to complete the subject and achieve well too (CSR-3).

6.6 Cycle One: Theme D - Time Factor

It became apparent that the students spend a lot of time on learning and recalling the various mathematical equations in A-level chemistry. They commented that having a mathematical formulae booklet would save them time during both revision and in the exam.

It would save me time during revision because l would not need to memorise the numerous mathematical formulae. I would also be able to save time in the exam because I would only have to refer to the formulae booklet and use the correct formulae without needing to spend time to recall which I may even get it wrong. Even if it is one minute that l save it is still important in the exam (CSR-9).

I found the formulae booklet very useful because all the time it takes a lot of time trying to remember all the mathematical formulae and just having a booklet so that l can look at it and use it to do the questions saved me a lot of time. I can quickly find the formula from the booklet and work better. It would help me to get work done on time and get higher marks because the formulae would be correct when l am using them (CSR-12).

The interviewees also explained that the provision of mathematical formulae booklet in the exam would help them to spend more time in learning the application areas of the A-level chemistry during revision and they would also have enough time to practice more questions which could increase their confidence in passing the final exam.

I will use much less time in learning the formulae and spend more time learning the theory, practical and definitions which would be more beneficial than what l am doing at the moment because l waste a lot of them learning the formulae (CSR-5).

If mathematical formulae is provided in the exam l can spend more time in revision trying to understand the main content in detail which will be of great help to me. I would not spend so much time to memorise the formulae. I will only learn how and when to use them (CSR-10).

I would spend more time on how to apply the formulae and learn the other content because l would have more time to learn instead of trying to memorise the formulae when revising. I would also spend more time to practice the maths in chemistry questions without getting worried about the numerous formulae knowing that they would be provided for use in the exam CSR-11).

6.7 Cycle One: Theme E - Motivation for Learning

The interviewees highlighted that if they are provided with a maths support session in A-level chemistry by the college it would motivate them to learn and complete the course. Additionally, a provision of mathematical formulae booklet like the one used by A-level physics and maths, which they had a benefit to use a sample during the intervention, would serve as a source of motivation for learning and achieving well in the final exam.

Getting maths support will help me to understand the content better and this will encourage me to do more revision. A provision of formulae booklet will motivate me to learn more because l would not need to remember the formulae from the top of my head. I think these would help me to achieve better (CSR-10).

The support sessions would encourage me to do better because l would have someone who can explain what l do not understand to me when l need help. It will make it easier to revise. If the formulae booklet is provided then most of my worries are gone and would feel more confident, then l would focus on the other things l need to know instead of memorising formulae (CSR-11).

Setting up a maths support session will help me to improve my maths in chemistry questions a lot. I would feel more confident doing them, and giving me the formulae *booklet would also make me feel more confident because at least I know I have a reference guide to help me to apply the formulae more correctly. I think I should be able to do well if I have such support and provision (CSR-12).*

For me I struggle to learn all the formulae so having the formulae booklet for revision and in exam would motivate me to do more revision for the exam. I think the extra support will make chemistry more enjoyable because at times I feel like giving up because some of the Maths are very difficult and complicated for me (CSR-6).

6.8 Summary

It became evidently clear from the interviews with the research participants that the maths in A-level chemistry is an issue that needs to be addressed because it is affecting their revision, motivation and progression. A maths support session set up was highly recommended by the students regardless of whether they do A-level maths in addition to A-level chemistry or not. They were all of the view that such a support session would help to improve the achievement and progression rate in A-level chemistry. Besides this, they mentioned that it would motivate them to revise their notes which may enhance their performance in both assessments and final exam. The interviewees were of the view that a chemistry teacher would be ideal to lead such maths support session for A-level chemistry students so as to make the application of the maths in chemistry easy and less complicated.

Although a mathematical formulae booklet is currently not in use or allowed in the A-level chemistry exam, the interviewees argued that it would be of great benefit to A-level chemistry students if it is considered and introduced because they would not need to memorise all the numerous formulae involved and could then focus more on the theories and other contents. Furthermore, it was mentioned that memorising the numerous formulae is causing stress and worry among the A-level chemistry students in the FE college.

Chapter 7

Analysis of Post Cycle 2 Student Interviews

7.1 Background information of intervention two

A second intervention, see section 5.18, was implemented after the first interviews. This covered three sessions with each session lasting a period of two hours. It emerged from the structured questionnaire analysis, see chapter five, that the A-level chemistry students in the college find it difficult to use the chemistry principles and concepts learnt to answer questions. In addition to this, they expressed concern that to apply chemical knowledge and understanding familiar situations requires long hours of studying. This challenge led to the second intervention. Each of the three sessions or lessons was planned to first enable the students to learn a systematic approach of answering questions using the chemistry concepts and principles learnt. This involved firstly identifying the commanding words in the question and what principles and concepts that could be used to answer them. Furthermore, the students were taught not to memorise their notes but spend time to understand the concepts and principles that each topic requires during revision so that it would enable them to answer questions in detail. Exam past papers were used to demonstrate how this could be done during the sessions and students were given similar questions to practice in class. This was planned to follow intervention one so that if any principle or concept requires the use of maths in chemistry and formulae, the students would be able to apply that with confidence.

7.2 Second Interviews

The interviewees from the first interviews were used in the second round because they had already signed a consent form to participate in all the interviews and also to ensure continuity. They were once again allowed to book convenient time and day that would suit them over a period of two weeks after the second intervention as was done during the first interview. The interviews were face-to-face in the college campus and were held in a room which was accessible to other colleague lecturers to ensure that proper safe guarding principles were adhered to. The interviews were recorded with the permission from the interviewees. Anyone who could not attend his or her appointment for interview had the opportunity to rebook another time. All the same twelve interviewees, who took part in the first interviews, participated in the second interviews.

7.3 Cycle Two: Theme F –Systematic approach to Learning

Ten out of twelve of the interviewees mentioned that they did not have a distinctive study method for revision in chemistry. They mostly use the same method across their other subject areas in A-level before the intervention.

> *I normally read the text book and make notes. I also make flash cards. I finally work past papers after that. I do the same thing for biology but maths there is not much to do but mostly working past paper questions (CSR-10).*

> *I use flash cards, mind maps for some of the big topics and work some past papers. It is similar for biology but not for Spanish. I don't do mind maps for Spanish. It is more of learning the vocabulary and do some past papers (CSR-12).*

The majority of the interviewees, 85% of them, explained that they mostly try to memorise their notes and practice past papers afterwards. This has resulted in memorization of notes during revision with lack of understanding mostly and a recall of the notes when answering questions.

> *I try to memorise the answers of the questions during revision so that if l get similar questions, then l try to recall. During exam, I would read the question and try to recall anything I know about it from memory (CSR-4).*

The interviewees expressed joy in the new method of revision which emphasised understanding the principles and concepts in the topic and focusing on that to answer questions during the intervention. They stated that it would make their revision easier and also help them to answer questions in an orderly manner.

> *It has also made my revision better because I now understand what I need to know and the detail I would need in answering questions. It has also helped me to understand how to answer questions with chemistry principles and concepts step by step instead of trying to memorise my notes and recall (CSR-6).*

> *It has changed the way I have been revising. My revision sessions have improved because the intervention has helped me to revise my notes with proper understanding based on the principles and concepts instead of memorising the notes. I now revise with understanding instead of memorizing (CSR-4).*

The interviewees explained the approach and skills they were using in answering A-level chemistry questions before the action research intervention sessions. They mentioned that they were not using the chemistry principles and concepts they learn in the specification as a guide in answering questions in exam:

> *I read the question and try to pick the key information to link it to the topic that would help me to answer it. I try to do as much as l can with it. The things that l do not know l try to link them with the one l know and kind of go from there (CSR-7).*

> *I was stuck in the same way I answered GCSE questions in chemistry so l could not do much in answering A-level chemistry questions. I normally read the question and try to answer as much as l could remember from my head without any systematic or orderly approach (CSR-8)*

> *I think I just panic after reading the question rather than breaking it down. I usually assume what I know about the questions and try to answer it like that (CSR-6).*

The interviewees commented that the skills they have learnt in using chemistry principles and concepts in answering A-level chemistry questions during the interventions are of great relief to them because the skills would enable them to complete questions on time and then achieve better.

> *The approach learnt focuses on the principles and concepts which also involve maths in chemistry skills so I think I would be in a better position to answer A-level chemistry questions very well (CSR-9).*

They explained that the approach learnt has helped them to answer questions in an orderly manner. Prior to the intervention they used to answer questions without following any method or structure.

> *I learned how to answer questions in a structured way based on principles and concepts learned in each topic. I also learned how to connect topics since l needed to use in some cases more than one topic to answer a particular question (CSR-2).*

> *I have learnt the systematic approach of answering questions, for example organic chemistry questions. Before l try to determine the product before trying to find the*

conditions. It was like l did the opposite way which was quite difficult. I would now put more emphasis on the principles and concepts and how to apply the systematic approach in answering questions instead of just wanting to answer the whole question at a go (CSR-10).

The interviewees also highlighted that because they did not use the chemistry concepts and principles in answering questions before the intervention, this limited their ability to completely answer the chemistry questions during an exam and instead, they would spend a lot of time trying to guess and answer the questions from memory based on what they had memorized which might not be what the question required. They explained further that as a result of that they did not often have time to go over their work and made unnecessary mistakes.

I usually did not get time to go over my work and so when I get my exam papers back, I always find out that l have made some silly mistakes that could have been avoided if l had gone over my work to correct them. These marks could be gained in future work and add up to my marks (CSR-3).

However, having learnt the skills of using chemistry principles and concepts in answering questions, they asserted that they would be able to complete answering questions on time and possibly go over their work to check possible mistakes.

This would afford me the opportunity to check my work and correct all possible mistakes because I would be able to complete my work on time due to the systematic approach method learnt using step by step approach, and the chemistry principles and concepts (CSR-12).

I would be able to finish the questions because there is a plan to follow which makes it easier. I can save time now with the systematic approach and check my work for any errors (CSR-8).

7.4 Cycle Two: Theme G – Significance of Change

The interviewees gave their impressions about the notion that applying chemical knowledge and understanding familiar situations is difficult after the interventions. They mentioned that there has been an improvement in their application of chemical knowledge and understanding familiar situations in answering chemistry questions:

> *I think it has become easier because the approach learnt during the interventions has given us a better way of answering question (CSR-10).*
>
> *It has changed a lot. The sessions have taught me how to apply chemical knowledge and how to understand unfamiliar situations by focusing on the principles and concepts in answering questions. It allows you to follow systematic plan to answer the question which was not the case with me before the intervention (CSR-3).*
>
> *I think it is a bit easier now. I would not say it is hundred percent easier now but it is better than before the sessions. I think with continuous practice during revision and practicing many questions, it would become much easier (CSR-8).*

The interviewees indicated that they are able to answer and give detail responses to questions when answering them now than before the intervention sessions. They attributed this to the intervention sessions:

> *I am able to answer questions better in more detail and clearer than before. I am also able to finish questions and confidently go over my work to check any errors (CSR-9).*
>
> *It is more motivational now to revise because it is longer just a matter of reading the textbook. There is more direction in what to do and how to do it better so that you can understand what you are revising and apply them to answer questions. My answers are also now more detail and less mistakes (CSR-11).*

Furthermore, they mentioned that the skills and approach learnt would potentially enable them to improve their grade in chemistry because they have learnt a better revision strategy using chemistry principles and concepts besides being able to give more detail answers in their responses to questions.

> *It has given me a better revision strategy and better responses with less likely mistakes. I have become quicker in my responses so I would save time to check my work for any mistakes and correct them. This is likely to add some extra marks to my exam marks and boost my grade (CSR-3).*

I have learned how to focus on the principles and concepts when answering questions. This has given me some structured way to answer questions in more detail than what l used to do. I have also realised I am able to finish answering questions quicker by following the structured plan so I can check my work when l finish to correct any errors to avoid losing any unnecessary marks. I hope to improve in my grade because I would not lose those marks that I used to lose any longer (CSR-2).

The interviewees expressed confidence in the approach and skills that they learnt during the interventions and were sure they would be able to use it in their revision.

I am confident because l have already been using it after the sessions and it is great. It is now easier to work questions and get them answered very well and in detail because I can now answer questions in a systematic way with a well organised approach (CSR-7).

I think I am very sure to use the skills because I have practiced more questions with it on my own after the sessions and l am very confident about it. I would continue to use it in my revision sessions and when practicing past papers. I am sure this would help me to do well in the exam (CSR-5).

Right now, I would say somehow confident, but with some more practice I think I would be able to say very sure because I would get into the routine and become more confident (CSR-1).

In addition to this, they indicated that the approach and skills learnt have also increased their confidence in using chemistry principles and concepts which involve mathematics in chemistry. This is because some of the chemistry principles and concepts use the application of mathematics. This enabled them to apply the skills learnt from the action research cycle one.

Definitely I would be able to do more chemistry questions with maths because the approach focuses on the use of principles and concepts in answering questions which includes the application of maths in chemistry. I am sure that I can answer questions that involve maths in chemistry with a better understanding than before (CSR-9).

I am confident in answering questions with maths involved better because the approach learnt emphasis the use of principles and concepts which some involve maths, so with *better understanding of the approach I would be able to answer all questions better including those that involve maths (CSR-7).*

7.5 Summary

It became clear during intervention two that the students' revision method was mostly about memorizing their notes and working past papers with less understanding of the concepts and principles in A-level chemistry. This is because they were not focusing on the principles and the concepts taught when revising their notes and this affected their means of answering the chemistry exam and assessment questions. However, there were about 15% of them who were conversant with their revision method and did not need much of what we did. The interviewees emphasized that the skills and the approach learnt by focusing on the chemistry concepts and principles in answering chemistry questions during the intervention has helped them to stop the over reliance on memorising their notes without understanding.

They also mentioned that the intervention sessions have helped them to learn how to answer the A-level chemistry exam questions in a step-by-step approach. They also indicated that this has helped them to finish questions on time and are able to check their work for any possible errors. Furthermore, they also mentioned that their responses to questions have become more detailed which could enable them to gain extra marks and thereby improving their grades. They have also become more confident in what they do and are more motivated to learn their notes, achieve well and progress. This is not to suggest that I was teaching to the test or exam, but I was offering a way of approaching learning in a systematic manner and applying learning in an organised way.

Chapter 8

Analysis of Post Cycle 3 Student Interviews

8.1 Background Information of intervention three

The final intervention, see section 5.18, was undertaken after the second interview. This covered one of the three major concerns and challenges the A-level chemistry students in an FE college in England raised. It emerged from the initial questionnaire that there was a challenge concerning how to select, organise and present chemical information clearly and logically. Some participants also mentioned that it was complicated to make connections between different topics in A-level chemistry. All these feed into the challenges in progression, retention and achievement in A-level chemistry in the FE college as revealed from the analysis of the questionnaire responses in chapter five.

The third intervention covered a period of two and half weeks. There were four sessions of lessons and each session was two hours long. The students were guided on how to select, organise and present chemical information clearly and logically. These were organised in a form of revision sessions when the students had completed their specification. Past exam papers and A-level chemistry text books were used as resource materials. The students were first led by the researcher into how to select, organise and present chemical information clearly and logically using exam questions. It was emphasized that deciding what principles and concepts to use in answering the question was the first thing to consider. Whether it will involve a mathematical formula or not would then follow. Once the principles and concepts have been decided upon, the chemical information has to be organised to respond accordingly to the commanding words in the question. Finally, the presentation has to be clear and logical to the examiner without being ambiguous. They were also taught how to connect the various topics in A-level chemistry in answering the chemistry questions. The topics which are inter-related were highlighted. The students were grouped into teams with a maximum of three students in a group afterwards. The groups were made smaller in numbers to ensure that each person in a group will have the opportunity to share their ideas as well as encouraging team work.

The groups were given questions to answer together and the researcher supported them as they worked in their various groups. The students were allowed to present their responses from each group to the rest of the class based on their respective questions given to them to work on. The sessions ended during each of the four lessons with a recap from the researcher to re-enforce the skills that they have been guided to use in answering the questions.

Furthermore, this was made the third intervention so that the students could apply the skills and knowledge they have acquired from both the first and second interventions. The first intervention lessons focused on supporting students to understand the mathematics in A-level chemistry and how to apply the numerous mathematical formulae involved in A-level chemistry in answering questions in a more effective way. On the other hand, the second intervention focused on how to enable the students to learn a systematic approach of answering questions using the chemistry concepts and principles learnt. This involved firstly identifying the commanding words in the question and then using the appropriate chemistry principles and concepts to answer the question. Thus, the students were able to apply the skills acquired during the first two sessions to clearly and logically answer questions more effectively. On the other hand, the reflection of the three action research interventions will be discussed at the end of this chapter.

8.2 Third Interviews

The same interviewees from the first and second interviews were used for the third time because they have already signed a consent form to participate in all the interviews and once again to ensure continuity. They went through the same protocol of booking interview time to suit their learning in the college. Under no circumstance were the interviewees time allocation for their interviews allowed to conflict with their lesson time in the college. The third interviews were face-to-face in the college campus and were also held in a room which was accessible to other colleague lecturers to ensure that proper safe guarding principles were being followed. All the interviews were recorded with permission from the interviewees. They were informed prior to the meeting that the interviews will be recorded to which they consented.

8.3 Cycle Three: Theme H – Response Strategy

The interviewees described their method of answering A-level chemistry questions before the intervention as not being helpful. They indicated that they did not have a clear direction as how to answer questions in order to feel comfortable when doing them:

I did not have a clear method of approach to questions before the interventions especially the long six marks questions (CSR-2).

Before the intervention what I usually do was to read the question and try to write as much as l can without any proper approach (CSR-9).

The students were taught how to plan and organise their responses to questions during the interventions. They spoke highly about the structured plan for answering questions as compared to what they used to do.

Before I look at the key words and try to connect that to the topic but without any structured plan like what we did in the interventions (CSR-1).

I used to recall all that I can think about after reading the question in terms of diagrams, formulae or figures but with no proper plan or organization of my thought (CSR-12).

I normally highlight the key words and use them to answer the questions by writing as much as I know without a particular plan (CSR-4).

The interviewees reiterated that the interventions have helped them to select, organise and present chemical information in a required manner, that is being clearly and logically. They recognised the importance of presenting the chemical information in a clearer manner so as to get more marks. Some of the statements made by the respondents are as follows;

This has helped me to select, organise and present chemical information clearly and logically compared to what l used to do before the interventions (CSR-3).

Yes, the intervention has helped me to select, organise and present chemical information very well. I can now plan and answer questions in a structured way and able to write with more details and explanation. It is also quite easier now when revising and practising questions on my own. It brings everything to perspective (CSR-6).

8.4 Cycle Three: Theme I- Sense of Satisfaction

Some students indicated that they were struggling with the connection of the topics in A-level chemistry during the questionnaire which was used to gather the initial information, though not the majority. They mentioned that it was difficult to link the various topics in A-level chemistry in order to answer the exam questions in a more meaningful way. They indicated that this was one of the hindrances to their achievement in A-level chemistry.

I think it is a lot easier now as I have learnt how to link the topics better. If l follow the same pattern, you have taught us l think l would become better especially in the exam l would become quicker using the pattern you have taught us (CSR-3).

Yes, the interventions have made things better. I don't think I was able to link topics as easy as now. I am now able to link things better across the topics. The sessions have made it easier to understand how to link topics but before that it was not easy for me (CSR-10).

Before the sessions I did not know how to link the topics. I would just pick the topic l know and use it to answer the question as much as l can. After the intervention l have become more aware about linking topics to answer questions (CSR-9).

The interviewees were of the view that the approach they learnt during the third intervention sessions gave them the opportunity to answer and present chemical information in a systematic and logical way. They were taught to follow a simple approach such as select the principles and concepts required for the question, organise the chemical information in orderly manner and present the information logically to meet the commanding words in the question.

The approach learned has given me a way to think clearly. It is like a little plan for each question basically. It helps you to focus and even if you miss something it helps you to correct it. The intervention approach has provided me with a plan to answer questions better. Specifically, for example, I never got full marks for mass spectrometry questions because I could not explain my thoughts very well (CSR-10).

The approach learned was great, even the way it has been planned such as select, organised and present. This gives you a plan to follow and enables you to think through your answer as you work your way through the question especially if is it a long question which needs multiple steps. This is because the long questions require a lot of planning before answering it. I hope to transfer these skills into the exam (CSR-4)

The interviewees explained that they would be able to transfer the expertise from the sessions to enrich their revision sessions. They were of the view that this would enable them to perform well in the exam since they would be able to answer questions in detail and logically.

> *This approach enables me to be logical in answering questions and as a result I would not miss marks that I would ordinarily lose. This would increase my marks and hopefully improve my target grade in the final exam. I can now revise more efficiently (CSR-6).*

> *I think the interventions have helped me to better understand how to select, organise and present chemical information clearly and logically during revision. These skills would help me to achieve my target grade because I would be able to answer the questions with more understanding and confidence and with less error in the exam (CSR-9).*

> *The interventions have helped my answers to become more concise and clearer. It has also enabled to me to finish answering questions on time without having to skip some questions due to lack of time. My revision and exam time management has improved. I would be able to reduce otherwise some of the marks I would have lost due to my inability to finish questions and also not being clear and concise and waffling (CSR-7).*

The students were taught skills and strategies to answer A-level chemistry questions in much more detail and logically. This resonated very well with them and one interviewee summed it up as follows;

> *This is a well organised approach of presentation of responses to A-level chemistry questions. It is 'life skills of chemistry'. It makes more sense to answer questions the way you have taught us during the interventions. It has indeed improved my confidence level too. No more stress when answering questions (CSR-11).*

The confidence level and motivation of the students play a key role in as how well they could perform in their exam and even during independent revision towards the exam. After the intervention sessions the interviewees expressed confidence in the systematic approach that they have learnt in answering A-level chemistry questions.

> *Yes, I am confident to use the approach because I have tried it on my own at home after the sessions in class and it worked very well. The plan is simple to follow. I think we*

should learn this from the beginning of year one. It saves time and makes your answers concise and well organised (CSR-8).

Yea, because the interventions made even the harder questions become easier to understand by following the structured plan of select, organise and present the chemical information clearly and logically. You cannot miss the principles and concepts required if you follow the plan. This has increased my confidence level (CSR-7).

I think one thing l have also gained from this intervention is confidence. I used to get stressed up when trying to do exam style questions because l struggled to answer them properly and in detail. However, having learned how to plan and answer questions has taken away that stressed a lot. This has given me more confidence (CSR-12).

The interviewees emphasised that the intervention will help them to achieve their target grade or improve it in the final exam. This is because the approach learned would enable them to complete most of the required questions if not all, and get extra marks unlike before the intervention when they used to skip some of the questions because they could not do them.

Yea I think so because the interventions have helped me to be more organised and better prepared than before. I feel I have enough information to do better in the summer exam because l have better and structured way of answering questions and the information to do so were easy to apply (CSR-1).

The interviewees upon reflecting back on the third intervention sessions, made mention also of how they have benefited from the entire intervention sessions and the effect this would have on their progression and achievement.

I think the intervention sessions have helped me most because I used to struggle about how to select the right formula during calculation questions in physical chemistry but the first interventions sessions made it easier for me. The last interventions sessions have even made it better because l have learnt how to select, organise and present chemical information which includes formulae more clearly and logically in answering questions. This would make my progression easier than before and the benefits are huge and I think you might have to be in my place before the intervention in order to understand this (CSR-5).

I think the intervention sessions has been great for me especially the last intervention; select, organise and present chemical information clearly and logically, because l always struggle to answer long questions clearly and logically. I used to lose a lot of marks because l just rush through it without proper planning and detail. This has benefited me a lot (CSR-12).

8.5 Summary

The final intervention was centered on the effective presentation of the chemical information in order to obtain higher marks. The interviewees were clear that they were not well informed as how to present their chemical information before the third intervention sessions during the interviews. They expressed their joy as how the third intervention sessions have helped them to improve their independent revision and answering of questions during practicing of past papers. They mentioned that they would be able to improve their target grades because the errors they used to make due to ineffective answering of questions have been resolved. They now have a clear view and structured plan to follow. The systematic approach; select, organise and present clearly and logically of chemical information, which was presented during the sessions have helped them to acquire skills and strategies as what to do and even how to plan their responses to A-level chemistry questions in order to be much detail in their answers. Furthermore, they stated that they are more confident now as what to do when answering questions. One interviewee exclaimed that this approach is like 'life skills of chemistry'.

The interviewees further mentioned that they are now able to answer long six marks exam questions in much detail because of the structured plan approach. This is because the systematic approach enables the students to be logical in a stepwise approach to their answers when answering A-level chemistry questions. In addition to these, the challenge of not being able to connect the various topics in A-level chemistry was dealt with during the sessions. The various topics which are inter-related in A-level chemistry were pointed out to them and a number of exam questions were answered to explain how such questions are answered. They said that the intervention sessions have reduced their stress when answering A-level chemistry questions because the struggle that they used to go through to answer questions properly and in detail have been dealt with. Thus, having learnt how to plan and answer questions has taken away that stress a lot and this has given them more confidence.

8.6 Reflection of the Interventions

There were reflections for the three cycles of interventions. These were to illustrate how things could be done differently or changes that could be made if the lessons were to be taught again.

During the first action research intervention, I assumed that every student would need the formulae booklet but there was one student who did not need it. The student indicated that she did not necessarily need the formulae booklet because she could remember the mathematical formulae as she is used to them. However, she mentioned that if it is available in exam, she could use it to check her work to ensure that whatever she has done is alright. In future, I would ensure that I focus more on those who need help. I would also do purposeful groupings during the group activities. This is to ensure that each group would have students who do both A-level mathematics and A-level chemistry among those who do not do such combination to enhance peer learning and support for maths application in chemistry.

For intervention two, I would decrease the number of students in a group during each first activity from three to two to encourage individual participation about how to use principles and concepts to answer questions since there would be only two students per group. This would encourage more communication between the two students and each of them would have more time to speak and make contributions. Discussions involving principles and concepts require more time and so bigger groups make time-management and completion of tasks within the time given sometimes challenging. Additionally, I would include some areas in inorganic chemistry because the teaching was mostly about physical and organic chemistry so that students can benefit from how to apply principles and concepts from all the areas in A-level chemistry.

The intervention three was done in the last term of the academic year. The four lessons enabled the students to apply the concepts they had learnt throughout the academic year to answer full exam questions. I would increase the number of intervention lessons to about six or more to cover about four weeks instead of two and half weeks. This would give the students more time and opportunity to benefit more from the third intervention. This is because the third intervention involves the application of the first two interventions and the skills required to present chemical information clearly and logically.

Lastly, I would like to include two minutes feedback concept in future for reflective practice after each lesson during the intervention lessons. That is to spend the last two minutes of each lesson to try to get feedback from the whole class. This could be done by giving students a post-it note at the end of each lesson for students to write something they liked about the lesson and what they did not like. I would then read the feedback to reflect on how to improve. This would also give the learners instant voice about each lesson.

Chapter 9

Analysis of Early Leavers' and Teachers' Interviews

9.0 Introduction

This chapter will look at two remaining areas in this research, the analysis of early chemistry leavers' (students) interviews and the analysis of chemistry teachers' interviews. This will consist of a detailed discussion on what the early leavers perceived as challenges and contributed to their dropout and the challenges that the chemistry lecturers in the FE college stated as hindrances to A-level chemistry students' achievement and progression. The first part of the chapter will be about the analysis of students' interviews and the second part will be the analysis of chemistry teachers' interviews.

9.1 Analysis of interviews with Early chemistry leavers.

9.1.1 Background information

Every attempt was made to contact three early leavers from A-level chemistry in the FE college. It was initially difficult to get hold of them because they had left the chemistry department and were pursuing other subjects. Once a student leaves a particular department in the college, the department does not have direct link or details of the student due to data protection. You will need to go through the student services before you can get hold of the student. All the three students who were approached agreed to be interviewed as part of the research study. They signed the consent forms and were interviewed. The same interview and ethical processes, which have been discussed in sections 4.4.2 and 4.6, were adhered to in relation to recruitment of research participants and informed consent for the interviews.

It was important to hear from the early leavers so that a balanced research report could be written. Having engaged and heard the voices of the continuing students, it was necessary to hear the students' voices of the early chemistry leavers in the FE college so as to enrich the research study about the challenges students face. Two of the students who were interviewed left A-level chemistry after one year and the third one left three months after starting the subject. For the sake of anonymity, the early leaver interviewees have been given pseudonym names such as ECL-1 to ECL-3. This means Early Chemistry Leavers for research. This would be used in quotations by the interviewees. These students were not part of the chemistry students who participated in the three action research interventions because they had left A-level chemistry by the time the interventions were implemented.

This interview data analysis is the students' voice obtained from the three early chemistry leavers before the end of the two years programme. Table 9.0 below is a summary of the themes from the analysis of the three students' interviews conducted.

Table 9.0 Themes and corresponding action research cycles

Themes	Title
Theme J	Acknowledgement of inadequate information
Theme K	Obstacles in progression
Theme L	Experience of Chemistry

9.2 Theme J- Acknowledgement of Inadequate Information

All the students indicated that they did not have enough information concerning career advice at the time they were making the important decision of their lives as what career pathway they should choose and the subsequent subjects to do at A-level. This was supported by the questionnaire analysis at section 5.9 which revealed that about 80% of the research participant did not have any career advice before choosing A-level chemistry. Some of the views expressed by the early chemistry leavers were as below;

> *If I am honest, I chose my A-level subjects including chemistry because of the good grades that I got in my GCSE exam, but not the subjects l had the best interests in. You see, because l did well in them at GCSE and so l was looking for careers that I could do with them in wider perspective. I chose medicine as a future career before checking the university entry requirements. I realised later that the requirements for medicine were too high for my ability (ECL-1).*

> *Personally, l am a high achiever and based on my GCSE results, l thought l could manage the A-level chemistry, but when we started the specification, I realised it was getting*

harder than l imagined. I began to struggle and lost confidence in my ability to complete the two years (ECL -2).

Much thought did not go into choosing my A-level subjects neither did l do any research nor enquiries about the science subjects. I thought because l was good at them in GCSE that should be fine if l do them at A-level, but that was not the case (ECL -3).

Every one of them indicated that it would have been helpful and even better if they had some form of career advice and A-level chemistry content briefing before choosing the subject. The only career advice mentioned was from parents. They shared the views as quoted.

I think an advice about A-level chemistry content and what it is like would have been helpful for me to decide if it was something l really wanted to do or whether it is a subject l would want to choose (ECL -2).

My parents told me to go for those subjects; chemistry, Biology and English Literature. They told me that l could do medicine at university and l would get a good job after completing university (ECL -1).

They all dropped A-level chemistry because they were struggling and also due to a change in career pathway.

I would say change in my career pathway was part of the problem. I realised later that medicine was not for me and l was no longer interested in it. l was also struggling in chemistry, but was more comfortable with my essay subject, English Literature (ECL -1).

The A-level chemistry specification content was too heavy and there were too many facts to retain. I struggled and opted for BTEC applied science after the first year, which is manageable (ECL -2).

The A-level sciences were too much for me. I dropped chemistry and Biology and changed to T-level laboratory science. My original intention was to work in the medical field like to become a doctor. That required me to have a science subject in A-level and that was why l chose chemistry. It was a career-based choice. (ECL-3).

This corroborated the questionnaire analysis in chapter 5 section 5.8 which showed that 46.2% of the second-year students would definitely not drop A-level chemistry if their career path changes as compared to 33.3% of the first-year group. Thus, about 66% of the first-year students would definitely drop A-level chemistry if their career path changes. This revealed that it was more likely for a first year A-level chemistry student to drop chemistry than a second-year student. Again, emphasising the importance of purposeful careers guidance.

9.3 Theme K - Obstacles in progression

The students explained some of the major challenges they faced before dropping the A-level chemistry. A mention was made about the maths content and the numerous mathematical formulae in chemistry which they needed to be memorised. These issues were also raised by the continuing A-level chemistry students in chapter 6 sections 6.3 and 6.5. Besides these, the early leavers also mentioned that making connection between different topics and understanding the key terminologies were some of the challenges they faced as well. Similarly, the continuing students expressed such concerns in chapter 8 section 8.4. Below are some of the quotes from the early chemistry leavers.

> *There were a lot of numbers and formulae and because l was not very good at applying them things got blurred for me. I did not know there were too many formulae and maths areas in A-level chemistry. When l got my GCSE results, I said wow, I have got good results in biology and chemistry so let me do science at A-level (ECL-1).*

> *Making links for the basic principles was quite okay but after we had covered a lot more it became challenging. Sometimes when you are not able to link the topics properly you get stuck and is like you don't know what to do. It does affect how you progress through the topic or the content because you feel stunt about it, l must say (ECL-2).*

> *The terminologies, especially those that have different meanings in chemistry and biology. For examples in biology a species is a living organism but in chemistry is a substance. That sort of differences in meaning for the same word in different science subjects threw me off because I struggled to apply them in different science subjects (ECL-1).*

Two students indicated that attendance and catching up on content missed were challenging and that affected them.

I travelled to India one week before Christmas break and stayed one week after Christmas. I lost two weeks for lessons. There were a lot to do when l returned. I had to increase my revision time to revise what we were doing in class and also to revise those that l missed. That was stressful. Additionally, anyone doing part time work may also find it hard to combine work with A-level chemistry, as l experienced. There are too much to learn and so if you combine that with work it makes it quite challenging too (ECL-2).

I think for me attendance played a part as well. When you attend lessons you get the first-hand information, but if you begin to miss lessons due to part time work and other personal issues it becomes difficult to catch up. It affected my achievement because I could not catch up quickly whenever l missed lessons for work. l began to lose confidence and the workload became too daunting (ECL-1).

The students, every one of them, mentioned that the A-level chemistry content was too heavy for them and assessment responses required specific facts which do not give room for exploring.

I felt that the further we got the less l understood. The initial part of the content had GCSE stuff so that was fine but as we progressed, l began to struggle because more areas which were challenging were covered and it went down the hill. It began to show in my grades. I struggled with the heavy content and on top of that l forgot what we had covered earlier so l could not apply myself well. I realised that l could not remember most of the content we had done before and the facts that l needed to know to answer questions appropriately (ECL-3).

There were too many scientific facts to know and remember. The only subject I was doing well was English literature because unlike science as long as you have an idea and you can write it you will get some marks. The science subjects like chemistry were looking for specific answers which did not allow room for exploring. That is how l saw it. I tried to revise as much as l could but there were too much facts to retain so l struggle to apply my chemical knowledge in chemistry (ECL-1).

9.4 Theme L- Experience of Chemistry

The early chemistry leavers indicated how certain aspects of A-level chemistry experience can be improved. Some specific suggestions, such as the link between chemistry and everyday life, enough laboratory work, nature of assessment and work placement opportunities were mentioned.

> *I think small tests which are done continuously will be fine. Not big test because it becomes stressful. This would encourage students to learn and apply their understanding to the questions. Feedback from teacher also helps you to know the grey areas and work on them. Group work and warmth classroom environment which is intentionally created by the teacher will enhance peer learning and support for one another (ECL-2).*

> *Linking a topic to everyday life, the environment or something in the community makes the topic more meaningful and it makes it more practical because you are able to link what you are studying in class with everyday life. You are able to take that away from the lesson. It helps you to remember what you have learnt better and any application becomes easier rather than just absorbing facts (ECL-3).*

> *The first thing is for the students themselves to be interested in the subject. I think also a work placement will also motivate students. It will help them to make a decision whether that career is for then or not. For example, when l went to a hospital to observe doctors at work, for a moment I said wow this is the work l want to do in future. It was really a good thing and l think it will help other students. I would have loved to be a doctor but the ability to achieve well in chemistry was challenging. I could not handle it any longer after one year that is why l drop it. The practical experiments were good though we could not have enough. It made the theory to become more clearer because when you are revising you could remember yes, I handled this or l did that or saw that. It helped (ECL-1).*

They all attended support sessions and they expressed diverse views concerning how students who may be struggling in A- level chemistry in future could be helped.

I went to a couple of support sessions but it did not help me because I was struggling with complex things but what was being discussed over there were basic things in a group session. I wish it was one-to-one because that would have addressed more of my kind of challenge that I was going through. One-to-one is less generic and you as a student is able to choose what you want to discuss and be addressed for you. For the group setting, someone may be struggling with something that you are not and as the teacher explains that then is like you are wasting your time there (ECL-2).

I attended the group sessions and on one occasion I have the opportunity to attend 1:1 support session. It helped to some extent, but I was still struggling in chemistry. I realised that I was not a science person, but was more comfortable with essay subject. I found that chemistry did not come natural for me so I dropped it eventually. I think I enjoyed the group sessions because I could get someone to talk to and shared ideas with when the teacher was attending to others (ECL-1).

Student to student mentorship and peer learning outside class sessions were highly recommended by two students. They opined that it creates friendliness and it allows students to share their personal learning experience with others.

The mentoring system, where the first years are paired with the second years for peer learning and support, was helpful. When you are alone and you are struggling it feels like you are drowning (ECL-1).

I had one girl that I worked with in the study area in the library sometimes. I noticed that she also did not understand some areas as well in some occasions. That made me felt like I am not alone. We tried to support one another (ECL-3).

9.5 Summary: Early Leavers' Interviews

The students interviewed explained the challenges they went through during their time in A-level chemistry and shared their experience. Students' choice of A-level chemistry as a subject was categorically mentioned as a decision they make mostly with less information. They explained that they wished they had someone to guide them or provide the relevant professional help before making a decision to do A-level chemistry. It became apparent that they chose A-level chemistry subject based on their GCSE grades, future aspirations, past experience from GCSE and influence from others, especially parents. This is corroborated by other research studies which indicated that the issue of students' choice has been the subject of some previous studies in science education in Europe (Archer *et al*, 2010; Bøe *et al*., 2011; Holmegaard *et al*., 2014). In an English case study, Bennett *et al.* (2013) investigated schools with both high and low post compulsory entry of students studying physical sciences. Data analysis from the study showed a complex interplay between factors operated by students in making A-level subject choices. They grouped these into five categories of choice strategies which were summarised as follows:

Aspiration: Intended career choice

Identity: choices made on the basis of the person they think they are

Tactical: choices made as a result of various future occurrences such as grades

Experiential: choices made as a result of past experience

Entirely outside: choices made as a result of timetable or influence of others

Additionally, Bennett *et al*. (2013) mentioned that they did not only focus on individual factors that could influence uptake, such as the perceived usefulness for future career, enjoyment and self-confidence, but also on school and other factors, as previous research has led them to believe these may impact on students' choice and interest.

Furthermore, early chemistry leavers shared their experiences in A-level chemistry and made suggestions about how to help other students in future who may struggle in chemistry so that they may not drop the subject. The interviewees suggested that there should be enough practical work to collaborate with the theory so that it can inform the theory. Other suggestions put forward included work placement opportunities, student-to-student mentorship, linking the lesson and topics with everyday life examples so that they can see the importance of what they learn in class. It was also mentioned that missing lessons for part time work affected the students' achievement and progression. According to Kantar (2020) students' experiences outside school play an influential role in the trajectories of their lives. For example, while poverty does not necessarily dampen enthusiasm for STEM, it is strongly linked to impeding progression in these fields.

On the other hand, there was a trend of some challenges such as heavy maths content in chemistry, numerous mathematical formulae, and the necessity of establishing maths support session which came up in both the continuing and early chemistry leavers responses during the interviews. These therefore appear to be a common concern among both category of students. None of the research studies reviewed conducted A-level chemistry students' interviews to obtain students' voices either from continuing students or early leavers. All the research studies basically conducted a survey instead.

9.6 Analysis of interviews with chemistry teachers.

9.6.1 Background information

The two chemistry teachers in the chemistry department who agreed to participate in the research study as earlier discussed in chapter four, section 4.4.1, were interviewed. As a quick reminder to readers, the teachers' interviews were conducted to address one of the research questions which can be found in chapter one, section 1.4; What challenges do chemistry lecturers foresee as hindrances to students' achievement and progression? The teachers were interviewed at the end of the three action research interventions and students' interviews. This is because the students' voice was the main focus for this research so as to address the gap in the literature review. None of the literature reviews as reported in chapter two included any students' voice. However, they are the very people who are affected by the perceived challenges in A-level chemistry and so I believe they can tell their story better. The teachers were interviewed separately and each of their interviews took nearly an hour. This was done to enable each teacher to voice their opinion freely, including sensitive topics the individual might like to discuss. The interviews were transcribed and analysed using thematic analysis as discussed in chapter four, section 4.5.2.

The two teachers have been given pseudonym names such as CTR-1 and CTR-2 for the sake of anonymity. The CTR means chemistry teacher for research. This would be used in quotations by the interviewees. Table 9.1 below is a summary of the themes from the analysis of the chemistry teachers' interviews conducted.

Table 9.1 Themes for chemistry teachers' interview

Themes	Title
Theme M	Students' lack of confidence
Theme N	Content shock
Theme O	Lack of financial support
Theme P	Nature of response
Theme Q	Learning satisfaction

9.7 Theme M – Students' Lack of Confidence

The teachers mentioned during the interview that some of the early chemistry leavers and even some of the continuing students struggle with A-level chemistry due to low self-confidence and motivation. They explained that when some students begin to get low marks in assessments compared to their peers in chemistry and their performance at GCSE, they become less interested in the subject and lose confidence. They become less motivated to continue the subject. Below are some of the comments made by the teachers.

> *Sometimes when a student realises that they are not achieving well it affects their confidence, attendance, achievement and they may drop off. This is because they may see other students doing well but they are not. This affects their confidence to speak or ask questions in class and often struggles to contribute to class discussions. Most often due to lack of confidence to ask questions such students do not understand some of the topics which affects their revision, retention and their intended career they wanted to pursue in science (CTR-1).*
>
> *There is a perception among the public that chemistry is difficult. Eight out of ten people that I have come across told me that chemistry is difficult and they were not good at it in school. This affects ability of people to choose chemistry as a subject in A-level because such conversation goes on in the communities among the general public.*
>
> *Even those who choose chemistry as an A-level subject already have the perception that chemistry is difficult and may drop the subject when they are struggling. They lose confidence to continue the subject easily as a result. Some also bury their heads in the*

sand and carry on with the subject, but end up not achieving well at the end of the two years at A-level (CTR-2).

Some of the students were said to become less interested in the physical sciences in the course of time and not necessarily in A-level chemistry alone. Such students may change their course programme and this affects retention and progression in A-level chemistry. A statement made by one of the early leavers in section 9.2 was in support of the quote below from one of the chemistry teachers.

We do have students who drop chemistry for a number of reasons; they may decide that they are no longer interested in the physical science programme they are doing at A-level so they move from science to business studies or another A-level programme (CTR-1).

Other students also do not have positive attitudes towards A-level chemistry in class due to personal reasons and will not hesitate to complain about the subject instead of persevering and seeking for help.

I think for some students it is due to lack of positive attitude towards A-level chemistry. A positive attitude towards the subject in class will be beneficial because the students will be more engaged and therefore take a better interest in the subject and will achieve well which will improve achievement and the retention (CTR-1).

Positive attitude will enable the student to enjoy the subject, think outside the box and develop better learning skills. They become more involved in group and individual activities and this enables them to develop learning skills. They are able to apply the chemistry concepts and principles better because they turn to have a better relationship with their peers and towards the teacher. They are more likely to ask questions in class for clarification and it increases their confidence and self-esteem. Such students tend to achieve well (CTR-2).

9.8 Theme N - Content Shock

Another challenge which was mentioned by the teachers as faced by the A-level chemistry students is the content of the specification. It was reported that a good number of students, especially the weaker ones, complain that the content is too heavy. This concern was also raised by the early chemistry leavers in section 9.3 which supports a teacher's quote below.

> *Some students are shocked by the heavy content of the A-level chemistry as compared to the GCSE chemistry and lose confidence about their ability to continue. For example, some years ago two of my students came to me after few months into A-level chemistry and said that they were struggling and wanted to drop the subject. I encouraged them to keep trying because they would be fine if they continue to work hard at it. The two of them completed the subject and had grade B and grade C respectively (CTR-1).*

Furthermore, some students also struggled with the mathematical areas in the specification. They tend to struggle with the application of algebra which are used in most of the topics like moles, titration, buffer and rate of reaction. The second year appears to be more challenging as reported by the teachers because the specification contains more mathematics as compared to first year.

> *Heavy mathematics in A-level chemistry is a huge challenge especially for the weaker students. Ratio is one example of the mathematical areas' students struggle with. I think there should be some form of maths induction test during the induction week to identify those who need help in maths so that support sessions are done for them to improve their maths skills in areas that they are lacking. Students who struggle with maths mostly lose confidence to continue the subject because the first part of the A-level content is heavy with maths. For example, moles and titration calculations. This affects some students' achievement and progression to the second year (CTR-2).*

> *Some students struggle with the mathematics involved because they did not know that there are quite a lot of maths application in chemistry. Some of such students begin to lose confidence and drop the subject. l always encourage them when l am teaching by explaining that these are application of algebra and with perseverance, they will be fine over time, but some students still find it challenging and it affects their achievement and retention (CTR-1).*

This was supported by similar statements from both continuing and early chemistry leavers which could be found in sections 6.3, 6.5 and 9.3 respectively.

9.9 Theme O - Lack of Financial Support

Some students do part time jobs and this was reported as serving as an academic distraction most of the time. It was reported that majority of students who do part time jobs tend not to complete their homework and lack detail revision for re-enforcement of work done in class. Some eventually become overwhelmed with the workload from college due to lack of time to do independent studies. This was supported by quotes from the early chemistry leavers in section 9.3. Some extracts from the chemistry teachers' interviews detailing this is as follows;

> *Unfortunately, some of the students have financial challenges and so they are compelled to do part time jobs, but others do the part time for personal experience. Some struggle to manage their jobs and academic work. As a result, they come to class tired and not able to focus on the lesson. (CTR-1)*
>
> *Some students take part time jobs which end up taken a lot of their revision and study time. These jobs sometimes take their minds off their main educational goal and some of them only realise later that they are far behind. Some do struggle and are not able to catch up to continue with the subject (CTR-2).*

Additionally, it was reported that for some students their part time jobs become a priority over their academic work due to the short-term monetary gains. One of the teachers summed it up as below;

> *Some of their part time jobs time clashes with lesson time table and sometimes they go to work instead of attending the lesson. This affects their attendance and not only that but they are not able to consolidate what they learn in class due to their busy life style and lack of revision owing to their part time jobs. This also leaves them with little time to do extra practice questions at home (CTR-2).*

9.10 Theme P - Nature of Response

The two chemistry teachers indicated that one of the major challenges that A-level chemistry students encounter is how to answer questions properly so as to obtain more marks or all the marks allocated for a particular question. This is a skill some students struggle with and it does affect their achievement. The continuing students raised similar concerns and challenges in sections 8.3 and 8.4 which is in support of what the teachers said.

Some students find the application of chemical knowledge in unfamiliar areas challenging. For example, in year two there is more application of the year one content where questions are not straight forward. Such questions are quite challenging for some students and they may not know what to do with the information they have, but if they are willing to put in effort to do more revision and practice questions, they should be alright (CTR-1).

The able students are comfortable when they apply their chemical knowledge in both familiar and unfamiliar situations but others struggle when they are required to do application in unfamiliar or new areas. Mostly they are found wanting. I think the skill they need is to learn how to get the data or the information for the new context or area of the application. Then go ahead to arrange the data or information by scaffolding it to derive the response for the question. A continuous practice is the only way to overcome this challenge (CTR-2).

The teachers further explained that for some students their challenge is so basic because they are not able to use the concepts and principles from the specification to appropriately answer questions.

I think the issue sometimes is about lack of proper understanding of the concepts and principles of the content in the specification. Understanding the concepts and principles are quite key because if you do not understand the concepts then you cannot apply them in new areas of problem solving and as a consequence the student cannot achieve well. Some students lack these skills and more so its application in new areas like stretch and challenge questions (CTR-1).

Not understanding the concepts and principles affects the achievement of the students because they cannot consolidate what they have been taught very well. If they have clear understanding of the concepts and principles then they can apply them to respond effectively in answering questions (CTR-2).

One significant impact on the performance of the A-level chemistry students which was also emphasized was the inability of some students to select, organise and present chemical information clearly and logically.

The high achieving students are able to select, organise and present chemical information clearly and logically most often. However, the weaker ones are not. This affects their achievement and hinders their progression. My suggestion is that every hour they spend with a teacher in a lesson they must spend similar or more hours for personal revision so that they can consolidate what they were taught and practice more exam style questions independently besides the questions done in class (CTR-1).

This challenge was raised by both the continuing and early chemistry leavers in sections 8.3 and 9.4 respectively.

9.11 Theme Q - Learning Satisfaction

The teachers have observed that some of the students do not have positive role models. This affects their motivation in achieving success. As a result, they are unable to become active learners and lacks the ability to accomplish goals through hard work and perseverance. Additionally, they are not able to strive to achieve their best selves.

Some students do not come from academic homes and so they lack academic learning environment and support for their homework. Such students often do not complete their homework. They do not have role models at home and lack expectation for learning. They also lack the relationship between good grades and internal strengths (CTR-1).

There are a number of students who go away during the summer after year one and do not do any academic work. They only return to year two to realise that they are behind, have knowledge gap and are not able to make appropriate connections between topics. Such students find it difficult to make any meaningful application for the chemical knowledge required from year one (CTR-2).

It was mentioned that some students do not attend support sessions even when it has been recommended by their teachers. Their unwillingness was attributed to fear of stigmatization for being weaker students by some of their peers.

Motivation to attend support sessions timely would be helpful especially when they begin to struggle. I think support sessions should be compulsory in the college especially for the weaker students with attendance register in place. This may stop students from *giving some unestablished excuses for not attending such sessions for their own good (CTR-2.*

The teachers suggested that though the A-level specification does not include research presentations and mini projects as done in BTEC, it will make the students enjoy the subject if it is incorporated into their studies.

I think one area that will make students enjoy A-level chemistry is to introduce an enrichment where students are allowed to choose their own topic of interest to do a mini research and do a presentation on it. This will also enhance their research skills, time management and study skills needed for higher education (CTR-1).

In the old chemistry B specification, students were required to design things by themselves. They were allowed to do three weeks research, write their reports and were marked for them. Though it gave more work for us as teachers to do in terms of marking but it was good for the students because they learnt a lot of skills like research, time management and independent learning. It was rewarding for them and it also increased their confidence in achieving something by themselves (CTR-2).

The two teachers agreed that some of their practical experiments that they use to do in addition to the required practical experiments have been taken off due to health and safety reasons. Even those experiments that are allowed, they are not able to do additional ones which are similar for consolidation because of lack of time to complete the specification.

More practical experiments help the students to enjoy the subject because the practical informs the theory and it helps the students to consolidate the theory. Lack of more practical work make the subject dry and students cannot enjoy it either. Some of the content become abstract for the students and this decreases their interest in the subject which subsequently affect achievement and retention

This was supported by the early chemistry leavers in section 9.4 that though the practical experiments were good way of informing the theory, but there were not enough.

9.12 Summary: Teachers' Interview Analysis

The teachers mentioned lack of confidence on the part of some students as a contributing factor to dropping out of A-level chemistry. It was also indicated that some students become less interested in A-level chemistry when they begin to struggle and are not achieving well as compared to their peers. Some students were said to complain that the content of A-level chemistry is too heavy and find it challenging. Some students do part time jobs due to financial challenges and this affects their achievement because some of them are not able to manage their studies and the part time jobs properly. This affects their academic work and some were reported to drop the subject due to that. Lack of academic role models in some homes was suggested as part of the challenges some students face because they do lack expectation for learning. Such students were said to lack the relationship between good grades and internal strengths. Some students were reported to lack motivation to attend or opt for support session when they are struggling in A-level chemistry and some of them drop the subject instead of attending support sessions due to stigmatisation by peers for being weak students.

Some practical experiments were reported to have been taken off the teaching outline due to health and safety reasons and this is limiting the exposure of students to more interesting and supporting experiments which inform the theory in a specific way for consolidation. This issue was also raised by the early chemistry leavers that though the practical experiments inform the theory but what they did were not enough.

Chapter 10

Discussion- Structured Questionnaire and Semi-Structured interviews

10.1 Introduction

The focus of this study is to explore current issues around retention and achievement for A-level chemistry students in an FE College in England. Inherent in this focus is the significance of seeking out A-level chemistry students' and teachers' voices on the perspective of the challenges A-level chemistry students face in progression, retention and achievement. All the previous studies reviewed, chapter 2, had relied mainly on analysis of surveys conducted with students, but I sought to add a unique contribution and add new insights by looking into the views and experiences of the current A-level chemistry students in an FE college in England via semi-structured interviews in addition to structured questionnaire. The students' voice from the semi-structured interviews have revealed some unique and detailed information that could not be obtained from questionnaire surveys only because the interviews allowed me to have one-to-one time with the students and enabled me to do follow up questions during the interviews for further clarification.

To achieve this, a total of eighty-nine questionnaires were sent out to the research participants via Qualtrics and eighty-one responses were received, representing 91% responses. Forty-one semi-structured interviews were conducted, comprising thirty-six continuing students' interviews, three early chemistry leaver students interviews and two A-chemistry teachers' interviews. The analysis of both the structured questionnaires and the semi-structured interviews identified some major key challenges faced by A-level chemistry students in the FE college. I will begin the discussions of these major challenges that emerged across the analysis of the questionnaires and various interviews data to varying extents: heavy maths content, stress from numerous mathematical formulae, maths support sessions, inadequate information for choice of chemistry, effects of type of GCSE science offered, approach to learning, response strategy, students' experience of A-level chemistry, practical experiments challenges, relative interest, financial support and demography effects. The research findings from this study will be discussed in this section and will develop my argument and contribution on how to support A-level chemistry students to improve their achievement, progression and retention in the FE college. This will be followed by recommendations, limitations and conclusion based on these analyses and interpretations.

10.2 Heavy Mathematics Content in A-level chemistry

A minimum of grade 5 is required in GCSE mathematics by the chemistry department in the FE college before a potential applicant can be allowed to do A-level chemistry. Analysis from the structured questionnaire, see Table 5.6, showed that 66.6% of first-year students and 61.5% of the second-year students respectively got grade 7-9 in GCSE maths. Overall, 52 out of the 81 respondents representing 64.2% got grade 7-9 in GCSE maths. This suggests that more than 60% of the A level students doing chemistry got high grades in GCSE Maths. On the other hand, analysis from Table 5.7 revealed that 69.2% of students who scored a grade 7-9 in GCSE maths either agreed or strongly agreed that A- level chemistry is difficult. Furthermore, 79.3% of students who got a grade 5-6 in GCSE maths agreed that A-Level chemistry is difficult.

This revealed that the students who got grade 7-9 in GCSE maths may be less likely to suggest that A-Level chemistry is difficult, but students who get grade 5-6 in GCSE maths may be more likely to have challenges in A-Level chemistry because they are less likely to be doing A-level maths that serves as an advantage for A-level chemistry students because they can apply their A-level mathematical skills in chemistry. Additionally, only students with grade 6 or higher are allowed to do A-Level mathematics in the FE college. This implies that the A-level chemistry students who got grade 5 in GCSE maths were not offered A-level mathematics in the FE college. This may affect their ability to apply maths skills in the maths areas in the A-level chemistry. Though they did GCSE maths but they may lose the fluency in the application of maths skills overtime since they do not often use them as compared to students who do both A-level maths and chemistry together. This point resonates with Grove (2015) who suggested that the importance of mathematics for chemistry should not be hidden to students especially its desirability for A-level. He indicated that students who did only GCSE mathematics and did not do A-level mathematics usually lose fluency and understanding in the mathematics ideas and skills required in chemistry over time because they were not continually reinforced. Additionally, Ogan *et al* (2017) asserted that mathematics should be taken alongside chemistry by students studying chemistry to enable them to understand the connection between mathematics and chemistry. They indicated that mathematics calculations are necessary to explore the concepts in chemistry. Furthermore, Musson (2013) reported that many students struggle in A-level chemistry not because they cannot do the chemistry, but because they find the maths hard.

Additionally, majority of the respondents (about 80%) during the interviews indicated that the maths areas in A-level chemistry are difficult and challenging, especially when a question involves maths and you have no clue of what to do in a test. They indicated that it makes them feel helpless. The respondents' comments and experiences could be found in section 6.3. All the three early leaving chemistry students interviewed also reinforced that the maths areas in chemistry are difficult. They further indicated that there are a lot of numbers and formulae in A-level chemistry and because they were not very good at applying them things got blurred for them. They also revealed that they did not know there were too many formulae and maths areas in A-level chemistry (section 9.3, Obstacles in Progression).

Similarly, the interview data analysis of the A-level chemistry teachers revealed that some of the students, especially the weaker ones are challenged with the heavy maths content in A-level chemistry. Some of them struggle with maths content because they mentioned that they did not know that there are quite a lot of maths application in A-level chemistry. It also came up that this affects such student's confidence and some of them drop the subject, section 9.8. I would suggest that students are given maths induction test during their induction week in first year so that those who will need maths support sessions are identified as early as possible and the appropriate support is arranged for them.

10.3 Stress from Numerous Mathematical Formulae

Approximately 50% of the respondents who did Triple science and combined science respectively agreed that there are too many mathematical formulae that are difficult to remember in A-level chemistry as discussed in session 5.17 and shown in Table 5.18.2. This may be one of the perceived challenges the A-level chemistry students are facing in the FE college, but there were sizable number of the respondents who neither agree nor disagree (15 out 81). This was reinforced by Mahdi (2014) who reported that 61.1% of the respondents in A-level chemistry questionnaire survey conducted in Cardiff agreed that A-level chemistry involves too many chemical formulae and it is difficult to remember.

Likewise, the early chemistry leavers during the semi-structured interviews commented that there are too many mathematical formulae in A-level chemistry. They made various comments to express this view point and their experiences under the themes ‘Learning Resources’ and ‘Obstacles in Progression’ (section 6.5 and section 9.3). During the interviews with the continuing students, it became apparent that one of the challenges the A-level chemistry students face is stress and worry of memorizing the numerous mathematical formulae during revision so that they could apply them correctly in internal assessments and final exam. Eleven out of twelve of the continuing students and all the three early chemistry leavers interviewed expressed worry about needing to memorise all the numerous mathematical formulae. They mentioned that it causes stress because they need to get the formulae quoted correctly in order to get the work done and there are a lot of them. So there appears to be an issue with both memorising the formulae and applying them in A-level chemistry.

During the first action research intervention, a model chemistry mathematical formulae booklet was given to the students. This is the first time such booklet has been produced and used for any research. The exam board also does not allow A-level chemistry students to use such formulae booklet though similar one is used in A-level physics and mathematics. This contained all the maths formulae required in A-level chemistry. The continuing students used the booklets during their activities. Every one of the respondents except one, indicated that this was a ‘’game changer’’ because it gave them the opportunity to focus on the work and the application of the formulae in answering the questions instead of struggling to remember the formulae before applying them. None of the research work reviewed reported on the use of such material to access its impact on students teaching and learning. One respondent explained that she could do the work without the formulae booklet but she confirmed that she used it to check if every formula she quoted was correct, which suggested that the formulae booklet gave her confidence in the work completed. The interviewees recounted various benefits of the mathematical formulae booklet provided. They indicated that they were able to finish the work set before time and therefore had time to go over their work, confident of what they were doing because they were sure that each formula, they were using was correct and being able to complete all the maths questions in the activities. A mention was also made about being able to complete each of the maths questions without any worry or stress because they could refer to the formulae booklet and choose the correct formula each time for a particular calculation involved in a question.

Additionally, it became evident from the interview data analysis (section 6.5) that over 70% of the respondents spent a lot of time during revision in memorizing the numerous maths formulae in chemistry. They argue that if a formulae booklet is provided for use in chemistry exam, it will help them to focus on other contents and learning the application in chemistry areas during revision instead of spending time to memorise the formulae. They further argued that the provision for a formulae booklet would be great because they would not have to remember all the formulae equations from the top of their head. This will take a lot of pressure from them and as a result they would get more time to study the other content in detail and revision would become less stressful. The booklet reduced stress and load on working memory. Significantly, the respondents showed that the numerous mathematical formulae in A-level chemistry is a challenge with the exception of one out of the twelve respondents

10.4 Effects of Maths Support Session in the Study of A-level Chemistry

The analysis of the research questionnaire (Table 5.12) showed that around 76.2% of all the respondents who did the various types of GCSE science (Triple science, combined science, other science) indicated that knowing that there will be a lot of help offered by teachers and the college helped them to decide they would stay and complete the A-level chemistry. This revealed how important support session is to the A-level chemistry students in the FE college. Additionally, the analysis showed that the students who did Triple science, combined science and other science strongly or somewhat agree by 76.6%, 77.3% and 100% respectively. There was not much significant difference in terms of percentages between those who did Triple science and combined science, which indicates that support session provision for students is essential for all the students no matter the type of science they did in GCSE. Similarly, analysis of the data from the semi-structured interviews of the research respondents (sections 6.3, 6.4 and 6.7) showed that the maths in A-level chemistry is an issue that needs to be addressed because it is affecting their revision, motivation and progression. A maths support session set up, which is solely about the mathematics in A-level chemistry, was highly recommended by the students regardless of whether they do A-level maths alongside A-level chemistry or not. They were all of the view that such a support session would help to improve the achievement and progression rate in A-level chemistry. This is supported by Mahdi's (2014) report which showed that 69.4% of the respondents agreed to study A-level chemistry knowing there will be a lot of help from the teachers and the school. Thus, having help from school (teachers) is an important factor that plays important role in students' preference to study chemistry. The interviewees in this research study asserted that maths support sessions would have a positive effect on their revision. For example, it would help them to develop the sense of independence in learning. This assertion was made after they had attended the first intervention session which provided such opportunity. The majority of the participants indicated that the support sessions had helped them to work on more maths questions at home because they got more understanding during the sessions and they were able to do more practice questions which would help them to do better in assessments. Additionally, they opined that the maths support sessions had helped them to know how to systematically approach maths questions in chemistry (see section 6.3).

The various literature reviewed supported the importance of a good understanding of maths in the study of A-level chemistry. Adigwe (2013) reported that the study of chemistry especially at A-level and above requires mathematical thoughts and methods which provide new thoughts and methods for chemistry learning. Furthermore, Bain *et al*, (2019) indicated that the study of chemistry requires mathematical knowledge, thought processes, and mathematical skills. Russell (2017) indicated that numerous facets of science are better expressed and demonstrated by using mathematical tools. The lack of maths preparation hinders many students' efforts to learn chemistry, and many others to pursue science at higher level (De Berg, 2012; Musson, 2013; Russell, 2017). Some A-level chemistry students are not able to transfer their mathematical skills to chemistry and most often have challenges in studying the maths areas in chemistry (Bain *et al*, 2019; Effiong *et al*, 2014). Additionally, it was revealed that some chemistry teachers always assume that students have learned the maths skills in chemistry in maths class and therefore overestimate their ability to transfer knowledge. Some students in chemistry lessons get stuck on the foundations of mathematics, and it may be better for the teachers to spend time during lessons to break through students' difficulties in relation to the mathematical areas in chemistry (Bain *et al*, 2019).

The respondents, every one of them, further stated that they would prefer that when the maths support session is set up it should be led by a chemistry teacher as compared to a maths teacher. They argued that a chemistry teacher would find it easier to do the application of the maths in chemistry during the sessions and that would make it more beneficial to them. This was corroborated by the teachers who mentioned that heavy mathematics in A-level chemistry is a huge challenge especially for the weaker students and some of the students who struggle with maths mostly lose confidence to continue A-level chemistry.

All the interviewees expressed their views on the format for the set up for the maths support session. Two main options were suggested by the respondents. Some of them were of the view that students should be allowed to drop in when they have a need for the extra support for maths in chemistry with their questions within the allocated time set by the college. However, others were of the view that it should be teacher led with topics advertised so that students could pick and choose when they want to be there. Moreover, there was one interviewee who suggested that the college should find a way of implementing the two options because either of them has a unique benefit for students.

Besides, a time tabled support session may be ideal for students in the FE college so that students who are identified by teachers to be in need of extra help could enrol into. This will ensure that all students who need help have been catered for because there may be some students who may lack confidence or motivation to attend the support sessions by their own evolution. The register will also afford the teachers the opportunity to monitor those who are not attending the support sessions so that they can motivate them to do so.

All the research work in the literature reviewed did not do interviews after questionnaire survey to find out in detail the form of support session the A-level chemistry will like to be set up for them and whom they would like to lead the support session so that they can get the full benefit from it. This study has revealed that the students would like a maths support session which should be led by a chemistry teacher so that the teacher will not just teach the mathematics as a topic, but its application in chemistry would be done for them as well.

10.5 Inadequate Information for Choice of A-Level Chemistry and Career Pathway

Advice for choosing A-level subjects appeared not to be a priority among the respondents. This is because 80% of the respondents indicated that they chose A-level chemistry without seeking any help. According to Table 5.10, only 20% of the respondents agreed that they did not choose A-level chemistry as a subject alone. Thus, only these few had outside influence which could be from parents, teachers or career advisors. Furthermore, only 17.1% of the first-year group and 23.1% of the second years respectively said they strongly or somewhat agree that it was not their decision alone in choosing A-Level chemistry as a subject. This is supported by the Sutton Trust (2022) who indicated from their research work conducted in UK secondary schools that only 36% of students in UK had attended any career related programme or participated in any career related activities. The report indicated that students from state schools are more likely to report not having taken part (38%) as compared to students from private schools (23%). The awareness of the Gatsby Benchmarks, the current framework for careers guidance, was found to be lower among classroom teachers in state schools (40%) though most (94%) of state school senior leaders are aware. Results from the questionnaire analysis from the FE college in this research study confirmed this and it was even lower (20%) comparatively. Additionally, the Sutton Trust, (2022) also reported that around about 36% of secondary school students in UK do not feel confident in their steps towards a future career, but about 56% said they felt confident. Students from state schools were reported not being confident in their next steps in education and training than those in private schools (39% compared to 29%). Furthermore, 21% non-specialists were reported to deliver careers guidance in schools in most deprived areas compared to 14% from the affluent areas. This implies that there is a high probability for a non-specialist to be delivering careers guidance in deprived areas than the more affluent areas. Furthermore, over three quarters (88%) of the teachers from state school felt that their teacher training didn't prepare them to deliver careers guidance to students. Fifty-one percent of the state school teachers felt there is not enough time for teachers to provide careers advice and guidance information to students compared to 34% for private school staff (Sutton Trust, 2022). This might have been a contributing factor for the low percentage (20%) of the respondents in this study who had help in choosing their career pathway because all the students in the FE college are from state secondary schools in the town. This could lead to students being in a wrong course and therefore not able to utilise their full potential.

However, the Office of National Statistics (2021) census showed that 53.4 per cent of household in the county and 49.3 per cent in the town where the FE is located are not considered deprived. The Office of National Statistics (2021) says 'a household is classified as deprived in the education dimension if no one has at least level 2 education (GCSE level) and no one aged 16 to 18 years is a full-time student'. Overall, both the county and town where the FE is located have a lower rate of households' deprivation than the national average across both England and Wales (51.71 per cent) (Office of National Statistics, 2021). This implies that there may be relatives or guardians who should be in position to guide these students if they wanted to seek help in selecting their A-level subjects. However, this might not be the case for all students participating in this research. This can affect future aspirations of such respondents and the potential STEM workforce for England as discussed in section 1.1.

All the early chemistry leaver students interviewed indicated that they did not have enough information concerning career advice and A-level subject chose at the time they were making the important decision of their lives as what career pathway they should choose and the subsequent subjects to do at A-level. They all indicated that it would have been helpful and even better if they had some form of career advice and A-level chemistry content briefing before choosing the subject. The only career advice mentioned was from parents. It became apparent that they chose A-level chemistry subject based on their GCSE grades, future aspirations, past experience from GCSE and on few occasions influence from others, especially parents. This is supported by other research studies which indicated that the issue of students' choice has been the subject of some previous studies in science education in Europe (Archer et al., 2010; Bøe *et al*., 2011; Holmegaard et al., 2014). This was corroborated by Bennett *et al* (2013) as indicated earlier in section 9.5.

Medicine is the most popular future career among the chemistry students in the FE college even though it is highly competitive career to enter into in the UK (Medical Schools Council, 2021). According to Table 5.3, 25 students (30.86%) of the A-Chemistry students in the FE college have chosen Medicine as their future career. On the other hand, 8 students (9.88%) wanted to become pharmacist. However, 9 students (11.1%) were not sure of what they wanted to do in future. This supports the need for continuous career advice in the FE college, especially during the induction week for first year students, so that students are well informed and can choose what career they want to pursue in future with confidence. Students who are not sure of what they want to do in future may not be focused and the motivational level of such students may be low as they may not have a goal or target to aspire to. Walker and Peterson (2012) suggested that making academic career decisions not only enhances students' ability to progress academically, but also increases their effective decision-making skills. They mentioned that learning how to effectively make career decisions and developing suitable goals are essential life skills for every student. Furthermore, Bertoch *et al* (2013) stated that students' career decision is related to their classroom performance because students with firm career decisions are usually highly motivated and more focused. They also indicated that the degree of instability in career decision by students' is directly related to their low classroom performance. Most young people and their parents seem to have limited understanding where science can lead (Archer *et al*., 2013; Kantar, 2020). Many of them believe that science qualification leads mainly to careers such as a science teacher, doctor or scientist.

Moreover, analysis from Table 5.9 shows that 64 out of 81 respondents indicated that they would not drop A-level chemistry if their career choice changes. However, 30 out of 42 first-year students compared to 34 out of 39 second-year students stated that they would not drop A-level chemistry if their career choice changes. It is more likely for a first year A-level chemistry student to drop chemistry than a second-year student is. This might be because the second-year students are more convinced or more confident perhaps and have a grip on the subject than the first-year students. It could also be that the second-year students do not want to waste the one year already spent doing A-level chemistry. The higher number of first year students probable to drop A-level chemistry compared to the second-years' could also be a challenge for the progression rate in A-Level chemistry. This suggests that the first-year students would need more support and motivation to ensure that their progression and retention are not affected. Year 11 students will also need more information and professional support in choosing A-level subjects. This was corroborated by Donnelly (2021) report which showed that between 2015-2019, learners at 16 pilot schools and colleges in England, who benefited from good and continuous career guidance provision became increasingly more likely to achieve their learning outcomes, compared to learners at other colleges. Similarly, teachers observed real changes in leaner's engagement in class because they understood the relationship between knowledge/ skills and their future career. Donnelly's report also indicated that the greater the career and guidance benchmarks were held, the greater the number of GCSE passes at 9-4/A*-C achieved by each learner. Additionally, Mahdi (2014) revealed that most of the respondents (66.7%) who offered chemistry in year 12 were not planning to continue chemistry in year 13 and 64.7% of the respondents said they considered taking A-level chemistry due to career choice. This affirms the notion that some students take chemistry at post-16 based on career options and when career options changes they may drop the subject. However, only 21% of the respondents in this research study indicated that they will drop chemistry if their career choice changes as compared to 64.7% in Mahdi's report.

The questionnaire and semi-structured interview analysis in this research study both showed that career advice and guidance sessions for students at GCSE about the workload and the suitable subject combinations based on their future career would help to prepare them for their two years at A-level so that they are not overwhelmed. The qualitative data analysis revealed that some students only focus on their future career and university requirements without considering the workload involved in their subject combination. Some students on the other hand choose subjects, which they think, can easily enable them to get their university requirements without considering if they can transfer knowledge and skills from one subject to the other to enhance their achievement. Subject combination requires guidance and support so that the students can achieve well at A-level and be able to pursue their future careers without any consideration for dropping a subject.

10.6 Effects of the Type of GCSE Science Offered.

Within the questionnaire (Table 5.5), 72.2% of the respondents who did Triple science agreed that A-level chemistry is a difficult subject compared to 81.81% who did combined science. This analysis suggests that students who did Triple science were less likely to find A-level chemistry challenging although both percentages are high. This was supported by Rodeiro (2013) who compared the various science progression routes to post-16 Science qualifications and indicated that students who take separate sciences (Triple science) at GCSE do better than any other group. Additionally, it was mentioned that students' confidence and expectations about their achievements may also be limited if they do combined science or applied science which are perceived as less challenging routes because the depth of the content is not much as compared to Triple science. Similarly, Rodeiro (2013) reported that level 2 science route with the highest progression rate was Triple science with 46% of the students progressing to a post-16 qualification in science compared to 26% who did double science and fewer than 5% of the students who followed applied science route at level 2. This supports the notion that students who want to do STEM A-level sciences may be faced with fewer challenges if they do Triple science at GCSE because they do cover in detail the respective science subjects (biology, chemistry and physics) at the GCSE. This may perhaps be the reason why a high percentage (66.7%) of the research participants in this research study did Triple science at GCSE.

According to the analysis from Table 5.15, 24.1% of the students who did Triple science agree that it is difficult to make connections between different topics in chemistry compared to

36.3% of the students who did combined science and 40% of those who did other science respectively. This result suggests that the FE college students doing A-level chemistry have challenges in understanding the chemistry principles, and making connections between topics. This is possibly because they have less in-depth background knowledge as discussed above, but those who did Triple science were more confident. This evidence once again supports the notion that students who do Triple science at GCSE may perform better than those who do combined science and other science at GCSE. The research evidence confirms the notion that doing Triple science at GCSE could be advantageous for studying A-level chemistry, but some students are disadvantaged. Kantar (2020) stated that one of the barriers to studying Triple science at GCSE is related to some schools being selective in who studies it, rather than not offering it at all. Additionally, uptake of Triple science sometimes are mainly personal factors such as confidence and lack of interest, although some students are discouraged by not meeting grade thresholds or by their teacher. Besides, a Teach First (2022) report indicated that among the three sets classification in schools, top set students are more probable to be offered Triple science compared to middle and bottom sets students, but Triple science is mostly required by schools and further education colleges for progression in the sciences in A-levels which grants access to higher education, and career in STEM. It seems that access to the prior qualification which may signal greater likelihood of success is controlled in a way which acts against the interests and motivations of the students themselves. The setting system is generating, in effect, the progression and retention issues that this study focuses on.

Further analysis of the questionnaire data (Table 5.13) showed that 26 out of 54 students (48.1%) who did Triple science, 15 out of 22 students (68.2%) who did combined science and 3 out of 5 students (60%) who did other science indicated respectively that understanding the chemistry principles and concepts are tricky. This is one of the challenges that the FE college A-level chemistry students are facing in terms of progression and achievement because the percentages from the analysis is high for the students who did all the three different categories of GCSE science. Results and analysis from Table 5.13.1 gives a similar trend when students were asked to express their views concerning explaining and interpreting A-level chemistry principles and concepts.

Moreover, the analysis (Table 5.14) also revealed that 74% of the students who did Triple science at GCSE agreed that applying chemical knowledge and understanding familiar situations require long hours of studying. This group of students got more in-depth chemistry content and practical at GCSE, but the percentage from the analysis is significantly high in terms of their understanding and application of chemical knowledge challenges faced in A-level chemistry. Moreover, 81.8% of the students who did combined science at GCSE answered this same question affirmatively. This is also one of the challenges from this research study which showed high percentages by both students who did Triple and combined science in the FE college.

However, 81.5% (Table 5.15.1) of the respondents who did Triple science agreed that they enjoy A-level chemistry lessons compared to 77.3% of the respondents who did combined science at GCSE. Hence, irrespective of whether the respondent pursued Triple science, or combined science, all of them enjoy the A-level chemistry lessons with about 4.2% percentage difference but both percentages are high. This may suggest that the chemistry teachers had been helpful and lively about the subject, making it fascinating and attractive for the student to learn. This was confirmed by Mahdi (2014) who reported that 63.9% of the students agreed that chemistry is an interesting subject and they enjoyed it.

10.7 Respondents' Approach to Learning

The respondents drew on their relational experiences of chemistry, as compared to other A-level subjects, stressing on how they experience A-level chemistry as being "harder" and "more difficult" subject than other A-level sciences. One of the challenges that the structured questionnaire and the semi-structured interviews revealed was the approach to learning by the A-level chemistry students in the FE college. It emerged from the structured questionnaire analysis, see chapter five, that the A-level chemistry students in the college find it difficult to use the chemistry principles and concepts learnt to answer questions. In addition to this, they expressed concern that to apply chemical knowledge and understanding in familiar situations requires long hours of studying. According to Cross *et al.* (2016) satisfaction with revision resources, revision for learning and the revision design are well defined factors in a student's experience. This challenge led to the second action research intervention. Three sessions were organised during which the respondents were taught to focus on the principles and concepts in the A-level specification when revising. They were also taught a systematic approach of answering questions using the chemistry concepts and principles learnt. Furthermore, the students were taught not to memorise their notes but spend time to understand the concepts and principles that each topic requires during revision so that it would enable them to answer questions in detail.

In the interviews, ten out of twelve of the interviewees mentioned that they did not have a distinctive study method for revision in chemistry before the intervention. They mostly use the same revision method across their other subject areas in A-level for chemistry. The popular method among them was reading the text book or revision guide to make notes, make flash cards and finally work past papers afterwards. Furthermore, majority of the interviewees, 85% of them, explained that they mostly try to memorise their notes and practice past papers afterwards. This has resulted into memorization of notes during revision with lack of understanding mostly and a recall of the notes when answering questions. The interviewees, every one of them, expressed joy in the new method of revision which emphasised understanding the principles and concepts in the topic and focusing on that to answer questions during the intervention so as to avoid the habit of rote learning as discussed above. The respondents stated that the approach learnt during the intervention would make their revision easier and also help them to answer questions in an orderly manner (section 7.3). This resonates with Busch and Watson (2022) who suggested that teachers should specifically teach students the benefits of retrieval practice such as the use of flashcards, mind maps, multiple choice quizzes or even verbal questions. This is because if students know how to use these study techniques and recognise why they work, they are more likely to use them. Furthermore, Rohrer (2009) stated that spacing and regular revision is important because we forget more than realise, so it is important to revisit materials regularly. Students who do this perform between 10% and 30% better than students who memorise their studies (Taylor and Rohrer, 2010).

It is was revealed during the second interviews that some students get stuck in the same way they revised and answered GCSE questions in chemistry so they could not do much in answering A-Level chemistry questions. They did not realise that there is a lot to learn in A-level chemistry and it is important to revisit materials regularly. Teachers should help students to plan and encourage them to regularly revise their notes because students often think they have more time to spare than they actually do.

All the interviewees indicated that the skills they have learnt in using chemistry principles and concepts in answering A-level chemistry questions during the interventions are of great relief to them because the skills would enable them to complete questions on time and then achieve better. Additionally, they explained that the approach learnt has helped them to answer questions in an orderly manner. Prior to the intervention around 75% used to answer questions without following any method or structure. The rest were good in answering questions in their own strategic ways to obtain top marks. About 70% of the interviewees also highlighted that because they did not use the chemistry concepts and principles in answering questions before the intervention, it limited their ability to completely answer chemistry questions during exams and they would spend a lot of time trying to guess and answer the questions from memory based on what they had memorized which might not be what the question required. They explained further that as a result of that they did not often have time to go over their work and they made unnecessary mistakes. However, having learnt the skills of using chemistry principles and concepts in answering questions, they asserted that they would be able to answer questions on time and possibly go over their work to check any possible mistakes (section 7.3).

The interviewees, every one of them, gave their impressions about the notion that applying chemical knowledge and understanding familiar situations is difficult after the interventions. They all mentioned that there has been an improvement in their application of chemical knowledge and understanding familiar situations in answering chemistry questions (section 7.4). Similarly, the interviewees indicated that they are able to answer and give detail responses to questions when answering them than before the intervention sessions. They attributed this to the intervention sessions. Furthermore, they mentioned that the skills and approach learnt would enable them to improve their grade in chemistry because they have learnt a better revision strategy using chemistry principles and concepts besides being able to give more detail answers in their responses to questions.

In addition to this, they indicated that the approach and skills learnt have also increased their confidence in using chemistry principles and concepts which involve mathematics in chemistry. This is because some of the chemistry principles and concepts use the application of mathematics. This enabled them to apply the skills learnt from the action research cycle one (see section 7.4).

10.8 Practical Experiments Challenges

In terms of students' experiences of A level chemistry, the importance of practical experiments was mentioned by both students and teachers. The respondents explained that practical experiments inform the theory and enables them to enjoy their lessons. It also helps their revision because they can remember how they conducted the experiment during the practical and the results achieved. Though they mentioned that the practical experiments were good, they indicated that they are not doing enough experiments.

The two teachers interviewed agreed that some of their practical experiments that they use to do in addition to the required practical experiments have been removed due to health and safety reasons. Even those experiments that are allowed, the two teachers stated they are not able to do additional similar ones for consolidation because of lack of time to complete the specification. They also resonated with the students' point that more practical experiments would help them to enjoy the subject because the practical informs the theory and it helps the students to consolidate the theory. Lack of practical work make the subject dry.

The teachers stated that lack of enough practical work makes some of the content become abstract for the students and this decreases their interest in the subject which subsequently affects achievement and retention. This was supported by the early chemistry leavers in section 9.4 that though the practical experiments were good way of informing the theory, but they were not enough. Shirazi (2017) supported this assertion by emphasising that lack of interesting science experiments in school makes students feel that science is mainly theory to be learnt for examinations. Such learning experience by students could make A-level chemistry more challenging because these basic practical experiments they do are meant to give them more understanding in the fundamentals they learn in theory.

Mahdi (2014) recommended that chemical education should be given a greater attention in diversity of activities and skills such as numeracy and experimental work to enable students to have hands on approach to the course. Moreover, Kershaw (2017) reported that 29% of GCSE science students in England did less than one practical experiment in a month or never. The report which questioned around 4,081 14 to 18-year-olds, including 2000 students taking GCSE, indicated that under half (45%) did at least one practical experiment once in a month. Over 22% said that even when they do a practical work, they mostly follow instructions without understanding the purpose of the experiment. It was further reported that 36% of the GCSE students from the most deprived areas in England do practical work at least once a month compared to 54% of students from wealthiest areas. About 58% of the students wanted to do more practical experiments especially those doing Triple science because their GCSE chemistry is more detailed and more practical experiments will reinforce the theory they study so that the fundamentals could be well understood for post-16. It appears students do not have the opportunity to experience more of the practical aspect of chemistry which would in a way act against the interests and motivations of the students themselves to consider further studies in STEM careers. Lack of required number of practical experiments would also affect students' development in scientific enquiry, and understanding of theory through practical experience, knowledge in practical skills such as measurement and observation that may be useful for further studies and future employment. Students development in skills such communication, teamwork and perseverance would be affected. This could be an issue for progression retention and achievement.

Furthermore, other research studies (Breuer, 2002; Godfrey, 2011; Kershaw, 2017; Shirazi ,2017; Broman & Simon, 2014) resonate with this narrative that lack of adequate practical experiments during chemistry lessons which are meant among other things to help chemistry students to develop practical skills, specific scientific knowledge and understanding of various processes of scientific enquiries, caused them to disengage in lessons. Students and teachers were all reported wanting to do more practical experiments. A large majority of the students felt that science experiments at secondary school decreased in quality and quantity as they progressed through the years in secondary school (Lindahl, 2007; Lyons, 2006). Similarly, Broman and Simon (2014) indicated that more practical work was selected as the second most important (48%) in Sweden post 16 chemistry research when students were asked to indicate three most important changes that could improve post-16 chemistry education. To improve their chemistry learning experience, the Sweden students recommended more practical work to inform the theory. The various research studies reviewed support the findings in this research study that inadequate practical experiment is a challenge for students' engagement, achievement and interest in chemistry. This can affect their retention and progression into higher education for further studies in STEM related courses.

10.9 Response Strategy

Chemistry is key subject in science and the majority of students will do well in the subject if they have the strategies needed to help them to revise and answer questions appropriately. Analysis of the structured questionnaire which was used to gather data for the corresponding action research intervention showed that 23 out of 81 students (Table 5.15) indicated that it is difficult to make connections between topics in chemistry. Appreciable number of students, 15 out of 81, neither agreed or disagreed. This gives some element of agreed narrative in this number too that it is difficult to connect different topics in chemistry together. After the third action research intervention, every one of the twelve interviewees indicated that the intervention has helped them to select, organise and present chemical information clearly and logically. They recognised the importance of presenting chemical information in a clearer manner so as to get more marks (sections 8.3 and 8.4).

The view point of the interviewees after the third intervention was that the approach they learnt during the third intervention sessions gave them the opportunity to answer and present chemical information in a systematic and logical way. This is supported by their responses to the interviews which could be found under the theme 'Sense of Satisfaction' in section 8.4.

The qualitative analysis from the interviews suggested that all the interviewees would be able to transfer the expertise from the sessions to enrich their revision sessions. They were of the view that this would enable them to perform well in the exam since they would be able to answer questions in detail and logically. They emphasised that the interventions have helped their answers to become more concise and clearer. They are able to finish answering questions on time without having to skip some questions due to lack of time. Exam time management has improved and would be able to reduce otherwise some of the marks they would have lost due to their inability to finish questions and also not being clear and concise and waffling.

The interviewees upon comparing what they have learnt to how they use to answer questions suggested that the approach they have learnt was a very good strategy to answer A-level chemistry questions in much detail and logically. This resonated very well with them and the approach was described as *'life skills of chemistry'* by one of the interviewees (see section 8.4)

Furthermore, the confidence level and motivation of students play a key role in how well they could perform in their exam and even during independent revision towards exam. This is supported by Edwards *et al.* (2016) who indicated that the biggest challenge for chemistry is not suspicion and negativity, but what is needed is to overcome people's disengagement and lack of confidence. Additionally, Wellcome Trust (2020) cited personal barriers such as lack of interest or confidence or concerns about the volume of work and perceptions of difficulty as their reasons for not offering science. After the intervention sessions the interviewees expressed confidence in the systematic approach that they have learnt in answering A-level chemistry questions. Majority of them, 90%, indicated that the systematic approach is simple to follow and it has even made harder questions become easier to understand by following the structured plan; select, organize and present the chemical information clearly and logically. They argued that you cannot miss the principles and concepts required to answer chemistry questions if you follow the plan. About 10% of the interviewees already had other means of answering questions to obtain high marks without necessary following the systematic approach learned. However, they contended that the systematic approach is great to use.

Besides their improved confidence levels which has become evident from their response in the interviews (see section 8.4), the interviewees emphasised that the intervention will help them to achieve their target grade or improve upon it in the final exam. They explained that the approach learned would enable them to complete most of the required questions if not all, and get extra marks unlike before the intervention when they used to skip some of the questions because they could not do them.

Additionally, the interviewees upon reflecting back on the third intervention sessions, made mention also of how they had benefited from the entire intervention sessions and the effect this would have on their progression and achievement (see section 8.4). When students benefit from motivation, support and encouragement to continue with chemistry from significant adults (e.g., teachers), this appeared to act in a number of cases as significant influences on them (Dorph *et al*., 2018; Reinhold *et al*., 2018). This resonates with the encouragement and influence the interventions had on the students. They commented that the intervention sessions have helped them very much because most of them used to struggle about how to select the right formula during calculation questions in physical chemistry but the first interventions sessions made it easier for them. The last intervention sessions have even made it better because they have learned how to select, organise and present chemical information which includes mathematical formulae more clearly and logically in answering questions. They indicated that this would make their progression easier than before and the benefits are huge.

The interviewees, every one of them, were clear that they were not well informed as how to present their chemical information before the intervention sessions during the interviews. They expressed their joy as how the third intervention sessions have helped them to improve their independent revision and answering of questions during practicing of past papers. The interview analysis also showed that the systematic approach; select, organise and present clearly and logically of chemical information, which was presented during the sessions helped the respondents to acquire new skills and strategies as what to do and even how to plan their responses to A-level chemistry questions in order to be much detail in their answers. Furthermore, they stated that they are more confident now as what to do when answering questions. They said that the intervention sessions have reduced their stress when answering A-level chemistry questions because the struggle that they used to go through to answer questions properly and in detail have been dealt with. This resonates with Reinhold *et al*. (2018) who emphasised that science teachers' support and encouragement greatly influence students' achievement.

10.10 Financial support and Demographic Effects

In the semi-structured interview data analysis, two out of the three early chemistry leavers indicated that attendance and catching up of content missed were challenging and that affected them. They indicated that they had to work and could not attend all the teaching sessions and do the preparation as well as doing paid work but they could do it for English A level, for example. This is because there are a lot of scientific facts in A-level chemistry that requires a professional explanation for students to understand them better. Students are meant to improve understanding of theory through practical experiments, so if a student misses lessons including practical experiments, it becomes challenging to understand the theory and more so the institution may not be able to set the experiment again for that student to do it. Additionally, the early chemistry leavers mentioned that missing lessons due to work affected their achievement and progression. This is supported by Kantar (2020) who stated that students' experiences outside school play an influential role in the trajectories of their lives. For example, while poverty does not necessarily dampen enthusiasm for STEM, it is strongly linked to impeding progression in these fields.

Furthermore, the two chemistry teachers interviewed supported this narrative that some students do part time jobs and serve as academic distraction most of the time. The teachers indicated that majority of students who do part time jobs tend not to complete their homework. They are not able to revise their notes in detail and eventually some become overwhelmed with the workload from college due to lack of time to do independent studies. The teachers also mentioned that some of these students come to class already tired and struggle to focus on the lesson. It was also mentioned that sometimes these students lose focus because their minds are taken off their main educational goal and some of them only realise later that they have fallen behind academically. The government should provide more financial support for the educational institutions so that they can in turn support all financially challenged students with basic supports such as payment for school trips, purchase of textbooks and bus pass. The government could also consider reintroduction of Education Maintenance Allowance (EMA) which is currently cancelled in England though it is still being claimed by students in Northern Ireland, Scotland and Wales. Some students may also not be aware of the various financial supports the government already provides. More financial support information should be made available in schools and colleges. Assessment of parents' income as a basis for granting financial support to students should be revisited because some parents may be financially alright but may not be providing for all the student's needs.

This was a unique information captured from the respondents because none of the literature reviewed had information concerning learner voice on post-16 chemistry students' experiences let alone A-level chemistry teachers.

Professional Reflection

10.11 Professional Reflection on the Research Study

The research study conducted gave me the opportunity to reflect on my professional practice. Upon a deep reflection after the qualitative data analysis, my choice of action research was confirmed as a valuable one given the new insights I gained into students' perspectives and preferences. I have noticed that it is not enough to teach the specification, mark homework set and give feedback. I have realised that I need to find out how the students are coping with their revision and not assume that they know how to revise. This is because some students may be stuck in the way they use to study or answer questions at GCSE, especially the first-year students. I will need to re enforce the need for the students to revise and answer questions using the chemistry principles and concepts and discourage dependence on memorisation as a form of learning. I need to print boundary descriptors for my students from the exam board so that during one-to-one academic review I will show them how to move from a lower grade boundary to a higher one using the appropriate concepts and principles in the boundary descriptors.

Furthermore, I will conduct termly a learner voice survey about teaching and learning so that the students can feedback regularly on their studies. Various research indicates that students who believe they have a voice are seven times more probable to be academically motivated than those who do not have such a choice (John and Lori, 2017; Quaglia Institute for School Voice and Aspiration,2016; Toshalis and Nakkula, 2012).

Besides, I have noticed that l need more emphasis on the concepts and principles during the teaching of each topic. When each topic is introduced, I will need to show students clearly the concepts and principles involved and repeat that as part of the recap. This will enable them to know clearly how they will be assessed. Moreover, I have also noticed that some students are stressed by the numerous mathematical formulae in A-level chemistry and as a result l will need to list all the formulae for each maths areas in the specification and take time to explain them when teaching the topic so that even the weaker students can understand how to apply the formulae in chemistry. According to Bain *et al* (2019) some students in chemistry lessons get stuck on the foundations of mathematics, and it may be better for the teachers to spend time during lessons to break through students' difficulties in relation to the mathematical areas in chemistry. Furthermore, it was revealed that some chemistry teachers always assume that students have learned the maths skills in chemistry in maths class and therefore overestimate their ability to transfer knowledge. This is something I am determined to avoid in my lessons so l will take time to teach the maths areas in chemistry and ensure that those who need support sessions are taught by a chemistry support teacher as recommended by the respondents in this research study.

Limitations and Opportunities

10.12 Limitations and Opportunities in the Research Study

I acknowledge that this research study has some limitations, including that it only pertains to the English context and in one college. However, it provided detailed responses and in-depth understanding of the challenges the A-level chemistry students in the FE college go through. This is because the research participants responded in detail about their views concerning the issues in this research study during the semi-structured interviews that gave me first-hand information, experiences and feelings from the students' point of view in their social context. Thus, the participants were offered the opportunity to construct their own world including the experiences of the early chemistry leavers, see chapter 5 to 9. The research study can therefore be generalised across other national and international settings with caution since the concepts and principles of chemistry are the same though resources, mode of teaching and cultural attitudes to STEM subjects may be different. Additionally, the samples are also for only one local FE college. However, any college or educational setting can take the results and see which areas of the research study can be replicated in their setting. I recognise that my data is only for a local state school and therefore private schools setting may be different in terms of resources and staff to student ratio. However, the findings offer useful depth on A-level chemistry students' experiences and how to support them so as to improve retention, achievement and progression. The nuances between gender could be explored further in future research study as this research study did not have a research question on it and so was not one of the main foci.

Conclusions and Recommendations

10.13 Conclusions and Recommendations of the Research Study

The research aimed to explore current issues around retention and achievement for A-level chemistry students in an FE college in England. Based on the research data analysis (structured questionnaire and the semi-structured interviews), it can be concluded that numerous mathematical formulae, heavy maths content, response strategy, inadequate career advice information, approach to learning, less practical experiments, lack of confidence and learning satisfaction are important factors to consider when considering challenges that A-level chemistry students face. The results indicate that;

- There are too many mathematical formulae that are difficult to remember in chemistry in the opinion of students.
- The application of chemical knowledge and understanding unfamiliar situations require long hours of studying.
- Explaining and interpreting chemistry principles and concepts are not easy.
- It is tricky to understand the chemical principles and concepts.
- There is inadequate information for choice of A-level chemistry and STEM career pathway, and
- There is a socio-economic status impact on some learners' engagement.

The research study sought to interact with the respondents in order to acknowledge their feelings and viewpoints concerning the challenges in progression, retention and achievement in A-level chemistry, which was the focus of this study. A lot was also learned from the small group of early chemistry leavers who consented to take part in the semi-structured interview, see chapter 9 and section 10.10. I settled on qualitative research approach because there was the need to interact with the research participants in their socio-cultural context in order to gather data and interpret them to create knowledge. This is in line with my theoretical and philosophical arguments about knowledge construction (chapter 3). I proposed to use practical action research methodology in this research which enables you to research specific school situations with the view to improve practice (Schmuck, 1997). I intended to apply three cycles of interventions, to address the research questions, which is a characteristic of action research (Moroni, 2011, McAteer, 2013). This enabled me to evaluate and reflected on the results from the data collected and the subsequent analysis (chapter 6-9) after each cycle to ascertain if the intervention had addressed the research questions. The results from the questionnaire analysis were used to inform the three action research cycles (section 5.19). The ensuing semi-structured interviews accorded me the opportunity to interact with the respondents to acknowledge their feelings and viewpoints concerning the challenges in progression, retention and achievement in A-level chemistry. The respondents' voices were used as the data for the analysis. This enabled me to report on the findings in the discussion.

The various literature reviewed in this study, chapter 2, did not include learners' voice through interviews, but they conducted survey questionnaires. This study used a structured questionnaire to initially gather data about the perceived challenges the A-level chemistry students in the FE college are facing. This informed the subsequent action research interventions and the follow up semi-structured interviews which accorded the respondents the opportunity to share their experiences before and after the interventions. The respondents' voices were used as data and analysed, which has produced the results reported in this research. A model mathematical formulae booklet, which contains all the mathematical formulae in A-level chemistry, was introduced during the first action research intervention and the students found it very useful. This will be recommended to the exam boards to consider its use in national exam to address one of the challenges that came up in this research study. The respondents indicated that there are too many mathematical formulae in A-level chemistry and they are difficult to remember. The findings suggest that this is causing stress and worries for students. It also takes a lot of their revision time as they attempt to memorise them.

Some unexpected insights were noticed in this study. It was realised that some students lack revision skills. Teachers mostly expect that students will go home and revise what they have been taught in school without necessary finding out if they have the required skills to enable them to revise appropriately. Students should be taught learning skills if possible as part of their induction when starting their A-levels. Additionally, it became apparent that the numerous mathematical formulae in A-level chemistry is causing worries and stress among the students in the FE college. This was evident during the interviews and is reported in the interview data analysis, chapter 6. The students also explained that though they need a maths support session but it should be led by a chemistry teacher so that the maths application in chemistry will be easier and well understood by them. It was revealed that some students drop chemistry not because they do not like the subject but due to a career change. This emphasise the need for availability of more professional career advice sessions at year 11 and during induction at first year in A-levels to ensure that students have been enrolled into or chosen appropriate courses. The various literature reviewed in this study have depicted low availability of professional career and advice sessions in schools. Furthermore, the early chemistry leavers interviewed revealed another new insight. Some students are affected by their socio-economic status. This is because some students have the desire to study chemistry at A-level but they struggle to combine part time work and chemistry. A-level chemistry demands more time and detail, but some students because of their circumstances drop chemistry because they cannot combine it with their part time work. The findings from this study (section 10.2 to 10.10) confirm the various literature reviewed that A-level chemistry students have some challenges which affect their retention, achievement and progression in addition to the new insights that have been reported by this study.

I will recommend that chemistry educational videos which are appropriate for post-16 chemistry (covering the A-level chemistry specification) be made available to the students. Additionally, recorded lessons, if possible, should be made available online for the students to enhance students' revision and performance in assessment. The analysis from the questionnaire (Table 5.17.1) indicates a high demand for these resources, 67 out of 81 (86.7%) respondents agreed that chemistry educational videos enable them to have a meaningful revision and perform better in assessments. The students appreciate the use and importance of educational videos and need to be made available and supervised by teachers so that students get the best out of them. This resonates with Montes (2022) who indicated that students who are able to access learning materials, interact and collaborate with their tutors and peers online enjoy flexible, engaging and motivating courses of study. Additionally, the use of lecture recordings was indicated to be positively related to students' academic performance (Zhang *et al*, 2022; Hung *et al*., 2018; Robertson and Flowers, 2020). However, Bezerra (2020) reported that the lowest performing students have less motivation to use recorded videos and therefore other resources may be required to improve the learning experience for these students.

Furthermore, the respondents indicated in both the questionnaire and interview data analysis (Table 5.8.1 and sections 6.5) that A-level chemistry contains a lot of mathematical formulae. They expressed worry about needing to memorise all the numerous mathematical formulae. They indicated that it causes stress and they spend a lot of time during revision to memorise them because they need to get the formulae quoted correctly in order to get the work done. I recommend that the exam boards should give a consideration to provide the A-level chemistry students with formulae booklet as done in both A-level physics and maths. I do not think students are being tested on how to recall a formula in the exam, but the application of these formulae to answer questions. It is not a requirement for any chemistry job because it is provided for use when needed. The respondents mentioned that it will be a ‘‘game changer’’ if it is provided after using a model one which was provided during the first action research intervention. They indicated that it gave them the opportunity to focus on the work and the application of the formulae in answering the questions instead of struggling to remember the formulae before applying them. This may be one of the reasons why chemistry is viewed as a difficult subject as indicated in the reviewed literatures and in this research study. Further research could be done in other schools and colleges in England to find out how reflective the findings from this research will be. None of the research work reviewed reported on the use of such material to access its impact on teaching, learning and students’ performance. I will also recommend that much attention is given to the support session given to students. This study has revealed that the students need a maths support session which is led by a chemistry teacher. Literature reviewed has also revealed that many students struggle in A-level chemistry not because they cannot do the chemistry, but because they find the maths hard (Musson, 2013).

This research study and the literature reviewed have confirmed that students who take combined science route at GCSE are disadvantaged at A-level as compared to students who take separate sciences (Triple science). I will recommend that a further research study needs to be done to understand this better. Finally, I will recommend that further research study is conducted to get more students’ voices especially from the early chemistry leavers, who do not complete the subject after enrolling. For example, there was an unexpected insight of a socio-economic status impact on the early chemistry leavers which contributed to their inability to complete the two years. When addressed it could also improve retention, progression and achievement in A-level chemistry.

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Appendices

Appendix A: Consent Form for Questionnaire – Student Participants

UWE Bristol University of the West of England

Samuel Asamoah – Consent form for questionnaire, v.1 15th April 2019

Consent Form

Title: What are the Challenges in progression, retention and achievement in A-level chemistry in Further Education Colleges in England?

This consent form will have been given to you with the Participant Information Sheet. Please ensure that you have read and understood the information contained in the Participant Information Sheet and asked any questions before you sign this form. If you have any questions please contact a member of the research team, whose details are set out on the Participant Information Sheet

If you are happy to take part in the questionnaire, please sign and date the form. You will be given a copy to keep for your records.

- I have read and understood the information in the Participant Information Sheet which I have been given to read before asked to sign this form;
- I have been given the opportunity to ask questions about the study;
- I have had my questions answered satisfactorily by the research team;
- I agree that anonymised quotes may be used in the final Report of this study;
- I understand that my participation is voluntary and that I am free to withdraw at any time until the data has been anonymised, without giving a reason;
- I agree to take part in the research

Name (Printed)………………………………………………………………………. (Student/Parent).

Signature………………………………………………….. Date…………………….

*If the research participant is under 18 years, then parent or guardian can sign on his/her behalf.

Participant's Name (under 18 yrs)…………………………………………………………………………………………………

Signature……………………………………………………………. Date ………………………………………………………………………

Appendix B: Consent Form for Questionnaire – Teacher Participants

Samuel Asamoah – Consent form for questionnaire, v.1 15th April 2019

Consent Form

Title: What are the Challenges in progression, retention and achievement in A-level chemistry in Further Education Colleges in England?

This consent form will have been given to you with the Participant Information Sheet. Please ensure that you have read and understood the information contained in the Participant Information Sheet and asked any questions before you sign this form. If you have any questions please contact a member of the research team, whose details are set out on the Participant Information Sheet

If you are happy to take part in the questionnaire, please sign and date the form. You will be given a copy to keep for your records.

- I have read and understood the information in the Participant Information Sheet which I have been given to read before asked to sign this form;
- I have been given the opportunity to ask questions about the study;
- I have had my questions answered satisfactorily by the research team;
- I agree that anonymised quotes may be used in the final Report of this study;
- I understand that my participation is voluntary and that I am free to withdraw at any time until the data has been anonymised, without giving a reason;
- I agree to take part in the research

Name (Printed)………………………………………………………………………. (Teacher).

Signature………………………………………………….. Date……………………

Appendix C: Consent Form for Interview – Student Participants

Samuel Asamoah – Consent form for interview, v.1 15th April 2019

Consent Form

Title: What are the Challenges in progression, retention and achievement in A-level chemistry in Further Education Colleges in England?

This consent form will have been given to you with the Participant Information Sheet. Please ensure that you have read and understood the information contained in the Participant Information Sheet and asked any questions before you sign this form. If you have any questions please contact a member of the research team, whose details are set out on the Participant Information Sheet

If you are happy to take part in the interview, please sign and date the form. You will be given a copy to keep for your records.

- I have read and understood the information in the Participant Information Sheet which I have been given to read before asked to sign this form;
- I have been given the opportunity to ask questions about the study;
- I have had my questions answered satisfactorily by the research team;
- I agree that anonymised quotes may be used in the final Report of this study;
- I understand that my participation is voluntary and that I am free to withdraw at any time until the data has been anonymised, without giving a reason;
- I agree to take part in the research

Name (Printed)……………………………………………………………………… (Student/Parent).

Signature…………………………………………………… Date……………………

*If the research participant is under 18 years, then parent or guardian can sign on his/her behalf.

Participant's Name (under 18yrs) ………………………………………………………………………………………………

Signature………………………………………………………………… Date …………………………………………………………

Appendix D: Consent Form for Interview – Teacher Participants

Samuel Asamoah – Consent form for interview, v.1 15th April 2019

Consent Form

Title: What are the Challenges in progression, retention and achievement in A-level chemistry in Further Education Colleges in England?

This consent form will have been given to you with the Participant Information Sheet. Please ensure that you have read and understood the information contained in the Participant Information Sheet and asked any questions before you sign this form. If you have any questions please contact a member of the research team, whose details are set out on the Participant Information Sheet

If you are happy to take part in the interview, please sign and date the form. You will be given a copy to keep for your records.

- I have read and understood the information in the Participant Information Sheet which I have been given to read before asked to sign this form;
- I have been given the opportunity to ask questions about the study;
- I have had my questions answered satisfactorily by the research team;
- I agree that anonymised quotes may be used in the final Report of this study;
- I understand that my participation is voluntary and that I am free to withdraw at any time until the data has been anonymised, without giving a reason;
- I agree to take part in the research

Name (Printed)…………………………………………………………………………. (Teacher).

Signature…………………………………………………………. Date…………………….

Appendix E: Questionnaire – Student Participants

Samuel Asamoah- Questionnaire for students

Research Questionnaire – Please tick, circle or provide details where appropriate

Year group: One……… Two……

1. Gender: Male……. Female……Non-binary/third gender……… Prefer not to say………
2. Ethnic origin: White ………. Mixed/Multiple ethnic group………… Asian/Asian British Black/African/Caribbean/Black British…………. Other ethnic group……………………..
3. What type of chemistry did you do in GCSE? Chemistry (Triple Science) …………….. combined Science………… other science………….
4. What were your GCSE Chemistry results? (Triple Science) ………… Combined science…………….other science……………..
5. Indicate your results for GCSE Maths……………. GCSE English…………..
6. How many A Levels subjects are you doing? Three…….. Four………. Five………………
7. What is your possible future career? ……………………………………………………………
8. What is the university requirement in A-Level chemistry for this career? ……………..
9. Will you drop A-level chemistry if your career choice changes? Definitely yes………………… Probably yes…….Might or might not………Probably not……. Definitely not……………….. If yes explain …………………………………………………………………
10. Did you receive advice in choosing A Level chemistry as a subject? Yes…….. No………
11. If you have indicated yes, please state your source of help? Parents………. Teachers………. Friends………… Career Advisers………….. Other…………………………………
12. How accurate is each of the following statements as it applies to your decision in doing A-Level chemistry?

Source of information:	Tick the appropriate column for each question				
	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
It was a hard decision for me					
I took a long time to decide					
I had to consider many factors					
I relied heavily on advice from others					
It was really not my decision alone					
I wish I did not have to make this decision					

13. Please answer the following questions by ticking the appropriate column

Items	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
Teachers play a significant role during the teaching and learning process as they influence students' attitudes towards the study of chemistry.					
I sometimes do not attend class because I do not enjoy the chemistry lessons					
The teacher engages us in practical activities which enhances my understanding					
The practical part of a chemistry lesson encourages me to study it					
The use of recorded chemistry educational videos enable me to have a meaningful revision and perform better in assessment.					
Having the opportunity to listen to a recorded chemistry lesson enables me to recap and perform better in assessment					
Teacher demonstration of what he/she teaches will be useful					
The teacher uses stories or everyday life events to help me to understand the importance of what I learn					
Knowing the importance of what I study will make me learn more					
I revise my notes after the lesson and do at least five hours of private studies per week					
I enjoy A-level chemistry lessons					
Chemistry is an easy subject					
Chemistry is a difficult subject					
The mathematics involved makes it difficult to understand					
There are too many mathematical formulae that are difficult to remember in chemistry					
Chemistry is a challenging subject that is why I like it					
Chemistry is a boring subject and I do not like it					
It is difficult to recall facts, terminology and relationships of topics					
Understanding chemical principles and concepts is tricky and challenging					

It is difficult to draw on existing knowledge to show an understanding of the responsible use of chemistry in the society					
Selecting, organising and presenting chemical information clearly and logically is not easy					
It is not easy to explain and interpret chemical principles and concepts					
To apply chemical knowledge and understand familiar situations require long hours of studying					
It is difficult to make connections between different topics in chemistry					
Knowing that there will be a lot of help offered by teachers and the college helps me to decide to stay and complete the A-Level chemistry.					
Positive attitudes towards chemistry in the classroom will enable me to form sound concepts and thereby perform better academically.					
I often do not understand the meaning of words used to teach or to test in chemistry exam					
I often get low exam marks in chemistry due to a failure to understand the language of the questions.					
I have difficulties developing understanding of words such as salt, neutral, weak and reduction that have scientific meanings that differ from their everyday meanings					
I struggled to retain scientific meanings of this dual meaning vocabulary. The more frequently used every day meaning persist and affects my understanding and correct use of some of these words in chemistry.					

Appendix F: Participation Information Sheet for Interview - Teacher Participants

Samuel Asamoah- Participation information sheet for interview, v.1, 15th April 2019

Participant Information Sheet- Teachers

Title: What are the Challenges in progression, retention and achievement in A-level chemistry in Further Education Colleges in England?

You are invited to take part in research taking place at the University of the West of England, Bristol. It is self-funded. Before you decide whether to take part, it is important for you to understand why the study is being done and what it will involve. Please read the following information carefully and if you have any queries or would like more information please contact Samuel Asamoah, Faculty of ACE, University of the West of England, Bristol, Samuel2.Asamoah@live.uwe.ac.uk

Samuel Asamoah is conducting the research. My supervisors are Dr. Jane Andrews and Dr. Fay Lewis. Dr. Jane Andrews is also my Director of Studies.

Overview

You have been invited to take part in a doctoral research study exploring current issues around retention and achievement for A-level chemistry students in FE colleges in England.

What you have been asked to do

You have been asked to participate in a confidential and anonymous face-to-face interview session lasting around forty-five minutes. The results of my study will be analysed and used for my doctoral dissertation. The anonymised results may also be used in conference papers and peer-reviewed academic papers.

As a professional, I am interested in gaining information about your experience and views so the interview will ask you about these things. I will not be asking any questions about religion, area you live or family relationships. The purpose of the questions will be to gain information about your experience and your views to enrich the research being undertaken and the report to be presented.

You do not have to take part in this research. It is up to you to decide whether you want to be involved. If you do decide to take part, you will be given a copy of this information sheet to keep and will be asked to sign a consent form. If you do decide to take part, you are able to withdraw from the research without giving a reason until the point at which your data is anonymised and can therefore no longer be traced back to you. This point will take place on 15th June 2021 from the date you signed your consent form. If you want to withdraw from the study within this period, please write to Samuel Asamoah, Samuel2.Asamoah@live.uwe.ac.uk.

If you agree to take part, you will be asked to take part in research interviews. Samuel Asamoah will conduct this. You will be allowed to choose your own convenient time for the interview. I am experienced in the subject matter and sensitive to issues that may raise. There will be three interviews and each will take approximately forty-five minutes. The interviews will take place in college and during college hours. The subject and focus of the discussion will be about the research aim, objectives and questions. Your answers will be fully anonymised. Your interviews will be recorded on a voice recorder but the recording will not contain your name. A unique identifier will be used to re-identify you if you choose to withdraw from the study within the period. At the point of transcription, your voice recording will be deleted. Your data will be anonymised at this point and will be analysed with interviews data from other anonymised participants.

I do not foresee or anticipate any significant risk to you in taking part in this study. If, however, you feel uncomfortable at any time you can ask for the interview to stop. If you need any support during or after the interview, I will be able to put you in touch with suitable support agencies. I am a professional and experienced in conducting interviews, and are sensitive to the subject area. The interviews have been designed with these considerations in mind.

Data

All the information I receive from you will be treated in the strictest confidence. All the information that you give will be kept confidential and anonymised at 15th June 2021. The only circumstance where I may not be able to keep your information confidential is when you disclose during the interview that your studies is affecting your mental health and you have not sort any professional help. I will be obliged to inform the safeguarding lead in the College for you to get professional help. Hard copy of the research material will be kept in a secured locked and secure setting to which only the researcher will have access in accordance with the University's and the Data Protection Act 2018 and General Data Protection Regulation requirements. Voice recordings will be destroyed securely immediately after anonymised transcription. Your anonymised data will be analysed together with other interviews and file data, and I will ensure that there is no possibility of identification or re-identification from this point.

A report will be written containing my research findings. This report will be available on the University of the West of England's open-access Research Repository. A hard copy of the Report will be made available to all research participants if you would like to see it. Key findings will also be shared both within and outside the University of the West of England. The college where the research will be conducted will be given a copy if requested. Anonymous and non-identifying direct quotes may be used for publication and presentation purposes.

The project has been reviewed and approved by the University of the West of England University Research Ethics Committee. Any comments, questions or complaints about the ethical conduct of this study can be addressed to the Research Ethics Committee at the University of the West of England at:

Researchethics@uwe.ac.uk

If something goes wrong please you can contact Jane Andrews (jane.andrewsedu@uwe.ac.uk), who is my Director of Studies in the first instance.
If you would like any further information about the research, please contact in the first instance: Samuel Asamoah, Samuel2.Asamoah@live.uwe.ac.uk

Thank you for agreeing to take part in this study. You will be given a copy of this Participant Information Sheet and your signed Consent Form to keep.

Appendix G: Participation Information Sheet for Interview – Student Participants

Samuel Asamoah- Participation information sheet for interview, v.1, 15th April 2019

Participant Information Sheet- Students

Title: What are the Challenges in progression, retention and achievement in A-level chemistry in Further Education Colleges in England?

You are invited to take part in research taking place at the University of the West of England, Bristol. It is self-funded. Before you decide whether to take part, it is important for you to understand why the study is being done and what it will involve. Please read the following information carefully and if you have any queries or would like more information please contact Samuel Asamoah, Faculty of ACE, University of the West of England, Bristol, Samuel2.Asamoah@live.uwe.ac.uk

Samuel Asamoah is conducting the research. My supervisors are Dr. Jane Andrews and Dr. Fay Lewis. Dr. Jane Andrews is also my Director of Studies.

Overview

You have been invited to take part in a doctoral research study exploring current issues around retention and achievement for A-level chemistry students in FE colleges in England.

What you have been asked to do

You have been asked to participate in a confidential and anonymous face-to-face interview session lasting around 45 minutes. The results of my study will be analysed and used for my doctoral dissertation. The anonymised results may also be used in conference papers and peer-reviewed academic papers.

As a student, I am interested in gaining information about your experience and views so the interview will ask you about these things. I will not be asking any questions about religion, area you live or family relationships. The purpose of the questions will be to gain information about your experience and your views to enrich the research being undertaken and the report to be presented.

You do not have to take part in this research. It is up to you to decide whether you want to be involved. If you do decide to take part, you will be given a copy of this information sheet to keep and will be asked to sign a consent form. If you do decide to take part, you are able to withdraw from the research without giving a reason until the point at which your data is anonymised and can therefore no longer be traced back to you. This point will take place on 15th June 2021 from the date you signed your consent form. If you want to withdraw from the study within this period, please write to Samuel Asamoah, Samuel2.Asamoah@live.uwe.ac.uk. Deciding not to take part or to withdrawal from the study does not have any penalty. It will not affect the standard of care you will receive or your chemistry assessment marks. On the other hand, participation in the research will have no bearing on your learning and grades as A-level student.

If you agree to take part, you will be asked to take part in research interviews. Samuel Asamoah will conduct this. You will be allowed to choose your own convenient time for the interview. I am experienced in the subject matter and sensitive to issues that may raise. There will be three interviews and each will take approximately forty-five minutes. The interviews will take place in college and during college hours. The subject and focus of the discussion will be about the research aim, objectives and questions. Your answers will be fully anonymised. Your interviews will be recorded on a voice recorder but the recording will not contain your name. A unique identifier will be used to re-identify you if you choose to withdraw from the study within the period. At the point of transcription, your voice recording will be deleted. Your data will be anonymised at this point and will be analysed with interviews data from other anonymised participants.

I do not foresee or anticipate any significant risk to you in taking part in this study. If, however, you feel uncomfortable at any time you can ask for the interview to stop. If you need any support during or after the interview, I will be able to put you in touch with suitable support agencies. I am a professional and experienced in conducting interviews, and are sensitive to the subject area. The interviews have been designed with these considerations in mind.

Data

All the information I receive from you will be treated in the strictest confidence. All the information that you give will be kept confidential and anonymised at 15th June 2021. The only circumstance where I may not be able to keep your information confidential is when you disclose during the interview that your studies is affecting your mental health and you have not sort any professional help. I will be obliged to inform the safeguarding lead in the College for you to get professional help. Hard copy of the research material will be kept in a secured locked and secure setting to which only the researcher will have access in accordance with the University's and the Data Protection Act 2018 and General Data Protection Regulation requirements. Voice recordings will be destroyed securely immediately after anonymised transcription. Your anonymised data will be analysed together with other interviews and file data, and I will ensure that there is no possibility of identification or re-identification from this point.

A report will be written containing my research findings. This report will be available on the University of the West of England's open-access Research Repository. A hard copy of the Report will be made available to all research participants if you would like to see it. Key findings will also be shared both within and outside the University of the West of England. The college where the research will be conducted will be given a copy if requested. Anonymous and non-identifying direct quotes may be used for publication and presentation purposes.

The project has been reviewed and approved by the University of the West of England University Research Ethics Committee. Any comments, questions or complaints about the ethical conduct of this study can be addressed to the Research Ethics Committee at the University of the West of England at:

Researchethics@uwe.ac.uk

If something goes wrong please you can contact Jane Andrews (jane.andrewsedu@uwe.ac.uk), who is my Director of Studies in the first instance.
If you would like any further information about the research, please contact in the first instance: Samuel Asamoah, Samuel2.Asamoah@live.uwe.ac.uk

Thank you for agreeing to take part in this study. You will be given a copy of this Participant Information Sheet and your signed Consent Form to keep.

Appendix H: Participation Information Sheet for Questionnaire– Student Participants

Samuel Asamoah- Participation information sheet for questionnaire, v.1, 15th April 2019

Participant Information Sheet – Students

Title: What are the Challenges in progression, retention and achievement in A-level chemistry in Further Education Colleges in England?

You are invited to take part in research taking place at the University of the West of England, Bristol. It is self-funded. Before you decide whether to take part, it is important for you to understand, why the study is being done and what it will involve. Please read the following information carefully and if you have any queries or would like more information please contact Samuel Asamoah, Faculty of ACE, University of the West of England, Bristol, Samuel2.Asamoah@live.uwe.ac.uk

Samuel Asamoah is conducting the research. My supervisors are Dr. Jane Andrews and Dr. Fay Lewis. Dr. Jane Andrews is also my Director of Studies.

Overview

You have been invited to take part in a doctoral research study exploring current issues around retention and achievement for A-level chemistry students in FE colleges in England.

What you have been asked to do

You have been asked to participate in a confidential and anonymous questionnaire. The results of my study will be analysed and used for my doctoral dissertation. The anonymised results may also be used in conference papers and peer-reviewed academic papers.

As a student, I am interested in gaining information about your experience and views so the questionnaire will ask you about these things. I will not be asking any questions about name, religion, area you live or family relationships. However, gender and ethnicity will be required as part of the questionnaire. The purpose of the questions will be to gain information about your experience and your views to enrich the research being undertaken and the report to be presented. The questionnaire will be administered to you online via Qualtrics

You do not have to take part in this research. It is up to you to decide whether you want to be involved. If you do decide to take part, you will be given a copy of this information sheet to keep and will be asked to sign a consent form. Deciding not to take part in the study does not have any penalty. It will not affect the standard of care you will receive or your chemistry assessment marks. On the other hand, participation in the research will have no bearing on your learning and grades as A-level student.

If you agree to take part, you will be asked to take part in research questionnaire. Samuel Asamoah will conduct this. I am experienced in the subject matter and sensitive to issues that may raise. The questionnaire will take approximately twenty minutes. The subject and focus of the questionnaire will be about the research aim and questions. Your answers will be fully anonymised.

I do not foresee or anticipate any significant risk to you in taking part in this study. If you need any support during or after the questionnaire, I will be able to put you in touch with suitable support agencies. I am a professional and experienced in administering the questionnaire, and are sensitive to the subject area. The questionnaire has been designed with these considerations in mind.

Your data

All the information I receive from you will be treated in the strictest confidence. All the information that you give will be kept confidential. Hard copy of the research material will be kept in a secured locked and secure setting to which only the researcher will have access in accordance with the University's and the Data Protection Act 2018 and General Data Protection Regulation requirements. Your anonymised data will be analysed together with other questionnaires and file data, and I will ensure that there is no possibility of identification.

A report will be written containing my research findings. This report will be available on the University of the West of England's open-access Research Repository. A hard copy of the report will be made available to all research participants if you would like to see it. Key findings will also be shared both within and outside the University of the West of England. The college where the research will be conducted will be given a copy if requested. Anonymous and non-identifying direct quotes may be used for publication and presentation purposes.

The project has been reviewed and approved by the University of the West of England University Research Ethics Committee. Any comments, questions or complaints about the ethical conduct of this study can be addressed to the Research Ethics Committee at the University of the West of England at:

Researchethics@uwe.ac.uk

If something goes wrong please you can contact Jane Andrews (jane.andrewsedu@uwe.ac.uk), who is my Director of Studies in the first instance. If you would like any further information about the research, please contact in the first instance: Samuel Asamoah, Samuel2.Asamoah@live.uwe.ac.uk

Thank you for agreeing to take part in this study. You will be given a copy of this Participant Information Sheet and your signed Consent Form to keep.

Appendix I: Participation Information Sheet for Questionnaire – Teacher Participants

Samuel Asamoah- Participation information sheet for questionnaire, v.1, 15th April 2019

Participant Information Sheet – Teachers

Title: What are the Challenges in progression, retention and achievement in A-level chemistry in Further Education Colleges in England?

You are invited to take part in research taking place at the University of the West of England, Bristol. It is self-funded. Before you decide whether to take part, it is important for you to understand, why the study is being done and what it will involve. Please read the following information carefully and if you have any queries or would like more information please contact Samuel Asamoah, Faculty of ACE, University of the West of England, Bristol, Samuel2.Asamoah@live.uwe.ac.uk

Samuel Asamoah is conducting the research. My supervisors are Dr. Jane Andrews and Dr. Fay Lewis. Dr. Jane Andrews is also my Director of Studies.

Overview

You have been invited to take part in a doctoral research study exploring current issues around retention and achievement for A-level chemistry students in FE colleges in England.

What you have been asked to do

You have been asked to participate in a confidential and anonymous questionnaire. The results of my study will be analysed and used for my doctoral dissertation. The anonymised results may also be used in conference papers and peer-reviewed academic papers.

As a teacher, I am interested in gaining information about your experience and views so the questionnaire will ask you about these things. I will not be asking any questions about name, religion, area you live or family relationships. However, gender and ethnicity will be required as part of the questionnaire. The purpose of the questions will be to gain information about your experience and your views to enrich the research being undertaken and the report to be presented. The questionnaire will be administered to you online via Qualtrics

You do not have to take part in this research. It is up to you to decide whether you want to be involved. If you do decide to take part, you will be given a copy of this information sheet to keep and will be asked to sign a consent form. Deciding not to take part in the study does not have any penalty.

If you agree to take part, you will be asked to take part in research questionnaire. Samuel Asamoah will conduct this. I am experienced in the subject matter and sensitive to issues that may raise. The questionnaire will take approximately twenty minutes. The subject and focus of the questionnaire will be about the research aim and questions. Your answers will be fully anonymised.

I do not foresee or anticipate any significant risk to you in taking part in this study. If you need any support during or after the questionnaire, I will be able to put you in touch with suitable support agencies. I am a professional and experienced in administering the questionnaire, and are sensitive to the subject area. The questionnaire has been designed with these considerations in mind.

Your data

All the information I receive from you will be treated in the strictest confidence. All the information that you give will be kept confidential. Hard copy of the research material will be kept in a secured locked and secure setting to which only the researcher will have access in accordance with the University's and the Data Protection Act 2018 and General Data Protection Regulation requirements. Your anonymised data will be analysed together with other questionnaires and file data, and I will ensure that there is no possibility of identification.

A report will be written containing my research findings. This report will be available on the University of the West of England's open-access Research Repository. A hard copy of the report will be made available to all research participants if you would like to see it. Key findings will also be shared both within and outside the University of the West of England. The college where the research will be conducted will be given a copy if requested. Anonymous and non-identifying direct quotes may be used for publication and presentation purposes.

The project has been reviewed and approved by the University of the West of England University Research Ethics Committee. Any comments, questions or complaints about the ethical conduct of this study can be addressed to the Research Ethics Committee at the University of the West of England at:

Researchethics@uwe.ac.uk

If something goes wrong please you can contact Jane Andrews (jane.andrewsedu@uwe.ac.uk), who is my Director of Studies in the first instance. If you would like any further information about the research, please contact in the first instance: Samuel Asamoah, Samuel2.Asamoah@live.uwe.ac.uk

Thank you for agreeing to take part in this study.
You will be given a copy of this Participant Information Sheet and your signed Consent Form to keep.

Appendix J: Intervention One Interview Questions – Student Participants

UWE Bristol University of the West of England

Samuel Asamoah – Interview Guiding Questions – Students Participants
Semi-structured interview

The following questions serve as guidelines to show how the interview will progress.

Duration of interview: 40 minutes

Introduction

Thank you once again for taking part in this research work.

The questions will focus on the first action research intervention cycle with the caption: Mathematics involved in A-Level chemistry makes it difficult to understand and there are too many chemical formulae that are difficult to remember.

This feeds into the overall research topic: What are the challenges in progression, retention and achievement in A-level chemistry?

There are no right or wrong answers to these questions; I am interested in what you have to say.

Feel free to ask me to stop the recording at any time of the duration if you feel uncomfortable. Your identity and what you say will not be divulged.

1. Did the sessions help you to understand the mathematics in A-Level chemistry better? Please explain
2. What is your perception about the maths in chemistry after these sessions?
3. What effect will this have on your revision and achievement?
4. Would you recommend that maths support session is set up for A-level chemistry? Please explain
5. Could you explain whom you would prefer to teach such a lesson?
6. How would you want it to be set up so that it could be beneficial to you?
7. How did you find the use of the formulae booklet in the activities and assessment?
8. Could you explain if you would like a similar formulae booklet to be provided during assessments and in the final exam?
9. What benefit would that be for you?
10. Could you explain if the provision of such a booklet would improve your achievement?

11. If a similar formulae booklet is provided during assessments and in the final exam, would that make you feel more confident to complete the A-level chemistry? Explain please
12. How would knowing that a formulae booklet be provided in both assessments and final exam affect the way you revise for exam?
13. How would the setting up of a Maths support session and provision of mathematical formulae booklet in assessments and final exam motivate and encourage you to learn and achieve better in A-Level chemistry?
14. What have you gained from these sessions?
15. Is there any additional information you would like to share concerning this intervention?

Appendix K: Intervention Two Interview Questions – Student Participants

Samuel Asamoah – Second Interview Guiding Questions – Students Participants

Semi-structured interview

The following questions serve as guidelines to show how the interview will progress.

Duration of interview: 40 minutes

Introduction

Thank you once again for taking part in this research work.

The questions will focus on the second action research intervention cycle with the caption: To apply chemical knowledge and understand familiar situations requires long hours of studying, and it is tricky to understand and use the chemical principles and concepts.

This feeds into the overall research topic: What are the challenges in progression, retention and achievement in A-level chemistry?

There are no right or wrong answers to these questions; I am interested in what you have to say.

Feel free to ask me to stop the recording at any time of the duration if you feel uncomfortable. Your identity and what you say will not be divulged.

1. Could you explain your study method in chemistry during your independent learning before the intervention? Is this different from other subjects you are studying?
2. Please could you explain the approach and skills you have been using to answer chemistry questions before the intervention? For example, what do you consider and how do you go about it?
3. Could you explain if any of the principles and concepts used during the sessions were completely unknown to you?

4. Did the approach and the study method learnt during the sessions helped you to understand how to use chemistry principles and concepts in answering chemistry questions more accurately or quickly? If yes please explain or if know please explain
5. Has the notion that applying chemical knowledge and understanding familiar situations is difficult changed from before the sessions? Please explain
6. Did you gain anything from these sessions? If yes, please explain and explain if no too.
7. Could you explain how this will improve your study method and revision?
8. Would this enable you to improve your responses in assessments and exam? Please explain

10. Do you think the intervention will help you to achieve your target grade or improve your assessments grades and the final exam grade? If so, why? And if not why?

11. What is your required grade for your UCAS application in chemistry or the route for your future career? How would your experience gained from these sessions help you to achieve your required grade for your progression?

11. Do you think the interventions would help you to use chemistry principles and concepts that involve maths to answer questions with a better understanding? If so, why? And if not why?

12. How confident are you to use the skills and approach learnt in the sessions? Very sure, somehow, not sure. Please explain.

13. Do you have anything further you would like to say concerning the intervention? It does not matter even if is negative.

Appendix L: Intervention Three Interview Questions – Student Participants

Samuel Asamoah – Third Interview Guiding Questions – Students Participants
Semi-structured interview

The following questions serve as guidelines to show how the interview will progress.

Duration of interview: **40 minutes**

Introduction

Thank you once again for taking part in this research work.

The questions will focus on the third action research intervention cycle with the captions:

1. It is not easy to select, organise and present chemical information clearly and logically.
2. It is complicated to make connections between different topics.

These feed into the overall research topic: What are the challenges in progression, retention and achievement in A-level chemistry?

There are no right or wrong answers to these questions; I am interested in what you have to say.

Feel free to ask me to stop the recording at any time of the duration if you feel uncomfortable. Your identity and what you say will not be divulged.

1. Please could you explain the approach and skills you have been using to select, organise and present chemical information before the intervention? For example, what do you consider and how do you go about it?
2. Did the approach and the skills learned during the sessions helped you to understand how to select, organise and present chemical information clearly and logically? If yes please explain or if no please explain
3. Did you feel confident in your knowledge about the skills and strategies to select, organise and present chemical information clearly and logically before these sessions? Please explain

4. Has the notion that it is complicated to make connections between different topics changed from before the sessions? Please explain
5. Did you gain anything else from these sessions? If yes or no, please explain.
6. Do you think the interventions would help you to select, organise and present chemical information clearly and logically? If so, why? And if not why?
7. Would these enable you to improve your responses in practise questions and exams? Please explain

8. Do you think the intervention will help you to achieve your target grade or improve it in the final? If so, why? And if not why?
9. How confident are you to use the skills and approach learnt in the sessions? Very sure, somehow, not sure. Please explain.
10. Did you perceive that you would be successful in the summer exam before these sessions? If so, did these feelings remain after the sessions? Please explain. If not please explain.
11. Do you feel like you have enough information as how to select, organise and present chemical information clearly and logically? Please explain if yes or no
12. Could you attribute this confidence level as partly due to the intervention sessions and strategies learnt during the research? How and why?
13. If you have said no to questions 11, please could you explain what may still be some of the challenges you still have concerning how to select, organise and present chemical information clearly and logically?
14. Reflecting back on the intervention sessions, what has helped you the most concerning your preparation for the chemistry summer exam?
15. Do you have anything further you would like to say concerning the intervention? It does not matter even if it is negative.

Appendix M: Interview Guiding Questions – Early Chemistry Leavers

Samuel Asamoah – Interview Guiding Questions – Students Participants
Semi-structured interview

The following questions serve as guidelines to how the interview will progress.

Duration of interview: **45 minutes**

Introduction

Thank you once again for taking part in this research work.

The questions will focus on the challenges in progression, retention and achievement in A-level chemistry. There are no right or wrong answers to these questions; I am interested in what you have to say.

Feel free to ask me to stop the recording at any time of the duration if you feel uncomfortable. Your identity and what you say will not be divulged.

<u>Questions about choosing A-level chemistry and progression</u>

1. Why did you choose to enroll in A-level chemistry?
2. a). Could you tell me your future career choice?
   b). How did this influence your enrolment for A-level chemistry?
3. What is the university requirement in chemistry for your future career?
4. Did you drop A-level chemistry because of your future career path change?
5. Did you receive any advice in choosing A-level chemistry as a subject? Can you explain?
6. a). How many A-level subjects are you currently doing?
   b). How do you feel in terms of workload and time management?

<u>Questions about challenges in retention</u>

7. Can you explain/tell me some of the challenges you faced in A-level chemistry?
8. How did your mathematical knowledge enhance or affect your study of chemistry?
9. How did you find the explanation of the principles and terminologies in A-level chemistry and the effect of these on your learning?
10. Can you explain to me how you find making connections between different topics in chemistry? How did this affect or enhance your learning?
11. What affected or enhanced your attitude towards chemistry in the classroom?
12. What would you suggest could have made you enjoy chemistry more both in class and during revision?
13. Were you ever worried about not understanding the language used in teaching and testing in chemistry exam? Explain please

14. How often did you get low exam marks in chemistry due to a failure to understand the language of the questions? (rank 1 - 5, 1 as the highest)

<u>Questions about challenges in achievement</u>

15. a). How did you feel about asking questions during discussions in class?
    b). Did you ask questions if you did not understand something, or not sure what to do, or want to know more? Why or why not?
16. To the best of your mind, how best can students be motivated to achieve well in chemistry? Explain
17. What would you suggest could be done to help students to remain and complete A-level chemistry?
18. What do you think students could do to make the study of A-level chemistry successful? Explain
19. How did you find tests, activities and homework? Explain
20. How did you find the mental health stretch in chemistry?
21. Were the resources given to you or directed to be used helpful and supportive for your studies? Explain
22. Did you ever work with your peers outside class? How did it help? Explain
23. Did you develop any skills in chemistry that are helpful to you in your new subject area? Please explain

Appendix N: Interview Guiding Questions – Teacher Participants

Samuel Asamoah – Interview Guiding Questions – Teachers Participants

Semi-structured interview

The following questions serve as guidelines to show how the interview will progress.

Duration of interview: 45 minutes

Introduction

Thank you for taking part in this research work.

The questions will focus on the challenges chemistry lecturers foresee as hindrances to students' achievement and progression in A-level chemistry in an FE College and how to support students to achieve well and enhance retention.

This feeds into the overall research topic: What are the challenges in progression, retention and achievement in A-level chemistry?

There are no right or wrong answers to these questions; I am interested in what you have to say.

Feel free to ask me to stop the recording at any time of the duration if you feel uncomfortable. Your identity and what you say will not be divulged.

1. Do students receive advice in choosing A-Level chemistry as a subject in the college? Yes........ No............ Please explain

2. Do you have any idea why the students choose to study A-level chemistry? Please explain

3. Do some of the students drop chemistry? If yes please explain

4. What are some of the reasons why students drop chemistry?

5. What are some of the challenges students face in studying A-level chemistry? How do such challenges hinder their progression and retention?

6. How do learners' perceived challenges of A-level chemistry influence their achievement and progression?

7. How do the understanding of the Chemistry concepts and principles enhance students’ achievement and progression?

8. Are students comfortable to select, organise and present chemical information clearly and logically? What effect does it have on their achievement and progression? What may be the challenge?

9. Do you consider the application of chemical knowledge and understanding familiar situations as a challenge students face in studying chemistry? Yes or No. Please explain
10. Are students able to make connections between different topics? How does this enhance or hinder their performance?

11. Would you consider the mathematics and the various mathematical formulae involve in A-level chemistry as one of the challenges for students’ achievement and retention? Explain
12. What would be your recommendation or suggestion to overcome such a challenge if you have answered yes?

13. Will an understanding of the responsible use of chemistry in the society give a positive attitude in studying chemistry by students? Explain

14. Do you think fostering more individuality, giving students a chance to design their own experiments, will increase students’ interest in chemistry?

15. Would you explain if the lack of more experiments in A-level has any effect in dropping the subject? Does the practical part of a chemistry lesson encourage students to study it?
16. Can you explain if teachers play a significant role during the teaching and learning process to influence students’ attitudes towards the study of chemistry?

17. Will positive attitudes towards chemistry in the classroom enable students to form sound concepts and thereby perform better academically?

18. Can the use of recorded chemistry educational videos enhance students learning and understanding? Please explain

19. Any further ideas or suggestions about challenges students face in studying A-level chemistry and how to support them or they would be able overcome them so that they can achieve well.

Appendix O: Privacy Notice for Research Participants

Samuel Asamoah- Privacy Notice, v.1 April 2019

Privacy Notice for Research Participants

Purpose of the Privacy Notice

This privacy notice explains how the University of the West of England, Bristol (UWE) collects, manages and uses your personal data before; during and after you participate in the research, which is being conducted by Samuel Asamoah. The aim of this research is to explore current issues around retention and achievement for A-level chemistry students in FE colleges in England. The research is a practical action research in an interpretive-qualitative framework involving students and teachers in one FE College in England.

The study seeks to

- To explore the experiences of chemistry A level students in an FE college and identify any challenges.
- Provide better understanding of the issues and challenges of A-level chemistry students in FE College who applied to do chemistry and stay to complete the subject.
- Identify through structured questionnaire and action research interventions how best students could be motivated and encouraged to complete A-level chemistry in FE College successfully.
- Identify strategies that may help colleague chemistry teachers, educational institutions and stakeholders to improve retention and achievement rate of A-level chemistry in FE colleges in England.

  The research involves FE students and teachers. The appropriate informed consent will be signed before their participation

The research questions under consideration in this research study are as follows:

1. How do learners' perceived challenges of A-level chemistry concepts influence their achievement and progression?
2. What challenges do chemistry lecturers foresee as hindrances to students' achievement and progression?
3. How does actual understanding of the Chemistry concepts enhance students' achievement and progression?
4. How can practical action research intervention(s) help to solve the perceived challenges students face in A-level chemistry?

The research questions have been designed to address the preceding broader research aims and objectives

'Personal data' means any information relating to an identified or identifiable natural person (the data subject). An 'identifiable natural person' is one who can be identified, directly or indirectly, including by reference to an identifier such as a name, an identification number, location data, an online identifier, or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person.

This privacy notice adheres to the General Data Protection Regulation (GDPR) principle of transparency. This means it gives information about:

- How and why your data will be used for the research;
- What your rights are under GDPR; and
- How to contact UWE Bristol and the project lead in relation to questions, concerns or exercising your rights regarding the use of your personal data.

This Privacy Notice should be read in conjunction with the Participant Information Sheet and Consent Form provided to you before you agree to take part in the research.

Why are we processing your personal data?

UWE Bristol undertakes research under its public function to provide research for the benefit of society. As a data controller we are committed to protecting the privacy and security of your personal data in accordance with the (EU) 2016/679 the General Data Protection Regulation (GDPR), the Data Protection Act 2018 (or any successor legislation) and any other legislation directly relating to privacy laws that apply (together "the Data Protection Legislation"). General information on Data Protection law is available from the Information Commissioner's Office (https://ico.org.uk/).

How do we use your personal data?

We use your personal data for research with appropriate safeguards in place on the lawful bases of fulfilling tasks in the public interest, and for archiving purposes in the public interest, for scientific or historical research purposes. We will always tell you about the information we wish to collect from you and how we will use it. We will not use your personal data for automated decision making about you or for profiling purposes.

Our research is governed by robust policies and procedures and, where human participants are involved, is subject to ethical approval from either UWE Bristol's Faculty or University Research Ethics Committees. This research has been approved by the University of the West of England University Research Ethics Committee. Any comments, questions or complaints about the ethical conduct of this study can be addressed to the Research Ethics Committee at the University of the West of England at: Researchethics@uwe.ac.uk

The research team adhere to the **Ethical guidelines of the British Educational Research Association (and/or the principles of the Declaration of Helsinki, 2013) and the principles of the General Data Protection Regulation (GDPR).**

For more information about UWE Bristol's research ethics approval process please see our Research Ethics webpages at:

www1.uwe.ac.uk/research/researchethics

What data do we collect?

The data we collect will vary from project to project. Researchers will only collect data that is essential for their project. The specific categories of personal data processed are described in the Participant Information Sheet provided to you with this Privacy Notice

Who do we share your data with?

We will only share your personal data in accordance with the attached Participant Information Sheet and your Consent.

How do we keep your data secure?

We take a robust approach to protecting your information with secure electronic and physical storage areas for research data with controlled access. If you are participating in a particularly sensitive project UWE Bristol puts into place additional layers of security. UWE Bristol has Cyber Essentials information security certification.

Alongside these technical measures there are comprehensive and effective policies and processes in place to ensure that users and administrators of information are aware of their obligations and responsibilities for the data they have access to. By default, people are only granted access to the information they require to perform their duties. Mandatory data protection and information security training is provided to staff and expert advice available if needed.

How long do we keep your data for?

Your personal data will only be retained for as long as is necessary to fulfil the cited purpose of the research. The length of time we keep your personal data will depend on several factors including the significance of the data, funder requirements, and the nature of the study. Specific details are provided in the attached Participant Information Sheet. Anonymised data that falls outside the scope of data protection legislation as it contains no identifying or identifiable information may be stored in UWE Bristol's research data archive or another carefully selected appropriate data archive.

Your Rights and how to exercise them

Under the Data Protection legislation you have the following **qualified** rights:

(1) The right to access your personal data held by or on behalf of the University;

(2) The right to rectification if the information is inaccurate or incomplete;
(3) The right to restrict processing and/or erasure of your personal data;
(4) The right to data portability;
(5) The right to object to processing;
(6) The right to object to automated decision making and profiling;
(7) The right to complain to the Information Commissioner's Office (ICO).

Please note, however, that some of these rights do not apply when the data is being used for research purposes if appropriate safeguards have been put in place.

We will always respond to concerns or queries you may have. If you wish to exercise your rights or have any other general data protection queries, please contact UWE Bristol's Data Protection Officer (dataprotection@uwe.ac.uk).

If you have any complaints or queries relating to the research in which you are taking part please contact either the research project lead, whose details are in the attached Participant Information Sheet, UWE Bristol's Research Ethics Committees (research.ethics@uwe.ac.uk) or UWE Bristol's research governance manager (Ros.Rouse@uwe.ac.uk)

Appendix P: Ethical Approval

Faculty of Arts, Creative Industries and Education
Frenchay Campus
Coldharbour Lane
Bristol BS16 2QY

Tel: 0117 328 1170

UWE REC REF No: ACE.21.01.023

22nd April 2021

Samuel Asamoah

Dear Samuel

Application title: What are the Challenges in progression, retention and achievement in A-level chemistry in Further Education colleges in England?

Thank you for responding to the conditions raised in my letter to you of 24th March 2021.

I can now confirm full ethics approval for your project, but please note the proviso below.

Please note: In light of the current situation regarding COVID-19, we can only authorise an immediate start for activities that do not breach either national laws or University. In these uncertain times, law and policy may change swiftly and frequently.

We are, however, continuing to scrutinise and grant ethical approval for activities that cannot take place at present, to ensure that once the situation changes and activities can go ahead, the research is not unnecessarily delayed.

What this means for your application:

1. If your application DOES NOT involve activities affected by the current crisis (e.g. online surveys or telephone interviews etc.) then you may start your research as soon as you receive this formal notification of your ethical approval;
2. If your application DOES involve activities affected by the current crisis then you must not start your research until you are lawfully and safely able to do so, and when it does not breach the University's policies. This will affect the dates you have supplied on your application form in relation to start and finish. When you have new dates, please can you write to us in order that we can add this information to your file.

If you are a doctoral student and this will affect your research timetable, please speak to your Director of Studies and the Graduate School for advice on how time delays will be supported by the University.

The following standard conditions apply to all research given ethical approval by a UWE Research Ethics Committee:

Appendix Q: Proposed Chemistry Formular booklet

Suggested Formulae booklet

A-level Chemistry

By

Samuel Asamoah

Disclaimer: This is currently not allowed in exam. Use it mainly to help you to get familiar with the various formulae during revision.

Calculating moles of a substance

n = m ÷ Mr

Where

n = moles

m = mass

Mr = molar mass

Calculating concentration and mole of a solution

C = n ÷V

Where

n = moles

C = concentration in mol/dm^3

V = volume in dm^3

Mass concentration

Mass concentration (g/dm^3) **=** concentration (mol/dm^3) x Molar mass (g/mol)

Molar mass **=** the sum of all the atomic masses in the compound

Moles from volume of a gas

n = v ÷ V

Where

n = moles

v = volume of the gas under consideration which is measured in dm^3

V = molar volume of gas (volume of one of a gas at RTP = 24dm^3 or 24000cm^3)

The ideal gas equation

$PV = nRT$

where

n = moles

P = Pressure (Pa)

V = Volume (m^3)

T = Temperature (K)

R = Ideal gas constant ($8.31 J mol^{-1} K^{-1}$)

Avogadro constant

Atoms or Molecules = n x N_A

n = moles

N_A = Avogadro constant, (6.02×10^{23})

Percentage Uncertainty calculations

Percentage uncertainty for a burette and Thermometer

$$\% \text{ uncertainty} = \frac{2 \times \text{maximum uncertainty}}{\text{Quantity measured}} \times 100\%$$

Percentage Uncertainty for balance

$$\% \text{ uncertainty} = \frac{2 \times \text{maximum uncertainty}}{\text{Mass weighed}} \times 100\%$$

Percentage uncertainty for pipette

$$\% \text{ uncertainty} = \frac{\text{maximum uncertainty}}{\text{Volume measured}} \times 100\%$$

Percentage uncertainty for measuring cylinder

$$\% \text{ uncertainty} = \frac{\text{maximum uncertainty}}{\text{Volume measured}} \times 100\%$$

Percentage uncertainty for volumetric flask

$$\% \text{ uncertainty} = \frac{\text{maximum uncertainty}}{\text{Volume measured}} \times 100\%$$

Percentage Yield

$$\% \text{ Yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

Percentage Atom Economy

$$\% \text{ Atom Economy} = \frac{\text{Molar mass of desired product}}{\text{Molar mass of all products}} \times 100\%$$

Arrhenius Equation to determine Activation Energy Graphically

Arrhenius equation: $k = Ae^{-Ea/RT}$

Where

R = Gas constant ($8.31 Jmol^{-1}K^{-1}$)

$$\ln k = -\frac{Ea}{R} \times \frac{1}{T} + \ln A$$

$$y = mx + c$$

Equilibrim constant in terms of contration

$$Kc = \frac{[\text{concentration of products}]}{[\text{concentration of reactants}]}$$

Where

Kc = equilibrium constant

$$Kc = \frac{[C]^p[D]^q}{[A]^m[B]^n}$$

$$mA + nB \rightleftharpoons pC + qD$$

[ ] means equilibrium concentration

m,n,p,q are the number of molecules from the balancing equation for each compound

Equilibrium concentration in terms of pressure

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

$$Kp = \frac{P^2(NH_3)}{P(N_2) \times P^3(H_2)}$$

Where

Kp = equilibrium constant in terms of pressure

p is partial pressure of that gas

Total moles at equilibrium = Sum of all moles at the equilibrium

Mole fraction = mole of a specie at equil ÷ total moles of all gases at equilibrium

Partial pressure = Mole fraction of a species x Total Pressure for all gases

<u>Determination of enthalpy change from an experimental result</u>

Energy transferred

$q = mc\,\Delta T$

q is energy transferred

m is mass of solution

C is specific heat capacity of water

ΔT is temperature change

$\Delta H = q/n$

ΔH is the enthalpy change of a reaction

q is the energy transferred

n is the amount of moles of the limiting reagent

Note: If the Temperature goes up during the reaction, then ΔH is negative but if the temperature goes down, them ΔH is positive

<u>Calculating Enthalpy Changes from Average Bond Enthalpies</u>

$\Delta_r H = \sum(\text{ reactants bond enthalpies }) - \sum(\text{ products bond enthalpies})$

<u>Using Hess's law to determine enthalpy changes from enthalpy of formation</u>

$\Delta_r H = \sum(\Delta_f H \text{ products}) - \sum(\Delta_f H \text{ reactants})$

<u>Using Hess's law to determine enthalpy changes from enthalpy of combustion</u>

$\Delta_r H = \sum(\Delta_c H \text{ reactants}) - \sum(\Delta_c H \text{ products})$

Calculating pH of solutions

Strong acid

$pH = -\log [H^+]$

$[H^+] = 10^{-pH}$

Weak Acid

$HA \rightleftharpoons H^+ + A^-$

$$Ka = \frac{[H^+][A^-]}{[HA]}$$

$pKa = -\log ka$

$Ka = 10^{-pka}$

$K_w = [H^+][^-OH]$

K_w = the ionic product of water

pH of a weak acid

$pH = -\log \sqrt{[HA]Ka}$

[HA] = concentration of the weak acid

Ka is the acid dissociation constant of the weak acid

$$[H^+] = \frac{Ka \times [acid]}{[salt]}$$

$$pH = -\log [H^+]$$

Calculating the ratio of acid: salt from buffer solution

$$\frac{[H^+]}{Ka} = \frac{[acid]}{[salt]}$$

Where;

[acid] is concentration of Acid,

[salt] is concentration of salt

Note:

$[H^+] = [10^{-pH}]$

Percentage Purity

$$\% \text{ purity} = \frac{\text{Mass of pure substance}}{\text{mass of the impure substance}} \times 100$$

Calculating entropy changes

$\Delta S = \sum(\text{entropy of products}) - \sum(\text{entropy of reactants})$

Enthalpy changes of a reaction

$\Delta H = \sum(\text{enthalpy of products}) - \sum(\text{enthalpy of reactants})$

Free energy change

$\Delta G = \Delta H - T\Delta S$

Where **T** is temperature in Kelvin

Converting temperature from degree Celsius to kelvin

Kelvin = degree Celsius + 273

Minimum temperature

T = $\Delta H \div \Delta S$

Feasibility of a cell reaction

E_{cell} = Reduction potential – Oxidation potential

Relative atomic mass calculation for two isotopes A and B

$$A_r = \frac{(\text{\% of isotope A x mass of isotope A}) + (\text{\% of isotope B x mass of isotope B})}{100}$$

Appendix R: Sample of Lesson Plans

Lesson plan

Course	A-level chemistry			Topic	Calculation of Kp and Kc in Equilibrium
Day and date	5/01/22	Venue	S22	Time	2-4pm

Learning Outcomes

Learners should be able to understand, explain and apply their knowledge about:
1. the use of the terms mole fraction and partial pressure
2. calculation of equilibrium moles, concentrations, mole fraction and partial pressure, given appropriate data
3. the techniques and procedures used to determine equilibrium moles, concentrations, mole fraction and partial pressure
4. the expressions for Kc and Kp for both heterogeneous and homogeneous equilibria
5. calculations of Kc and Kp and determination of units

Transferable skills developed

1. Analysis
2. Creativity and innovative thought
3. Contextual awareness
4. Information management.
5. Interactive and group skills
6. Knowledge and understanding
7. Planning and management of learning
8. Oral communication
9. Written communication
10. Problem-solving

Plan of activities

Time (in minutes)	Teacher activity	Learner activity (what students will do)	Hand-outs & resources needed
Prior to session:-	Are there extra activities for those who may finish early?	Are the learners expected to do any reading or activity before attending the lesson?	What hand-outs or resources are needed to be inclusive to all students?
5 mins Welcome and recap of topic covered in the previous lesson	Welcome students and take register. Recap of previous lesson	Respond to names and listen to recap	Class register
5 mins Introduction of lesson objectives/ outcomes and expected developmental skills	Explains the lesson objectives Introduces dynamic equilibrium calculation in terms of Kp and Kc.	Listening Take notes and ask questions	Note books PowerPoint presentation

10 mins Give and /or demonstrate necessary information	Reviews features of a dynamic equilibrium Explains equilibrium constant expression Calculating the values of the equilibrium constant; concentration and pressure quantities present at equilibrium and use of **RICE** Method for Kp and Kc calculation	Listening Take notes and ask questions	Note books PowerPoint presentation
20 mins Introduction of first activity and completion by students.	Sets the first activity to reinforce understanding	Individual students work using mini whiteboards to complete text book questions, p. 33, 37 Complete review questions, text book page 43 by those who finish early for differentiation	Mini white board Chemistry Text book Mathematical formulae booklet Marking scheme
40 mins Second activity (Group activity) Students are grouped into groups of three per group	Puts learners in groups Supports students as they complete worksheet questions in groups Facilitates class discussion of group presentation	Work in groups to complete worksheet questions Groups share their answers for the given questions with the class via class discussion Q&A	Worksheet Marking scheme Note books Mathematical formulae booklet
25 mins Third activity (Independent work)	Verifies understanding by all students using voting pad quiz activity	Completion of voting pad quiz questions	Mathematical formulae booklet Voting pad
5 mins Recap lesson and set homework	Recaps the lesson to reinforce the key skills and learning outcomes Sets homework	Q&A	Homework booklet on equilibrium of reactions Mathematical formulae booklet
Reflection of the lesson Lessons focused on supporting students to understand the mathematics in A-level chemistry **What learning took place?**			

Students were able to use the terms mole fraction and partial pressure, calculate quantities present at equilibrium, given appropriate data. They were able to write expressions for Kc and Kp for homogeneous and heterogeneous equilibria and did calculations of Kc and Kp using the mathematical formulae booklet.

Which aspects of lesson went well?
Group activity and class management. Students were able to work together and did very good presentation of their findings during class discussion.

Which aspects could be improved upon?
Ensuring every student will have one marking scheme instead sharing during marking of work. It delays the sessions .

Actions for the future
Learners to perform practical experiment of equilibrium in the next lesson so that learners can demonstrate their skills and knowledge acquired in practical work to consolidate learning.

Appendix S: Changes in Questionnaire

Summary of change made after testing the questionnaire with colleagues

The panel of experts suggested that I should drop question 7 below because the answer for question 8 will cover that. The reason given was that most students choose their A-level subjects based on their future career. I agreed with them after given a second thought to their suggestion. The question 7 was therefore removed from the questionnaire as suggested.

Samuel Asamoah- Questionnaire for students

Research Questionnaire – Please tick, circle or provide details where appropriate

Year group: One……… Two……

1. Gender: Male……. Female……Non-binary/third gender……… Prefer not to say………
2. Ethnic origin: White ………. Mixed/Multiple ethnic group………… Asian/Asian British Black/African/Caribbean/Black British…………. Other ethnic group……………………
3. What type of chemistry did you do in GCSE? Chemistry (Triple Science) …………….. combined Science……….. other science………….
4. What were your GCSE Chemistry results? (Triple Science) ……….. Combined science…………….other science……………..
5. Indicate your results for GCSE Maths……………. GCSE English…………..
6. How many A Levels subjects are you doing? Three…….. Four………. Five………………
7. What informed your decision to do A-Level Chemistry?……………………………………….
8. What is your possible future career? ……………………………………………………………….
9. What is the university requirement in A-Level chemistry for this career? ……………..
10. Will you drop A-level chemistry if your career choice changes?

    Definitely yes………………… Probably yes…….Might or might not………Probably not…….. Definitely not……………….. If yes explain ……………………………………………………………
11. Did you receive advice in choosing A Level chemistry as a subject? Yes…….. No………
12. If you have indicated yes, please state your source of help? Parents………

    Teachers………. Friends………… Career Advisers………….. Other………………………………
13. How accurate is each of the following statements as it applies to your decision in doing A-Level chemistry?

Source of information:	Tick the appropriate column for each question				
	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
It was a hard decision for me					
I took a long time to decide					
I had to consider many factors					
I relied heavily on advice from others					
It was really not my decision alone					
I wish I did not have to make this decision					

14. Please answer the following questions by ticking the appropriate column

Items	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
Teachers play a significant role during the teaching and learning process as they influence students' attitudes towards the study of chemistry.					
I sometimes do not attend class because I do not enjoy the chemistry lessons					
The teacher engages us in practical activities which enhances my understanding					
The practical part of a chemistry lesson encourages me to study it					
The use of recorded chemistry educational videos enable me to have a meaningful revision and perform better in assessment.					
Having the opportunity to listen to a recorded chemistry lesson enables me to recap and perform better in assessment					
Teacher demonstration of what he/she teaches will be useful					
The teacher uses stories or everyday life events to help me to understand the importance of what I learn					
Knowing the importance of what I study will make me learn more					
I revise my notes after the lesson and do at least five hours of private studies per week					
I enjoy A-level chemistry lessons					
Chemistry is an easy subject					
Chemistry is a difficult subject					
The mathematics involved makes it difficult to understand					

There are too many mathematical formulae that are difficult to remember in chemistry					
Chemistry is a challenging subject that is why I like it					
Chemistry is a boring subject and I do not like it					
It is difficult to recall facts, terminology and relationships of topics					
Understanding chemical principles and concepts is tricky and challenging					
It is difficult to draw on existing knowledge to show an understanding of the responsible use of chemistry in the society					
Selecting, organising and presenting chemical information clearly and logically is not easy					
It is not easy to explain and interpret chemical principles and concepts					
To apply chemical knowledge and understand familiar situations require long hours of studying					
It is difficult to make connections between different topics in chemistry					
Knowing that there will be a lot of help offered by teachers and the college helps me to decide to stay and complete the A-Level chemistry.					
Positive attitudes towards chemistry in the classroom will enable me to form sound concepts and thereby perform better academically.					
I often do not understand the meaning of words used to teach or to test in chemistry exam					
I often get low exam marks in chemistry due to a failure to understand the language of the questions.					
I have difficulties developing understanding of words such as salt, neutral, weak and reduction that have scientific meanings that differ from their everyday meanings					
I struggled to retain scientific meanings of this dual meaning vocabulary. The more frequently used every day meaning persist and affects my understanding and correct use of some of these words in chemistry.					