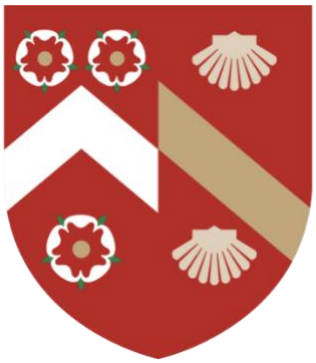
Investigating Gender Bias in Oxford MChem Chemistry Tutorials



Hannah Bruce

Wadham College

University of Oxford

Abstract

There is a gender attainment gap in Oxford's MChem degree outcomes, which the university aims to eliminate. One hypothesised explanation for the gap is unconscious gender bias in chemistry tutorials.

This study investigated what makes tutorial experiences positive or negative for students and how female students experience chemistry tutorials.

Qualitative data were collected through interviews with current MChem students which were subsequently transcribed and analysed. These data provided a rich insight into the experiences of students in chemistry tutorials.

Students' autonomy, competence and relatedness are not always supported in tutorials. According to self-determination theory, this could cause students to develop less autonomous motivation, leading to poorer learning outcomes. When exploring the gendered elements of chemistry tutorials, it was found that female students do a substantial amount of extra work in tutorials compared to their male peers. Female students must: push themselves to speak up; battle imposter syndrome; and deal with negative emotions such as anxiety, frustration and loneliness. This adds to their extraneous cognitive load, restricting the mental space they can devote to understanding chemistry, which could potentially lead to poorer learning outcomes.

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Abbreviations

CL: Cognitive load

CLT: Cognitive load theory

FHS: Final honours school

IAT: Implicit Association Test

SDT: Self-determination theory

STEM: Science, technology, engineering, and mathematics

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Chapter 1: Literature Review

1.1. Introduction

Gender bias in education is a global problem that impacts the learning of women worldwide (Raina, 2012). It is embedded within textbooks, lessons, language used in classrooms, curricula, and teacher-learner interactions. Progress has been made in trying to eliminate gender bias in UK education, but unconscious gender bias (also referred to as implicit bias) persists and contributes to the prevention of the advancement of women (Brown et al., 2020).

Perkin (2016) established that there is a gender attainment gap in chemistry final honours school (FHS) at the University of Oxford. The report found that male chemistry students scored a significantly higher proportion of firsts compared to female students, despite females having slightly better grades at point of entry.

One hypothesis for why this occurs is unconscious gender bias in chemistry tutorials. Unconscious gender bias takes place when a person unconsciously makes judgements based on gender stereotypes, despite consciously rejecting them (American Association of University Women, 2016). If this were occurring during chemistry tutorials, it could impact students' study of chemistry at Oxford.

1.2. Gender Differences in Chemistry Education

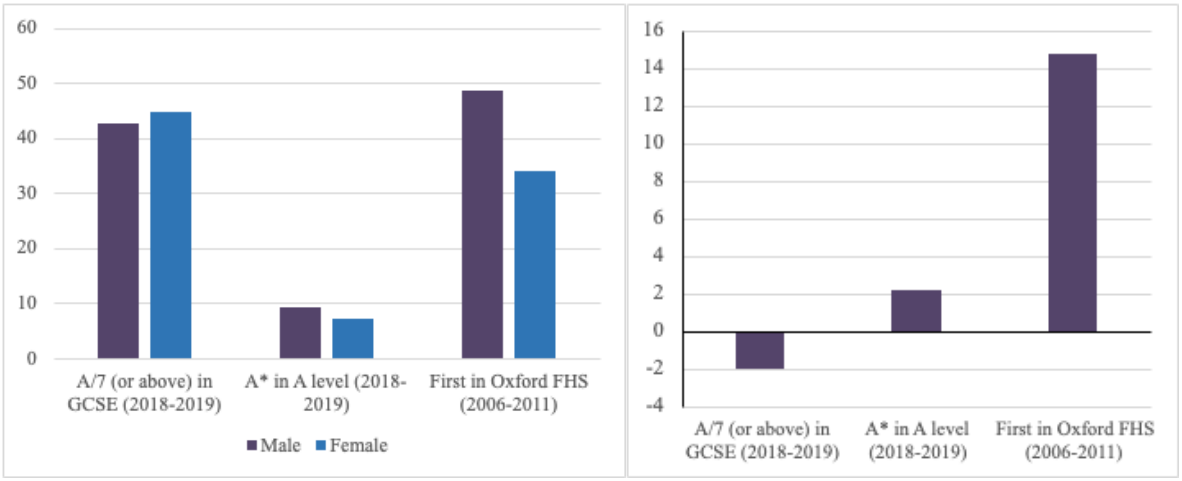
There is a rich literature describing how academic environments are experienced differently by people of different genders. This section considers attainment, representation, and stereotypes within chemistry education, showing how learning chemistry is a gendered process.

In most gender gap reporting, data are gathered for students' sex which is not always the same as their gender. The reports are limited as conclusions are made based on the sex of the students, rather than their gender identity. This is the case for all research referenced here and the terms male and female are used to describe sex in this thesis.

1.2.1. Differences in Attainment

At GCSE level in the UK, female students outperform male students in most subjects, whilst in chemistry, male and female students broadly perform equally (Bramley et al., 2015). In senior secondary education men start to outperform women in chemistry at A level with a greater proportion achieving the highest grades (Joint Council for Qualifications, 2021). This attainment gap continues into higher education. Data from the University of Oxford also show this attainment gap with male students continuing to achieve a greater proportion of first-class chemistry degrees (Gazette, 2020). **Figure 1.1** shows how chemistry outcomes differ by gender for GCSE, A Level, and Oxford qualifications.

Figure 1.1: left: percentage of students achieving the top grade in chemistry qualifications by gender right: percentage point gap between male and female students achieving the top grade (JCQ, 2021) (Perkin, 2016)



Pinot de Moira (2020) found that male students perform better than female students in GCSE specifications assessed exclusively by examination, whereas female students' outcomes exceed that of males where internally set and marked coursework is included. However, Elwood (2005) suggested that coursework cannot fully explain gendered differences in performance for GCSE students. Azmat (2015) found that female students in all academic years perform significantly better in low-stakes classroom tests whereas male students outperform female students in the high-stakes national exams. This trend is observed across all subjects but is more pronounced in maths and science subjects.

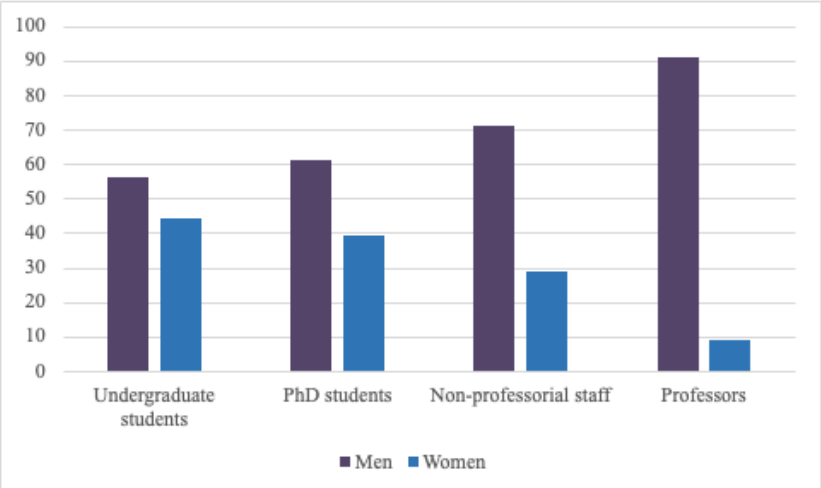
1.2.2. Differences in Representation

In higher education, there are more male than female students studying STEM subjects (STEM Women, 2021). Some researchers have sought to explain this by suggesting men have a genetic ability in STEM subjects (Halpern et al., 2007). However, Spelke (2005) found that the measurement of cognitive abilities does not support this claim.

Role models are important to student motivation and can suggest future possibilities (Lockwood & Kunda, 1997). Lockwood (2006) found that effective role models must be of the same gender. Women are more likely to leave STEM areas compared to men, partly because they lack similar role models such as peers, teaching assistants, and instructors (Herrmann et al., 2016). Men comprise the majority of the chemistry faculty at the University of Oxford. Such inequality in gender representation may signal to women that they do not belong or cannot succeed in this field (Walton & Cohen, 2007).

A 'leaky pipeline' metaphor is commonly used to describe the progressive loss of capable women from senior STEM roles (Resmini, 2016). This attrition can clearly be seen from research from the Royal Society of Chemistry (2018) presented in **Figure 1.2**. The study found that the key themes influencing progression are: academic funding structures, academic culture, and balancing work with other responsibilities. These issues affect both men and women, but they disproportionately affect female academics in the chemical sciences.

Figure 1.2: the proportion of male and female chemists at key academic career stages (RSC, 2018)



Sanford et al (2020) saw the shortage of women acting as role models in high-profile STEM positions as an important reason for pipeline problems in the sciences. Ceci & Williams (2010) argued that women leave maths-intensive scientific fields such as chemistry because of lifestyle choices both freely made and constrained by biology and society. However, Moss-Racusin et al. (2012), whilst acknowledging that lifestyle choice is likely to contribute to the gender imbalance in science, suggested that gender discrimination also plays a part.

1.2.3. Differences in Stereotypes

Hastie (2016) defines gender stereotypes as 'generalised beliefs about members of each gender category that are socially shared'. They include traits, behaviours and abilities that are associated with men or women. For example, assertiveness and ambition are viewed as male traits whereas women are seen as more caring and intuitive (Heilman, 2012). Gender stereotypes can affect the perceived potential of men and women and how their work is valued. Therefore, they have important consequences in men and women's education and career progression (Ellemers, 2018).

STEM subjects are often stereotypically coded as male and humanities subjects as female (Hill et al., 2010). Consequently, females studying STEM subjects suffer from negative stereotypes about their abilities in the subject: girls are not as good as boys at maths, and scientific work is better suited to boys and men (Hill et al., 2010). These negative stereotypes can cause an underdevelopment in female students' motivation and interest in their subject, resulting in fewer women choosing STEM-related careers which perpetuates the leaky pipeline (Dancy et al., 2020). Hill et al. (2010) found that girls may actively avoid STEM fields by declaring a lack of interest to avoid judgement based on negative stereotypes. Parents and teachers transfer their conscious or unconscious negative stereotypes about women's maths and science abilities thus shaping girls' attitudes to maths and undermining performance and interest in STEM fields (Gunderson et al., 2011).

Stereotype threat is the fear of confirming a negative stereotype about one's group. It contributes to the gender gaps in attainment and participation in science subjects (Marchand & Taasoobshirazi, 2013). Stereotype threat can affect performance as students from underrepresented groups may stop trying hard; failure can be explained by a lack of effort rather than confirming the stereotype. Conversely some female students feel the need to work harder than male students to disprove the stereotype and prove themselves in the field (Dancy et al., 2020). Hill et al. (2010) note that even female students who strongly identify with their subject and think they are good at it are susceptible to stereotype threat. This may discourage talented female scientists continuing in the field.

1.3. Gender Attainment Gaps in Higher Education

Attainment gaps between well-represented and under-represented students are increasingly recognised as an urgent issue in higher education (Harris et al., 2020). Attainment gaps are particularly prominent in STEM subjects where women and underrepresented minorities often underperform in comparison with their better-represented peers.

1.3.1. Gender Attainment Gap in STEM

Harris et al. (2019), link the gender attainment gap in STEM subjects with a negative effect on the retention of female students. Cromley et al. (2016), find that lower grades, even if they reach the pass mark, are associated with attrition and that among the students who leave STEM disciplines, female students are overrepresented. However, Eddy and Brownell (2016), whilst recognising that a gender attainment gap could be an important factor in why more women than men leave STEM, suggest that engagement and affective measures also contribute to the persistence of the gender retention differences.

1.3.2. Gender Attainment Gap in Oxford

At the University of Oxford, more men achieve first class degrees than women. From 2017-2019, undergraduate male students were 8.5% more likely to earn a first-class degree than their

female counterparts (University of Oxford, n.d.). This is unusual in the UK; the Higher Education Statistics Agency found that in the graduating year 2018, female students outperformed male students in obtaining first class degrees (HESA, 2018).

Mellanby et al., (2000) concluded that the gender attainment gap at Oxford is unlikely to be explained by a difference in the general ability of male and female students. They suggested the cause was the nature of the academic assessment system. In a newspaper interview, Professor Jo-Anne Baird, director of the Department of Education at Oxford University, agreed that the format of tests may favour male students and noted that the content and mark schemes of examinations can be gendered (Oxford Student, 2019). Anonymised marking has been introduced as a result of research into gender bias in marking. However, personal characteristics, including gender, can be recognised through handwriting and the content and style of the language used (Baird & Bridle, 2012).

1.3.3. Gender Attainment Gap in Oxford MChem

The gender attainment gap at the University of Oxford is seen in chemistry FHS, with male students achieving a significantly higher proportion of firsts than female students; from 2006-2011, the attainment gap was 14.4% (Perkin, 2016). Perkin's quantitative investigations into the causes behind the gap were largely inconclusive, suggesting the need for qualitative research in this area. She hypothesised that unconscious bias in tutorials, academic self-concept and stereotype threat may contribute to the gap.

1.4. Unconscious Bias

Staats (2015) defines unconscious (or implicit) bias as 'the attitudes or stereotypes that affect our understanding, actions, and decisions in an unconscious manner'. This can cause people to employ discriminatory behaviour without any deliberate intent (Pritlove et al., 2019). Furthermore, because these stereotypes are unconscious, the biases do not always fall in line with stated beliefs and intentions (Staats, 2015).

Fiarman (2016) posits that ‘we all harbor unconscious biases’. When tested for unconscious bias, people from all backgrounds demonstrate partiality based on identity markers such as gender and race.

1.4.1. Unconscious Gender Bias

Unconscious gender bias takes place when a person makes unconscious judgements based on gender stereotypes whilst consciously rejecting them (Madsen & Andrade, 2018). Unconscious gender bias can be compared to ‘deeply entrenched habits developed through socialization experiences’ (Devine et al., 2012) and is a result of cultural and societal expectations, learned behaviours and associations (Phillips et al., 2016).

Accordingly, Phillips et al. (2016) note that unconscious gender bias is not one-way; women are just as likely as men to make unconscious evaluations and decisions based on gender. For example, research into implicit bias in the workplace shows that women workers exhibit unconscious bias against female managers (American Association of University Women, 2016).

Multiple studies note that unconscious gender bias is not simply a concern within science, but that women tend to be rated as less competent than men across a broad area (Raymond, 2013). This can lead to poorer outcomes for women from the seemingly inconsequential, such as quality of interaction, to the substantial, such as employment opportunities (Devine et al., 2012).

However, whilst recognising the importance of raising awareness of gender inequalities, the focus on unconscious bias can risk masking social and political barriers to women’s advancement (Pritlove et al., 2019). It is impossible to separate gender inequity from the broader context of race, class, sexuality, location and many other factors, but this is often ignored in implicit bias research. Furthermore, it is important to note that explicit and

intentional gender bias continues to persist; this can sometimes be overlooked by focusing on unconscious bias.

1.4.2. Unconscious Gender Bias in STEM

Unconscious gender bias is particularly pronounced in STEM (Pritlove et al., 2019). Individuals tend to associate men with science and career and women with arts and family (Raymond, 2013).

This bias may influence the likelihood of women pursuing their interest in STEM (Hill et al., 2010). It can also impede the progress of women in science. Moss-Racusin (2012) found that in a blind, randomised study, male applicants were consistently rated as more hireable with greater potential than identical female applicants.

Unconscious bias amongst educators is significant as it can influence their judgements and actions towards individual students (Dee & Gershenson, 2017). Thus, the professionals who strive for their students' success may unconsciously create invisible barriers to opportunity and achievement (Staats, 2015). For example, Khan et al. (2021) found that there were significant differences in the gendered language used to describe male and female medical students in reference letters. Male students were more likely to be described using adjectives such as 'exceptional' and 'leader', while female students were more likely to be described as 'delightful' or 'compassionate'; this led to a higher residency match for male applicants.

Unconscious bias is particularly important in STEM education where there are significant gender representation and attainment gaps. Many STEM faculties recognise this problem, leading to institutions introducing implicit bias interventions (Pritlove et al., 2019).

1.4.3. Unlearning Unconscious Bias

Everyone has unconscious biases (Fiarman, 2016). Awareness of one's own unconscious biases is the first step in unlearning them (Staats, 2015). It is critical that individuals confront the discrepancy between their conscious ideals and their unconscious biases to align the two.

One way for individuals to assess the unconscious biases they hold is to complete an Implicit Association Test (IAT). The test uses reaction time to assess people's implicit associations between two concepts, such as men with science subjects and women with arts subjects. Vianello & Bar-Anan (2021) argue that the IAT is the best available test for people to measure their automatic judgments.

Staats (2015) suggests next steps for individuals to counteract their unconscious biases after they have been identified. Engaging on a personal level with individuals whose identities evoke implicit biases can allow for the creation of new associations about the groups those individuals represent. Moreover, exposure to individuals who contradict commonly believed stereotypes (such as female scientists) can help to break down existing biases. It is suggested that using counter-stereotypical images in posters and décor for classrooms could help students override their pre-existing unconscious biases.

Implicit bias training can be implemented to counteract unconscious bias (Pritlove et al., 2019). It involves encouraging people to confront their own unconscious biases and teaching them strategies to reduce prejudiced thoughts and actions. Implicit bias training often succeeds in changing individual beliefs but is mostly ineffective at an institutional level.

Unconscious bias can be reduced by educators taking more time to process a situation before making a decision (Staats, 2015). Implicit stereotyping is automatic and can lead to unintentional discrimination. In order to override this automatic process, an individual needs to have sufficient cognitive resources and motivation (Burgess, 2010).

1.5. Tutorials

Tutorials at Oxford are a highly regarded educational framework (Cosgrove, 2011). They are differentiated from tutorials at other universities (except perhaps the Cambridge supervision) by their low student:teacher ratio and focus on work completed in advance (Ashwin 2005).

1.5.1. What Makes a Good Tutorial?

A student's view of the purpose of tutorials can influence their experiences and learning outcomes (Ashwin, 2005). Some students view tutorials as an opportunity for their ideas to be explored, constructively criticised and reconstructed. Students with this view of tutorials engage in higher quality learning and have better learning outcomes compared to students who view tutorials as a tutor-centred learning environment.

Yang (2021) explored what makes a good chemistry tutorial for MChem students at Oxford. The key finding was that being able to effectively *participate* made the tutorial better for students. Participation was linked to the student having a good affective experience and a better understanding.

1.5.2. Gendered Differences in Tutorials

Gaston & Duschinsky (2020) researched how undergraduate arts and social science students experienced supervisions (tutorials) at Cambridge differently, based on their gender and class. It was found that supervisions caused feelings of inadequacy and a sense of non-belonging for female students. Furthermore, female students experienced less opportunity for participation and learning than their male peers during supervisions. These findings were echoed by Yang (2021) who found that female MChem students at Oxford could not fully participate in tutorials compared to their male peers and were often talked over in tutorials.

1.6. Relevant Educational Theories

This thesis focuses on the tutorial environment. It is important to be aware of relevant theories underpinning modern understanding of small-group teaching.

1.6.1 Affective Chemistry Education Research

Education and emotion are often considered to be separate entities, but in fact they are profoundly intertwined. How a student is feeling has an impact on how they learn (Immordino-Yang & Damasio, 2007). A student's affective (emotional) experiences can influence effective

learning outcomes. Chan and Bauer (2014) used quantitative methods to show a correlation between high affect and high performance in chemistry students.

Flaherty (2020) reviewed affective chemistry education research from the last 20 years, finding a dominance of quantitative research. Flaherty suggested that more qualitative research should be undertaken to create a deeper understanding of affective chemistry education. This loosely parallels the conclusions of the Perkin report, which call for qualitative work into the hypothesis that Oxford chemistry tutorials are somehow gendered.

1.6.2 Self-Determination Theory

Self-determination theory (SDT) explores human motivation and how it is best supported. There is a long-established link between students' motivation and a variety of positive learning outcomes such as engagement, well-being and academic performance (Wang et al., 2019; Ryan & Deci, 2000).

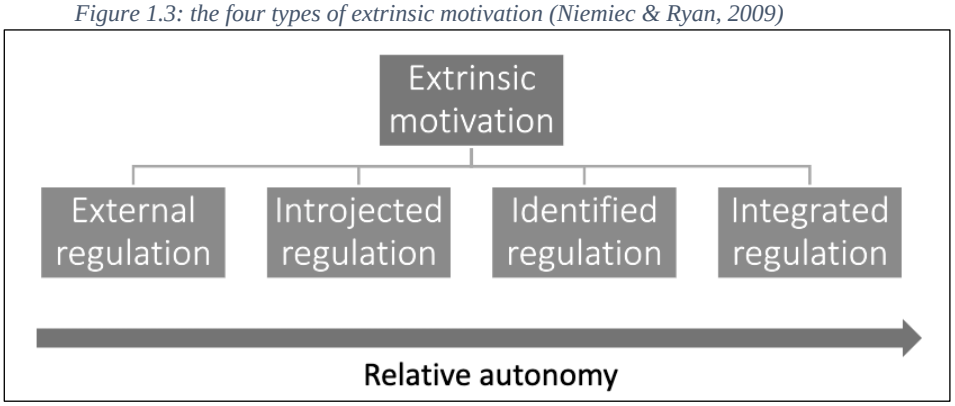
In SDT, motivation can be autonomous or controlled (Deci et al., 2017). Autonomous motivation involves people engaging in activities willingly, whereas in controlled motivation, people behave in response to external factors such as rewards or punishments. Intrinsic motivation is a sub-type of autonomous motivation in which the motivation stems from innate interest or enjoyment gained from the behaviour (Ryan & Deci, 2000). Students who are intrinsically motivated learn more effectively and retain knowledge for longer (Trenshaw et al., 2016).

In order to sustain intrinsic motivation, a student's need for autonomy and competence must be satisfied (Niemiec & Ryan, 2009). Autonomy is the sense that an individual controls their own choices and competence refers to a sense of having the necessary knowledge and skills to succeed (Trenshaw et al., 2016). Autonomy can be supported in an educational context by minimising the importance of evaluation and by ensuring students feel they 'have a voice' and some degree of choice in the academic activities in which they partake (Niemiec & Ryan,

2009). Competence can be supported through learning activities that allow students to test and expand their academic capabilities and through good feedback from teachers.

Many behaviours required to succeed in education are not immediately enjoyable or interesting (Niemiec & Ryan, 2009). For example, a student may not find memorising the periodic table to be enjoyable. Students will not be intrinsically motivated to do such tasks and will require other incentives. Extrinsic motivation describes an individual demonstrating a behaviour to obtain an outcome separate to the act of learning itself (Ryan & Deci, 2000). Extrinsic motivation can be broken down into four key sub-types that vary in their degree of autonomy from external regulation (least autonomous) to integrated regulation (most autonomous) (Niemiec & Ryan, 2009) as shown in **Figure 1.3**. External regulation involves behaviours being controlled by others in the form of rewards or punishments (Deci et al., 2017). In introjected regulation, behaviours are carried out in response to internal contingencies such as self-esteem, ego and guilt. Both lower-autonomy sub-types are external, originating from outside the self (Niemiec & Ryan, 2009). Identified regulation involves an individual enacting a behaviour that they consider to be valuable or important. Integrated regulation involves an individual integrating their identified regulations into other aspects of themselves. Both higher-autonomy sub-types are internal, originating from the self.

Figure 1.3: the four types of extrinsic motivation (Niemiec & Ryan, 2009)



Autonomy is valuable. More-autonomous extrinsic motivation in students has been linked to better engagement, higher performance and higher quality learning (Ryan & Deci,

2000). Therefore, the internalisation of extrinsic motivation is critical for students' academic functioning (Niemiec & Ryan, 2009). Autonomous regulation for extrinsically motivated behaviours is facilitated by the satisfaction of students' needs for autonomy, competence and relatedness (Ryan & Deci, 2000).

Relatedness refers to feeling a sense of belonging and connection to others. In a classroom environment, students feel relatedness when they feel genuinely liked, respected and valued by their teacher and peers (Niemiec & Ryan, 2009). Competence and autonomy are required to sustain intrinsic motivation as well as to autonomously regulate extrinsic motivation. Relatedness becomes important when discussing extrinsic motivation. Individuals will behave in ways that do not interest them primarily because the action is prompted, valued or modelled by someone the individual feels related to (Ryan & Deci, 2000). When a student's autonomy, competence and relatedness are supported, they are more likely to autonomously regulate their extrinsic motivation, which can lead to better learning outcomes.

Chapter 3 will establish how SDT can be used to describe important features of Oxford chemistry tutorials, and Chapter 4 will explore how SDT parameters can be gendered.

1.6.3. Cognitive Load Theory

Cognitive load theory (CLT) assumes that an individual's working memory is limited (Bannert, 2002). In the working memory, information is constantly processed, and new knowledge is constantly constructed (Plass & Kalyuga, 2019). According to CLT, in order to maximise learning, the capacity of working memory should not be overloaded by cognitive load (Bannert, 2002). Cognitive load (CL) is the load on the working memory that is required to perform a cognitive task (Plass & Kalyuga, 2019). CL can be split into three types: intrinsic CL which is directly associated with learning; extraneous CL which does not contribute to learning; and germane CL which is concerned with developing practised, automated behaviours (Bannert,

2002). The three types of CL are additive and can all contribute to a CL overload (Moos & Pitton, 2014).

One method to externally manage CL is to reduce extraneous CL which does not contribute to learning and reduces the working memory capacity (Bannert, 2002). Extraneous CL occurs when an individual is exposed to information or task-elements that do not directly contribute to completing a cognitive task (Moos & Pitton, 2014).

Chapter 4 will use CLT to argue that women are doing extra work in tutorials in some very specific ways. This risks overloading women's cognitive capacity in the tutorial environment, leading to poorer tutorial outcomes.

1.7. Conclusion

This literature review provides a summary of the gendered differences in chemistry education, exploring how attainment, representation and stereotypes are influenced by gender.

The literature shows that unconscious gender bias occurs in STEM education and that it impacts women's achievement. Research into theories of learning and motivation help explain how students learn in tutorials, the main teaching mechanism for the Oxford MChem.

It has already been established that STEM and chemistry at Oxford have gendered dimensions. This thesis will explore how the specific environment of the Oxford chemistry tutorial can be another site of gendered education and how this affects female MChem students.

Chapter 2: Aims

2.1. Aims of Project

Perkin (2016) described the gender attainment gap in Oxford's MChem degree outcomes, with male students scoring a significantly higher proportion of firsts compared to female students. This study aims to explore one of the hypotheses for the gap: unconscious gender bias in chemistry tutorials.

Tutorials are a central pedagogy in the MChem degree. Therefore, it is important that they are effective for all students. This project aims first to understand what makes a tutorial experience positive or negative for students of all genders (Chapter 3).

If unconscious gender bias were occurring during chemistry tutorials, it could impact female students' learning. The second aim of this project is to explore female students' experiences of chemistry tutorials (Chapter 4).

2.2. Research Questions

The specific research questions this study aims to answer are:

1. *As interpreted through self-determination theory, what makes a student's experience within a chemistry tutorial positive or negative?*
2. *How do female students experience chemistry tutorials?*

To answer these research questions, current MChem students were interviewed about their experiences during chemistry tutorials.

Chapter 3: Tutorial Experiences

3.1. Chapter Aims

This research chapter aims to explore how students of all genders experience tutorials. A rich description of the tutorial experience will allow a better understanding of what makes a good tutorial for students, informing approaches to improving teaching.

3.1.1. Research Question

This chapter addresses the research question:

As interpreted through self-determination theory, what makes a student's experience within a chemistry tutorial positive or negative?

To answer this question, current MChem students were interviewed about their experiences during tutorials.

3.1.2. Instrument Justification

Interviews are used in this research as they are ideally suited to experience-based research questions (Braun & Clarke, 2013). Students have a rich, detailed understanding of chemistry tutorials from their direct participation. Interviews can gather these detailed accounts in order to identify patterns and construct categories within the students' experiences of chemistry tutorials. Semi-structured interviews, like the ones in this study, are often used in qualitative research projects as they can provide rich and in-depth information about the contextualised experiences of individuals, (DiCicco-Bloom & Crabtree, 2006).

3.2. Methodology

3.2.1. Design

The qualitative study consisted of interviewing current MChem students about their experiences in chemistry tutorials. The interviews were conducted during Hillary term 2022, during which time ten students were interviewed. Of these, eight were conducted in person in

the PTCL building, and two were conducted online using Microsoft Teams. The interviews were semi-structured and lasted approximately 30 minutes.

3.2.1.1. Recruitment

All current MChem students in years one, two and four were invited to take part in the interviews. Students in year three were not included to avoid adding additional pressure as they were close to taking their Part IB exams. Students were invited to interview through an email sent from Dr Michael O'Neill, circulated across the three included year groups. A flyer advertising the interview (**Appendix A**) was displayed in chemistry buildings. Students who wished to take part in the interview sent an email to Dr Michael O'Neill and were subsequently contacted to arrange the interview.

3.2.1.2. Recording and Transcription

The interviews were recorded using a dictaphone. Recording was required to allow analysis of participants' responses. The Microsoft Teams transcription function was used to create a transcript which was later manually amended to correct for automatically generated text errors.

3.2.1.3. Format

The participants were asked questions about their experiences in chemistry tutorials. The questions (**Appendix B**) were open-ended and loosely structured. This allowed the interview to diverge from the question, enabling the participant to explore an idea in greater depth. Therefore, the exact questions that were asked varied from participant to participant.

3.2.2. Ethical Considerations

3.2.2.1. CUREC Approval

This project gained ethical clearance from the Medical Sciences Interdivisional Research Ethics Committee (reference: R79438/RE001). This allowed the recruitment process to begin.

3.2.2.2. Consent

Obtaining informed consent from all participants is generally regarded as central to ethical

research practice (Wiles et al., 2007). This is the case for most research projects involving human participants. The Social Research Association (2003) defines informed consent as 'a procedure for ensuring that research subjects understand what is being done to them, the limits to their participation and awareness of any potential risks they incur'. To ensure informed consent for this research, a consent form and participant information sheet were circulated to the participant ahead of the interview. The consent form was signed by all participants before the interview took place. This confirmed their consent to take part in the interview and to being voice-recorded. Participants had the option to consent to anonymised quotes from the interview being used in the research outputs; nine of the ten participants agreed to this, with one opting out. Exit consent was obtained orally during the latter stages of the interview. Confirming consent at the beginning and end of the interview allowed the participants to make an informed decision. Furthermore, it was made clear that the participants were under no obligation to take part in the interview, and they could withdraw their consent at any time.

3.2.3. Analytical Framework

The transcription data from the interviews have been analysed using the category analysis approach, as outlined by Salta et al. (2012). The entire dataset (47,000 words) was coded completely to identify the concepts repeatedly present in the data. Following this, certain codes that were judged to follow a pattern were combined to form categories. These categories have been defined and explored.

3.2.4. Positionality

As a current, female MChem student, I have a certain perspective about chemistry tutorials which differs from that of others. This allows me to construct a rich understanding of the context of the participants' experiences. I have intuitive contextual knowledge of chemistry at Oxford, allowing me to better understand the participants' terminology and perspectives. On the other hand, this experienced knowledge is not free from bias: my own experiences, gender

and unconscious bias may indirectly influence how I interpret student responses. This is important to acknowledge and consider when looking at my findings. However, there is no neutral perspective and other people conducting this research would have their own (different) biases.

3.3. Results & Discussion

The categories developed from the participants' responses are displayed in **Table 3.1**.

Table 3.1: Category summary

Category	Summary
Effect of the other students in tutorial	How the other students in the tutorial affect the participant's experience. In particular: smart students, number of students and comfort with other students.
Effect of the tutor in tutorial	How the tutor affects the participant's experience of the tutorial. In particular: tutor caring about students, tutor not helping, teaching style and feedback.
Purpose of tutorial	How students view the purpose of a tutorial, and what students get out of tutorials.

3.3.1. Effect of the Other Students in Tutorial: Overview

Participants note that the other students in a tutorial make a difference to their experience. The perceived intelligence of the other students, how many there are and how comfortable the participant feels with them, all influence how enjoyable and effective tutorials are.

3.3.1.1. Smart Students in Tutorial

Having particularly smart (clever) peers in their tutorial group affects participants' experiences. Most participants view having smart students in their tutorials as impacting their experiences negatively, for example by taking up tutorial time to discuss chemistry beyond the scope of the syllabus.

> *'There was one tutorial I remember, it was a physical chemistry tutorial and one of the guys in my year, he was first at the end of basically every year, like he's excellent, and he started asking questions on some really obscure, difficult proof and led the tutor to go through that for like half an hour and everyone else was just sitting there, waiting for it to happen, having no idea what was going on. So yeah, that was a pain 'cause we were just listening to this thing that we had no idea about.'*
>
> *-participant 7, female*

'If I was in a tutorial with someone who was very good and they were a guy, they probably would try [to show off], at least it felt that to me. Maybe that's just me being insecure, but it did sort of sometimes feel like, why are you trying to go beyond the scope of the syllabus and it was just like do it in your own time rather than doing it in tutorial time'

-participant 8, female

Smart students also adversely affect tutorials for the participants by making them feel insecure about their own chemistry knowledge.

'There was this one guy in my group who I had had several tutorials with who would always ask very out of the box questions and I remember I always would feel like oh why didn't I think of that, why am I not having these kinds of thoughts and it kind of made me doubt myself a lot, kind of like imposter syndrome'

-participant 2, female

Students feel less comfortable speaking up in tutorials with smart students from fear of taking up too much time. This idea of self-censoring is particularly common amongst the female participants and will be explored in greater depth in Chapter 4.

'We had two groups, for tutorials, kind of a smart group, and a less smart group, like people aiming for a first and people aiming for 2:1. And whenever I was in the group that was only for a 2:1, it was a lot easier to ask questions because it went a lot slower and it seemed like the questions I asked were more relevant to them as well'

-participant 4, female

'...when they were people who understood the content vastly more than I did, I would struggle to get the kind of assistance I needed on topics because other people would say like, this bit's really easy, let me explain it to you, and I would be happy to let them explain it to me, but it felt like I was dragging the tutorial behind.'

-participant 1, female

In contrast, some participants describe how they prefer having smart peers in tutorials as they feel less pressure to answer the difficult questions asked.

'I know there's like two students at [college] who are really good, and so, if I was in a tutorial with either of them, I would find it far more relaxing because they would often be the ones being able to answer all of the difficult questions.'

-participant 6, male

'Sometimes, you'd try to pick your tutorial group based on who you knew would be confident in that topic, so you'd have someone who was more confident than you in the tutorial to take the harder questions.'

-participant 3, female

The ‘smart students in tutorials’ category speaks to different aspects of SDT. Smart peers taking up tutorial time does not support the autonomy of other students as it causes them to feel they have less control over the learning in the tutorial.

Another component of SDT is competence. Niemiec and Ryan, (2009) define competent students as feeling able to meet the challenges of their work. Smart peers openly displaying knowledge or ‘showing off’, can lead to other students in the tutorials doubting their own abilities in their work, ultimately causing them to feel a lack of competence.

Allowing someone else to ‘take the harder questions’ is also detrimental to the students’ competence. It may allow the students to have a more positive affective experience but leads to a less effective cognitive learning experience. This does not test or expand students’ academic capabilities, needed to support their competence (Niemiec & Ryan, 2009).

Furthermore, when particularly smart peers exhibit their knowledge, it can cause other students to feel different and alienated from them. This can diminish students’ sense of relatedness.

When a student’s autonomy, competence and relatedness are not supported, they are less likely to exhibit autonomous motivation (Ryan & Deci, 2000). This can lead to poorer learning outcomes. Therefore, smart students can sometimes have a negative influence in tutorials.

3.3.1.2. Number of Students in Tutorial

The number of other students in the tutorial impacts the experience. Some students prefer tutorials with a greater number of other students, as this enables them to avoid answering questions. Once again this induces a more positive affective experience but a less effective educational one, not allowing students’ competence to be supported.

> *‘I did definitely prefer to be in a group of three, rather than two, just 'cause, then you feel less pressure to answer questions and it feels slightly less intense […] most people wanted to have more people to spread the work around.’*
>
> *-participant 3, female*

Each student is less involved in the teaching in larger groups. In part, this is because they can afford to answer fewer questions and in part because they feel more pressure to answer correctly and not appear wrong in front of more people.

> *'I probably did get a little bit less involved if there were more of us, just 'cause like you can kind of afford to, if you don't necessarily feel that confident, whereas obviously if it's just the tutorial with like two or three of you, you can't get away with not saying anything.'*
>
> *-participant 8, female*

> *'I think the two person tutorials are better. I think I'm more likely to talk to the tutor and you have a bit more freedom to mess up because it is just one other person. Whereas in the three people ones it can be like, I'm gonna mess up in front of two people now.'*
>
> *-participant 10, female*

The data suggest that tutorials with fewer students are better at encouraging participation and understanding from all students and are therefore better at supporting students' competence.

3.3.1.3. Comfort with Other Students in Tutorial

The tutorial experience is influenced by how comfortable the student feels with the other students. Amongst friends, students are more likely to participate as they are less worried about making mistakes and feel less embarrassed when they do. This leads to a more effective learning environment as students are more actively taking part in the tutorial.

> *'I think it's just a level of comfort that you get like there were some people in the cohort where I'm far more comfortable saying stupid things or presenting ideas that aren't quite right.'*
>
> *-participant 10, female*

> *'I didn't feel embarrassed to make mistakes 'cause I was quite comfortable with my tute partners.'*
>
> *-participant 1, female*

Students value the tutorial space to discuss ideas with peers.

> *'...because we got on well, it made the tutorial experience better, because we could sort of feed off each other.'*
>
> *-participant 3, female*

Ryan & Deci (2000), define relatedness as the ‘need to feel belongingness and connectedness with others’. Relatedness leads to better academic engagement and learning outcomes (Niemiec & Ryan, 2009). Therefore, students’ affective and cognitive learning experiences are more positive when they feel connected to the other students in their tutorial group.

3.3.1.4 Effect of the Other Students in Tutorial: Summary

The other students in the tutorial and the social dynamics between the students have an important impact on the tutorial experience that pertains to all three components of SDT. Smart peers threaten other students’ autonomy by taking up valuable tutorial time to discuss content beyond the syllabus, and competence by causing other students to feel insecure about their own chemistry knowledge. Peers in a tutorial can provide a barrier to students answering difficult questions, either through allowing particularly smart peers to take those questions or through not being asked as many questions in a tutorial with more students. This may make the tutorial experience more enjoyable, but also impacts students’ learning and understanding by not allowing their competence to develop. Finally, students' relatedness can be supported if they feel similar to and comfortable with the other students in their tutorial, leading to a more positive affective and cognitive learning experience.

3.3.2. Effect of the Tutor in Tutorial: Overview

The tutor has a significant impact on the student tutorial experience. The personality, teaching style and even gender of the tutor can influence how a student experiences the tutorial.

> *‘How much I looked forward to a tutorial definitely was affected by the tutor.’*
> *-participant 3, female*

3.3.2.1. Tutor Caring about Students

The relationship between the student and the tutor impacts the tutorial experience. A friendlier and more caring tutor will improve students’ affective experience.

'I think if you have a nice tutor, you have a better experience'
-participant 10, female

'Different tutors will have different ways of teaching and different personalities, there's some who are a bit more welcoming and friendlier, so that makes a difference.'
-participant 2, female

An increased sense of comfort with the tutor enables students to speak up more and ask questions, leading to a more successful cognitive learning experience.

'There are some tutors who, 'cause, I felt like we get on better, I was more likely to be willing to embarrass myself a bit and ask what I felt was a silly question.'
-participant 3, female

'I definitely think that the relationship with the tutor definitely affected things a lot […] I think if I'd got along better with them, I would have had more confidence in bringing things up.'
-participant 7, female

Students need to feel relatedness to their tutors as well as their peers to exhibit more autonomous extrinsic motivation, which is associated with enhanced learning outcomes (Niemiec & Ryan, 2009). When tutors act in a caring manner towards students, it makes the student feel more valued by the tutor, which is deeply associated with relatedness.

3.3.2.2. Tutor Not Helping Students as Much as They Would Like

Some participants express not receiving as much help as they would like from their tutors.

'I didn't feel like my tutors gave me as much help as I needed.'
-participant 1, female

This mainly takes the form of tutors not recognising what the students are not understanding or going too far above the level of the student's knowledge. This leads to the student feeling frustrated and confused.

'There was definitely a lot of frustration when I wasn't understanding something and I would ask the tutor specific questions and he would not really grasp what I was not getting, and we'd go back and forth until like one of us just gave up […] one of my tutors, sometimes he goes off on tangents and he's quite hard to focus in on what I don't find easy. I think, some tutors are extremely clever, they don't understand when you're wanting it to be dumbed down to a specific level.'
-participant 4, female

These negative cognitive experiences lead to negative affective experiences.

'I had a physical tutorial about quantum mechanics, and it was basically the same in every single one that this tutor taught, where he would assume we all had this, like very solid basic understanding of quantum mechanics and didn't really understand how to explain it to us if we didn't get it, and often didn't really try... I didn't end up revising it for my finals, I don't think I got anything out of those tutorials, if anything that tutor made me feel like terrified of quantum mechanics and made me feel like I didn't understand it because he made it seem so much more complicated than like I felt it needed to be.'

-participant 1, female

In order to support students' competence, tutors need to provide students with the 'appropriate tools to promote success and feelings of efficacy' (Niemiec & Ryan, 2009). When tutors do not enable student understanding (by explaining complicated content or addressing student questions) they are not providing these tools. Furthermore, when tutors discuss topics that are irrelevant or are beyond students' understanding, it causes students to feel a lack of control over the tutorial and is not supportive of their autonomy. This can also alienate students from the tutor, leading to their relatedness not being supported.

3.3.2.3. Teaching Style

How the tutor leads the tutorial greatly impacts students' tutorial experience. Students find it helpful when the tutor explains the topic before going through the problem sheet questions.

'I think in physical tutorials where our tutor basically just went through, like it was basically just a summary and like basically another lecture. I enjoyed that style of teaching more.'

-participant 6, male

'...he kind of goes through the tutorial in a good way 'cause rather than going straight for the problem sheet, he goes through the content of the thing and then is like this is the content that related to these questions, here's why you were getting those questions wrong.'

-participant 10, female

Going through the problem sheet answers without a broader explanation leads to a tutorial with less effective learning outcomes.

'...in one of our tutorials our teachers just went through the answers, instead of explaining what was going on, so it was kind of like we were marking our work in the tutorial, which was good in a way, but we didn't get much of a description or like an explanation as such.'

-participant 9, female

'...we just went through the answers rather than actually covering content and I really struggled with that one.'

-participant 2, female

Here, tutors fail to support students' competence by not allowing them to test and expand their academic capabilities. Without their competence supported, students may find it harder to maintain intrinsic motivation, which is essential for better learning of tasks requiring conceptual understanding (Niemiec & Ryan, 2009).

Receiving answers to the problems before the tutorial decreases anxiety during the tutorial. This positive affective experience leads to a better cognitive learning environment.

'Sometimes you'd get answers beforehand and sometimes you wouldn't, and I much preferred getting answers beforehand, 'cause that made me feel much more confident about whether or not my answers were right before I went in, so that teaching style, I definitely preferred.'

-participant 3, female

'I like having the answers given to us before the tutorial, it makes you feel a lot more comfortable like coming in because you have the right answers now. So you can take the time to look where you've gone wrong from the work you've already done, so you have less questions coming in and you're not as confused.'

-participant 10, female

Students can feel anxious when they are asked to explain their answers on the whiteboard in tutorials. However, students acknowledge that this teaching method benefits their learning; it can be a negative affective experience but effective teaching.

'I think the tutors that make you go to the board and answer questions will always be a little bit anxiety-inducing, but I think you do get a lot out of them […] it is a good teaching method, it just means sometimes you're standing at a board waiting to do something and you have no idea what you're doing and kind of like trembling, not trying to not make a mistake on the board there.

-participant 10, female

'I liked it [going up to the board] when I knew what was going on, when I didn't and I knew I was being chosen to go to the white board because I didn't know what was going on, I found that stressful and probably perhaps not as helpful.'

-participant 6, male

This is an example of an optimally challenging learning activity that allows students' knowledge to be tested and is an example of how students' competence can be supported in

tutorials (Niemiec & Ryan, 2009). On the other hand, students feel a lack of control when they are required to work on the whiteboard, especially when they do not know the answer. This could lead to a diminishing of students' autonomy.

3.3.2.4. Feedback from Tutors

Detailed, personalised feedback on the problem sheet increases how effective learning is for students in tutorials.

> *'...one-on-one feedback was the biggest thing I've got from tutorials, just really personalized feedback from your previous worksheets, I've seen you've done this a couple times now, do we need go over it again. I've seen you make this mistake, stuff like that, or I've seen you tend to do this, let's work on that, like personalized feedback […] I think generally my tutors were good at picking up on that. It did feel personalized'*
>
> *-participant 3, female*

> *'...if they gave me more solid feedback, I probably would have spent more of my own time going back over tutorial sheets, 'cause, I could have gone back and been like, OK, this question I got wrong, they've kind of explained why, whereas obviously, they might go over it in the tute, but I don't necessarily remember that off the top of my head […] So, yeah, that probably would have been helpful.*
>
> *-participant 8, female*

To support students' competence, it is important that tutors provide feedback that emphasizes student efficacy over evaluation (Niemiec & Ryan, 2009). Good feedback will aid students in their mastery of the tasks at hand. For example, an explanation of why an answer is wrong and how to improve it is more helpful and competence-supporting than putting a cross next to an incorrect answer. Feedback that is personalised to a student's specific understanding allows their competence to be supported, enhancing their intrinsic motivation and leading to better cognitive learning outcomes (Ryan & Deci, 2000). This idea is reflected in the data, with participants noting that personalised feedback on their problem sheets assists their learning.

3.3.2.5. Effect of the Tutor in Tutorial: Summary

The tutor has an important impact on students' tutorial experience. A more caring tutor with whom students feel comfortable, leads students to feel a greater sense of relatedness, which is essential to autonomous self-regulation. Students' competence is not supported when a tutor

fails to grasp what students do not comprehend or assumes students have a higher level of understanding than is the case. On the other hand, students' competence can be supported by a tutor: providing an explanation of the topic prior to going through the questions; encouraging students to work through their answers on the whiteboard; and providing personalised feedback, that includes explanations and addresses individual students' misunderstandings.

3.3.3. Purpose of Tutorials: Overview

Students have mixed views on the purpose of tutorials. In general, students benefit from tutorials through being able to ask questions and improve their understanding. Students do not benefit from tutorials when their individual learning needs (such as a tricky concept or misunderstanding) are not met nor when tutorials are conducted to emphasise the importance of exam results. The social aspect of tutorials has the potential to aid or hinder student learning.

3.3.3.1. What Students Gain from Tutorials

Tutorials aid student learning by helping students understand concepts and providing a place and opportunity for students' questions to be answered.

> *'I think the purpose of a tutorial is for you to get to talk through your thoughts and your understanding and work through your misconceptions about the specific topic and the tutor will help you and answer any questions you have and get you to talk through your understanding beyond just what you've read in a textbook.'*
>
> *-participant 7, female*

> *'...in the tutorial you can ask questions on stuff you didn't understand.'*
>
> *-participant 4, female*

This is an example of the appropriate tools being provided for students to best support their competence. Some participants describe tutorials in which they were confused before the tutorial but emerged with a better understanding.

> *'I think the main things that I got out of tutorials was like the stuff that I didn't understand that I then understood after or like, you know, like easier ways of doing things and especially like working through problems.'*
>
> *-participant 6, male*

'...there's times where I went in not sure about the topic at all and I came out feeling like I understood it so much better thanks to the tutorial.'
-participant 2, female

In this way, tutorials are benefiting the cognitive learning of students. On the other hand, some participants find they do not gain as much as they would like from tutorials as their specific needs are not met, or the tutorial makes them doubt their knowledge.

'I learned the odd little nugget of information here and there, but I feel like I don't necessarily get as much as I want […] I mean obviously in some tutorials you would come out and you'd be like, oh, I've actually learned a lot, I feel like I've benefited a lot from that. But there would also be probably more, I think more often than that would be like you come out of it and realize, oh, I actually just don't know anything.'
-participant 8, female

'I wish they [tutorials] could have been more. I think it's difficult to target everything, each individual person's problems, but sometimes I wish that the things that I had struggled with had been gone through as opposed to just the generic thing.'
-participant 7, female

This shows a lack of support of the students' competence and autonomy, with no provision of the necessary tools to promote understanding. This can undermine intrinsic motivation, leading to poorer learning outcomes (Niemiec & Ryan, 2009).

Many participants view tutorials as a space to go over the problem sheet questions.

'...in practice it is really just to go over work that you've already done, so you typically would have also done the problem sheet or whatever it is beforehand, and then you just go to the tutorial and like go through the questions you bring, you raise any questions that you have.'
-participant 8, female

Discussing the problems is important to enhance critical thinking and problem-solving skills. However, when the sole focus of the tutorial is the problem sheet, this often does not produce as effective results as when general understanding of the topic is also considered.

Some of the participants describe the learning of content as central to tutorials.

'I'd say the point of the tutorial is primarily to learn the content.'
-participant 3, female

'...it's a chance to go through the concepts and be taught the content'
-participant 2, female

This view contradicts the university policy, 'Tutorials are not intended to be a mechanism for delivering subject knowledge' (University of Oxford, 2017). This could show some misalignment in how tutorials are viewed amongst policy makers, tutors, and students.

3.3.3.2. Tutorials as Preparation for Exams

From the data, it is suggested that students view a tutorial as being more valuable if it prepares them for their exams.

> *'I'd say for organic chemistry [...] I felt like [tutorials] helped me a lot because the questions are exactly the same in finals as they are in all of the tutorials, so I'd say it definitely gave me an idea of what to expect.'*
> *-participant 1, female*

> *'I definitely remember having some tutorials where none of the questions we had were anything like any exam questions and I thought OK, that was a complete waste of my time and then some of them were very much like you'd look at past papers and you'd be like, OK, I've seen this exact thing before, so it really, again, it kind of just depended on what was in the problem sheet that was set. So sometimes they'd be really good and sometimes maybe not at all.'*
> *-participant 8, female*

Viewing tutorials in this exam-focused way might allow students to achieve higher marks in their exams. On the other hand, it could be argued that this comes at a cost to more in-depth understanding and love of the subject. Participating in work as a response to extrinsic rewards or punishments (such as good or bad grades) diminishes autonomy and undermines intrinsic motivation. If tutorials are conducted to emphasise these extrinsic results, students lose initiative and learn less effectively (Ryan & Deci, 2000).

3.3.3.3. Tutorials as Social Interaction

The social aspect of tutorials is also discussed by participants.

> *'I also think [the purpose of a tutorial] is like just getting to know other people in your college and getting to know your tutors, like the social aspects of it.'*
> *-participant 6, male*

> *'If we had time at the end, or just during as well, if it wasn't a super rushed or stressful tutorial, we could have a chat, we could have a laugh with the tutor or each other, so it wasn't all stress and anxiety.'*
> *-participant 3, female*

Positive social interactions improve the affective experience of tutorials for students. These interactions can increase students' sense of belonging and feeling of connection with the tutor and other students in the tutorial. This is conducive towards a greater feeling of relatedness (Ryan & Deci, 2000). Students having an increased sense of relatedness has been linked to better academic development (Beachboard et al., 2011). Therefore, creating an environment for positive social interactions in tutorials could produce better learning outcomes for students. Beachboard et al. (2011), states that the 'group dynamics of particular cohorts are likely a key to their success or failure'. This emphasises the point that only positive social interactions increase the affective and cognitive learning experiences for students: negative social interactions have the opposite effect. This idea will be explored further in Chapter 4.

3.3.3.4. Purpose of Tutorials: Summary

University policy states that the purpose of a tutorial is to 'develop an individual student's capacity to think in depth about a subject area' and should 'promote increased understanding of the subject for both tutor and student' (University of Oxford, 2017). Students' views on the purpose of tutorials somewhat align with this idea. Some students view tutorials as a helpful space to ask questions and improve their understanding; this supports their competence and leads to a better cognitive learning environment. However, some students do not feel that their specific needs are met in tutorials, thus undermining their feelings of competence and autonomy, and leading to poorer learning outcomes.

Many participants view tutorials as helpful when they prepare students for exams. Tutorials having such a focus can encourage students to view the purpose of learning as obtaining good exam results. This is an example of controlled motivation and lack of autonomy for students, leading to poorer learning outcomes. Finally, the social aspects of tutorials can impact students' experiences, with positive social interactions leading to a greater sense of relatedness and ultimately better learning outcomes.

3.4. Limitations

Any piece of qualitative research is necessarily limited by the context of the study. It is important to address these limitations transparently to clarify what conclusions can and cannot be drawn.

3.4.1. Qualitative Versus Quantitative Research

This research aims to explore how students experience chemistry tutorials. How students' experiences are shaped by subtle social cues cannot readily be explored quantitatively. Students' own words are the key to answering this qualitative research question. The study does not aim to understand the average experience, but is focused instead on unique, rich experiences of individual participants. This limits the generalisability of the conclusions; while these experiences might extend beyond the sample group, they are likely not universal. However, quantitative research also has limitations. Perkin (2016) concluded that there was a significant gender attainment gap in chemistry final honours school at Oxford. The report listed several hypotheses which could not be answered on a statistical basis, some of which were qualitative. It is perhaps useful to consider quantitative and qualitative work as complementary, with each giving different insights into social phenomena.

3.4.2. Practical Limitations

The project might have been strengthened by conducting more interviews, as this would have led to a more generalisable understanding of the chemistry tutorial experience. The sufficiency of interviews is commonly identified by 'saturation'; when an interview has no substantially new ideas. The saturation point was reached for some ideas and categories but increasing the number of interviews would have led to complete saturation. Specifically, interviewing more male students would have given a better understanding of the male experience during chemistry tutorials, which would allow for a better comparison with female students. On the other hand, the sway towards the female perspective in this research provides a rich understanding of the

experiences of that group and addresses itself to the immediate problem of women's under-performance in the Oxford MChem.

3.4.3. Miscellaneous Limitations

As with much research conducted this year, the consequences of Covid-19 might have impacted this study. During the last two years, tutorials have mainly taken place online, only returning to in-person more recently. Online tutorials differ greatly to in-person tutorials, particularly regarding social dynamics and teaching styles (Nambiar, 2020). Many of the specific mechanisms that occur between people interacting in a tutorial, such as body language and non-verbal cues, are limited in the virtual world. This could lead to a different experience of tutorials, particularly for first and second year students who have not experienced tutorials uninterrupted by the effects of the pandemic. The number of participants who volunteered for interview and the identities of those who participated might have been influenced. For example, students experiencing negative consequences from the pandemic (e.g., fatigue, social anxiety) might not volunteer to be interviewed about their experience of tutorials.

3.4.4. Methodological Limitations

Third year students were not invited for interview because of the high pressure of their upcoming IB exams. This reduced the representative nature of the results. The specific loss of the third year voice could be particularly important as this is the period when students sit the exams where the gender attainment gap is most apparent. Students might have specific experiences or insights related to this high-pressure year, which this research overlooks by design. However, fourth year participants could redress this, as they may recall experiences from their third year which would supply insight into the specific third year perspective.

It is possible that there was an element of selection bias within the participants who signed up for interview. It is feasible that students chose to sign up because they wanted to express their strong feelings about tutorials or unconscious gender bias. This could potentially

reduce the generalisability of the findings as their experience might not be indicative of the average experience of Oxford chemistry students. However, this does not diminish the individual accounts provided by the participants; students experience the course differently and there is great value in describing their perspectives.

3.5. Conclusion

Using SDT, this chapter has explored different social and academic interactions that render a chemistry tutorial more positive or negative for students. To make a tutorial more positive for students, it is important that students' autonomy, competence and relatedness are supported. When these needs are satisfied, students are more likely to maintain intrinsic motivation and autonomously regulate their extrinsic motivation, which is critical for effective academic functioning (Niemiec & Ryan, 2009).

On the other hand, when students' feelings of autonomy, competence and relatedness are diminished, their intrinsic motivation is not sustained and their extrinsic motivation is less autonomous. This is associated with academic disengagement and poorer learning outcomes (Niemiec & Ryan, 2009). Therefore, students have a more negative tutorial experience when their autonomy, competence and relatedness are not satisfactorily supported.

Examples of what can threaten students' autonomy in tutorials include: smart peers taking up tutorial time, tutors discussing topics that are irrelevant or are beyond the students' understanding, and when tutorials are conducted to emphasise the importance of exam results. Students' competence can be diminished by: smart peers, more peers in the tutorial, and tutors not providing an explanation alongside answers or useful feedback. Finally, students' relatedness is supported if they feel comfortable with their peers in the tutorial and they feel that their tutor values and respects them.

Chapter 4: Female Students Doing Extra Work

4.1. Chapter Aims

Following investigation into what makes a tutorial experience positive or negative for all students in Chapter 3, this research chapter explores the gendered elements of tutorials. Chapter 4 investigates how female students experience chemistry tutorials. This focus develops a deeper understanding of the specific mechanisms and interactions affecting the tutorial experience. In turn, this articulates one potential mechanism for the gender attainment gap in chemistry final honours school and suggests how to improve tutorial experiences for female students.

Overall, this chapter will argue that chemistry tutorials are experienced differently for female students. They perform a substantial amount of hidden work in tutorials: from pushing themselves to speak up, to battling imposter syndrome. This hidden work adds to their extraneous CL, taking mental focus away from their learning. Furthermore, their relatedness is often not supported in tutorials and their affective experiences are influenced by negative emotions such as anxiety and frustration.

In this chapter, the hidden work is referred to as 'extra' work, as the hidden work results from behaviours (such as self-censoring) exhibited predominantly by women. This can result in female students having to work harder than male students in tutorials. It is possible that male students also engage in these behaviours (as evidenced within this chapter), but the data and wider literature suggest that they are significantly gendered. Exploring the experience of male students would be a valuable avenue of further research.

4.1.1. Research Question

This chapter addresses the research question:

How do female students experience chemistry tutorials?

To answer this question, current MChem students were interviewed about their experiences during tutorials.

4.2. Methodology

This chapter uses the same corpus of data as Chapter 3.

4.2.1. Analytical Framework

The transcription data from the interviews have been analysed using the thematic analysis approach outlined by Braun & Clarke (2021). The entire dataset was coded completely, and codes were clustered together into core ideas (themes).

4.3. Results & Discussion

The themes developed from the participants' responses are displayed in **Table 4.1**.

Table 4.1: Theme summary

Theme	Summary
Female students self-censoring	Female students not speaking up in tutorials for fear of appearing stupid or slowing down the tutorial for other students.
Imposter syndrome	Female students doubting their abilities in chemistry. Female students thinking they are not smart enough to be here and believing they only got into Oxford to fill a quota.
Female students not feeling relatedness	How female students experience a lack of relatedness in tutorials and how their relatedness is affected by the other people in the tutorial. How the lack of female chemist representation in non-tutorial settings does not support female students' relatedness.

4.3.1. Female Students Self-Censoring: Overview

Female students often censor themselves during tutorials. They do this to avoid slowing the tutorial down for their peers or to avoid appearing stupid. Not speaking up in tutorials can negatively impact their affective and cognitive experience.

4.3.1.1. Holding Up the Tutorial

One reason why female students censor themselves in tutorials is because they do not want to take up valuable tutorial time or 'drag the tutorial behind' for their peers.

> *'...to me, asking a question felt like I was taking the time from the important stuff.'*
> *-participant 7, female*

'There were lessons where it felt like I was dragging the tutorial behind with my lack of understanding, and in those situations, I would tend to push less for clarity because I'd be like, OK well I'll just email the tutor later to ask for help or I'll ask one of my friends for help later. I wouldn't actually get assistance in those tutorials 'cause I felt as though I was holding my peers back from understanding more complicated content […] I felt like I was being annoying and like holding people back.'

-participant 1, female

Female students prioritise their peers' learning over their own. This can lead to tutorials being less useful for female students as they are not allowing their own ideas, questions, and misconceptions to be explored. Sometimes female students search for answers elsewhere instead of asking their tutor in a tutorial. This takes up time and might not be as effective in addressing their query. Therefore, female students not speaking up for fear of holding up the tutorial could result in poorer learning outcomes.

According to CLT, an individual's working memory is limited (Bannert, 2002). In order to maximise learning, this capacity should not be overloaded by CL. Extraneous CL does not contribute to learning, occurring when students have thoughts that do not directly help with completing a cognitive task (Moos & Pitton, 2014). Female students considering their peers' education adds to their extraneous CL, allowing less mental space for their own understanding in the tutorial.

Sometimes female students do speak up, despite worrying that this will hold up the tutorial.

'I feel like sometimes I just don't have a clue what's happening, and I know the others know, and I'm like I'm really sorry because I know you know it and it's probably really frustrating for you that you have to wait for me to understand something that you probably just knew.'

-participant 9, female

'...when you're stuck on something and then you feel guilty for keeping everybody else on that point when they all understand it.'

-participant 8, female

The students feel guilty for taking up tutorial time and are worried that their questions are frustrating their peers. These thoughts add to the extraneous CL of female students and take

mental energy away from the chemistry they are learning. This leads to a less affectively and cognitively successful tutorial experience for female students.

The other students in the tutorial can affect whether female students feel as though they are slowing the tutorial down.

> *'...if I was in tutorial with those two I mentioned [male peers aiming for a high grade], then it was definitely a slightly less enjoyable tutorial because I felt like I was slowing the tutorial down. Whereas if I was in the group with my peers that I get on with slightly better, then it was more like we had this allotted time and we would all ask questions and back each other up.'*
>
> *-participant 4, female*

Feeling comfortable with their peers can sometimes allow female students to speak up and engage more with the tutorial, improving both their cognitive and affective experience. With these peers, female students are not as worried about slowing the tutorial down, thus reducing their extraneous CL. This allows them to focus more mental energy on the tasks at hand in the tutorial which could lead to better understanding. As discussed in Chapter 3, when students feel more comfortable with their peers, their relatedness is better supported. This is linked to better learning outcomes.

Some female participants describe their peers expressing negative feelings about them holding up the tutorial. This behaviour is particularly exhibited by smart peers.

> *'I could sense annoyance amongst my tute partners that they wanted to continue and that I was getting stuck on something that for them was really easy. I don't think that it was ever intentional, but there were times where I think they unintentionally showed me, through like their emotions, that they were annoyed.'*
>
> *-participant 1, female*

> *'...two of them [male peers], I found particularly intimidating to be in tutorials with, just 'cause they were aiming for a much higher grade than I was and have a slightly, I wouldn't say they're demeaning, but they are like, if it's not going at the pace they want to do, they get a bit aggy and, you can tell that they're wanting to move on.'*
>
> *-participant 4, female*

> *'...there was definitely that guy that was like, way better than all of us and like I definitely, could practically feel the resentment radiating when I asked something that felt, you know, too basic for him or whatever [...] he definitely made me feel like I was stupid, basically, like made me feel like I wasn't very good basically.'*
>
> *-participant 7, female*

Peers exhibiting negative emotions leads to a poorer affective tutorial experience for female students. Moreover, thoughts of making other people annoyed by slowing down the tutorial add to the extraneous CL of female students, leading to a poorer cognitive tutorial experience as well.

4.3.1.2. Appearing Stupid

A further reason why female students censor themselves in tutorials is to avoid appearing stupid in front of the tutor and their peers

> *'I was a bit anxious and a bit stressed about bringing up something and sounding like an idiot basically and bringing up something that was very obvious and I just hadn't got it and feeling like I was gonna say something stupid […] I think that's the biggest thing, kind of a bit worried I was gonna say something stupid basically.'*
>
> *-participant 7, female*

> *'I was worried that they [tutor] would think it was a stupid question or give me some sort of condescending or not very useful answer. So I just thought, OK, I'm not gonna bother.'*
>
> *-participant 8, female*

Female students worrying about saying something stupid in tutorials causes anxiety and stress which worsens their affective experience. Focussing on not appearing stupid in tutorials adds to the extraneous CL for female students. These thoughts and avoidance behaviours take up mental space, preventing female students from focussing all their energy on their understanding in tutorials. Furthermore, not bringing up concepts they do not understand or not making mistakes does not allow their specific learning to be targeted in tutorials. This decreases the cognitive potential of tutorials and could cause poorer learning outcomes for female students.

The tutor can influence whether a female student feels confident enough to ask a 'silly' question or provide an answer during a tutorial.

> *'Depending on how happy I was in a tutorial might depend on how many questions I ask and I might be less likely to ask a silly question if I feel less confident […] There are some tutors who, 'cause, I felt like we go on better, I was more likely to be willing to embarrass myself a bit and ask what I felt was a silly question.'*
>
> *-participant 3, female*

'There's one tutor who will ask questions and I will not have the confidence to answer out loud, so I kind of mutter under my breath and often it is the right answer, but it's like, why didn't I just say that? I just didn't feel comfortable to do so […] I feel like if I don't know things with certainty, with him in particular, I won't say them. Whereas with [other tutor], if I don't know things with certainty, I'm just like, well, this is what I think and it'll be a lot easier to go like, yeah, this is what I think.'

-participant 10, female

When students feel more comfortable with their tutor, they are more likely to ask 'silly' questions or give an answer that might be wrong. Asking questions allows students to obtain clarification, seek information and receive confirmation (Daly et al., 2009). Questions enable students to access deeper understanding and improve their cognitive tutorial experience. Similarly, answering a question can allow students' misconceptions to be corrected or their understanding to be acknowledged. Therefore, it is important that tutors create a comfortable environment in their tutorials. This can work to support students' sense of relatedness, further improving their learning outcomes.

4.3.1.3. Gendered Aspect of Students Self-Censoring

Female participants note that their male peers, unlike them, have the confidence to give answers even if they are wrong.

'In general, men tend to be a lot more confident than women and I would always notice how one of the guys would just say things and maybe they were wrong but he just had the confidence to say stuff and whenever the tutor would ask the question I was always kind of like double checking in my mind, is this right, should I say it if it's not going to be right.'

-participant 2, female

'My thing with tutorials is I think they're about being wrong with confidence and there's something about being a woman, where it's kind of bad to be wrong about things and especially I think at Oxford, where, it feels like you've kind of broken every barrier and managed to finally get here, and now you have no room for mistake, I think that's how it feels, and I feel like, whereas the men will have the confidence to say things incorrectly and be corrected, I think there's a bigger pressure to say things correctly first time and so I think that definitely affected it.'

-participant 7, female

Nadile et al. (2021) note that answering questions enhances university students' learning and critical thinking; male students can have a more effective tutorial experience when

they give incorrect answers and are corrected as their misconceptions can be addressed. Female students, however, often feel unable to give answers that might be incorrect which can prevent them from reaching their potential for understanding in tutorials.

Participant 2 describes constantly double checking her answers before giving them. Female students often have to put in extra work to speak in tutorials, creating additional extraneous CL which hinders their learning.

It is possible that some male students have similar feelings of not wanting to hold up the tutorial for other students.

> *'I think, particularly when I'm in a tutorial with the two really smart people in my tutorial group, then I like, don't really want to take up more time, just for myself.'*
> *-participant 6, male*

This view contrasts with participant 5, a male student who did not consent to his direct quotes being used in the research output. His view is that if he has a question to ask, he deserves to ask it. He does not share the view expressed by many female students of being worried about holding up the tutorial for other people. He prioritises his own learning over any fear or embarrassment regarding what his peers think of him. The sample of male students in this dataset is small; only two male students signed up for interview. It is important to remember that this is not representative of all male students, but the contrast between participants 5 and 6 serves to emphasise how students are not stereotypical representatives of their gender. Instead, they are complicated individuals with subtle responses to varied contexts. It would be interesting to explore men's tutorial experiences in future studies.

While the phenomenon of self-censoring is exhibited by male students as well as female students, within this dataset and within wider research it is more apparent for female students than male students. Various studies using self-reporting and observation methods show that female students participate less in college STEM classes than male students, across all disciplines (Eddy & Brownell, 2016). Students asking and answering questions in a class

environment enables the instructor to gauge students' understanding and indicates if they are ready to move on or require further help (Nadile et al., 2021). This mechanism suggests that female students obtain less understanding from a tutorial than their non-self-censoring male peers. Furthermore, when students feel able to ask and answer questions, they perceive the learning environment as being more welcoming (Nadile et al., 2021). When male students participate more in tutorials, their relatedness is better supported, which has been linked to improved learning outcomes.

Participant 7 expresses that self-censoring and 'people-pleasing' are traits more typically exhibited by women.

> *'I think definitely a gendered thing is like people-pleasing and you know, you don't want to take away from other people that might have other problems and you don't wanna prevent them from understanding it, but it means that you like, put yourself at a disadvantage 'cause you're trying to let everyone else do the best that they can. I think that's definitely a gendered thing, instead of kind of being selfish, I suppose, and just bringing up the things you want, you wanna let the others ask their questions first.'*
>
> *-participant 7, female*

These claims are supported in the wider literature. Nadile et al. (2021) show that women's voices are heard less frequently than men's in college science classrooms, even when more women are present. Women are more commonly people-pleasers than men as girls are often trained from an early age to accommodate others (Svoboda, 2008). Self-censorship as a gendered phenomenon is also supported by participant 5; this male student discusses being internally focussed on his own education during a tutorial, allowing him a more effective learning space. In contrast, participant 7 argues that female students often focus on the needs of others instead of their own learning needs. Accommodating others adds to the extraneous CL of female students and prevents them from making the most effective use of tutorials.

4.3.1.4. Female Students Self-Censoring: Conclusion

Female students often censor themselves during tutorials. They do this to avoid slowing down the tutorial for their peers or to avoid appearing stupid. Yang (2021) found that participation is

a key factor for students to have a successful chemistry tutorial experience. By censoring themselves, female students participate less and have less-successful tutorials. Thinking about whether they should speak or if their answer is going to be wrong causes stress and anxiety. These thoughts add to the extraneous CL of female students, taking mental energy away from their learning in tutorials. Male students can also exhibit these self-censoring behaviours, but it is more apparent for female students and there is some suggestion from participants that self-censoring is closely tied to women's experiences of Oxford.

4.3.2. Imposter Syndrome

4.3.2.1 What is Imposter Syndrome?

Imposter syndrome is the sense of feeling like a fraud amongst equally skilled peers (Abdelaal, 2020). It is a phenomenon that is frequently discussed amongst the female participants. Students who experience imposter syndrome have persistent feelings that they lack competence and intelligence. They feel constant self-doubt and often feel anxious (Tiefenthaler, 2018). Female students battling imposter syndrome must deal with constant thoughts that they are not good enough and do not deserve to be here. Having these thoughts in a tutorial increases a female student's extraneous CL. The mental effort that female students require to fight these thoughts takes focus away from their studies which leads to a less successful affective and cognitive tutorial experience.

Tiefenthaler (2018) argues that women who have imposter syndrome often work harder than others to try to battle the feelings of self-doubt. This has the possibility of leading them to greater success but also risks overload and burnout.

4.3.2.2 Smart Peers Evoking Imposter Syndrome

As mentioned in Chapter 3, smart peers displaying their knowledge in tutorials can cause other students to compare and doubt their own chemistry abilities. Students' perception of themselves as having a poorer understanding than their peers can induce imposter syndrome.

'There was this one guy in my group who I had had several tutorials with who would always ask very out of the box questions and I remember I always would feel like oh why didn't I think of that, why am I not having these kinds of thoughts and it kind of made me doubt myself a lot, kind of like imposter syndrome, like if I don't think this way, maybe I don't deserve to be here. That's what was running through my head whenever I had a tutorial with him […] it was just me wasting so much energy on having to convince myself that I am good enough to be here.'

-participant 2, female

Imposter syndrome can be evoked when students feel they are not as smart as their peers (Abdelaal, 2020). When in tutorials with particularly smart peers, imposter syndrome and associated thoughts add to the extraneous CL. Participant 2 describes wasting energy in tutorials on convincing herself she is good enough to be here. This takes focus away from her learning, leading to a less successful cognitive tutorial.

4.3.2.3. Filling a Quota

Some female students discuss moments in tutorials when they question if they were accepted into this university based on their ability or to fill a quota (to get enough women in the cohort).

'Often, you have moments where you're sitting there and you're like, was I cut out for this, or was I just filling a quota or a box to say that they've now reached the number of female students that makes it, like, not seem sexist for the uni.'

-participant 10

'I suppose there is this general complex about, you know, like being a woman in science, and you almost go into it sort of thinking people might assume I'm less good, or that I only got in because I'm a woman, to fill quotas, like all that kind of classic stuff […] I think that's probably the main time it's affected me, where I've kind of sat there, essentially like the sort of heightened impostor syndrome for being a woman in science, is probably the biggest thing.'

-participant 8

Imposter syndrome can be experienced by people of all genders but within this dataset it is more prevalent among women than men. This is supported by wider research; Cowie et al. (2018) found that female graduate students experience greater imposter syndrome than male students. In Clance & Imes' classic 1978 study, men experience imposter syndrome much less frequently and at a lower intensity than women. They argue that this is because men tend to attribute their success to themselves, whereas women tend to attribute their success to an

external cause such as luck. In this case, female students are attributing their success in getting into this university to the external factor of filling a quota. As participant 8 explains, this can lead to feeling 'heightened imposter syndrome' during tutorials. This adds to the extraneous CL experienced by female students and can impede their learning in tutorials.

4.3.2.4. Imposter Syndrome: Conclusion

Female students often experience imposter syndrome in tutorials. Smart peers in tutorials can evoke imposter syndrome in other students, leading to less effective tutorials. Some female students attribute themselves getting into Oxford University as a result of their colleges filling a quota, rather than their ability. Having to constantly battle feelings of self-doubt adds to the extraneous CL of female students and takes focus away from their learning.

4.3.3. Female Students Not Feeling Relatedness: Overview

Relatedness is the 'need to feel belongingness and connectedness with others' (Ryan & Deci, 2000). According to SDT, students need to feel relatedness in order to autonomously regulate their extrinsic motivation, which is essential for effective academic functioning (Niemiec & Ryan, 2009). Female students discuss how the gender of the tutor and the social dynamics with other students can impact their feelings of comfort and relatedness in tutorials. This influences their affective and cognitive experience of tutorials.

4.3.3.1. Female Students and Male Tutor

Female participants note a difference in the relationship their male tutors have with them compared to their male peers.

> *'I think there's an aspect of comfort that the male tutors have with male students that they don't particularly have with female students, they have a more impersonal relationship. With male students, they are a lot more casual, will talk about things other than the tute work, will have like a more relaxed kind of thing. Whereas with the female students, they seem a bit more cautious. I don't know how much this affects our actual learning.'*
>
> *-participant 10, female*

'I think he [male tutor] is just very awkward, I mean, even not in a tutorial context, he's just like very awkward […] Maybe tutors that are already awkward are maybe like a little bit more awkward with girls. There wasn't necessarily anything kind of like malicious or like horrible but he was just kind of like maybe he didn't know how to navigate it [female students] quite as well.'

-participant 8, female

The way male tutors have more friendly relationships with male students than female students is an example of affinity bias, the tendency to incline towards and develop better relationships with people who are similar to oneself (Nalty, 2016). It is a type of unconscious bias and leads to male tutors investing more energy and resources into male students while unintentionally leaving female students out.

Female students describe feeling less connected than their male peers to their male tutors. This decreased connection leads female students to have a diminished sense of relatedness which can negatively affect their learning outcomes. Students feeling that their tutor likes and values them is essential to their feelings of relatedness. When female students see male tutors having more friendly relationships with male students, it can cause the female students to feel less like they belong as they do not have a similar relationship with the tutor. Students who feel disconnected from their tutors are less likely to exhibit autonomous regulation of their extrinsic motivation. Consequently, they are more likely to respond only to external controls which has been linked to a negative impact on learning (Niemiec & Ryan, 2009). Moreover, navigating male tutors who are cautious or awkward around them, adds to the extra work that female students have to do in tutorials.

Some female students express feeling that their tutor thinks less of their chemistry ability because of their gender.

'I definitely felt, and there were experiences that made me feel like my tutors had less faith in me because, and I mean, I can't chalk it up to anything but gender, unfortunately.'

-participant 1, female

'I'm not sure if it's a gender-specific thing, but me and the other girl, we've spoken about how one of our tutors seems to talk to us slightly differently. It's not like a visibly or like very obviously difference, it's just a slight, I don't know, he maybe expects a little bit less.'

-participant 9, female

'I think maybe once or twice I've felt like you're picking on me because I'm a girl or you're speaking to me differently, because I'm a girl, it feels like you're dumbing this down.'

-participant 10, female

Students need to feel that the tutor genuinely respects and values them to feel relatedness which allows them to control their extrinsic motivation more autonomously. This leads to better learning outcomes (Niemiec & Ryan, 2009).

Female students think that their chemistry abilities are viewed more negatively by male tutors because of their gender. These thoughts can make female students question their own capabilities which contributes to imposter syndrome and increases the extraneous CL of female students.

4.3.3.2. Female Students and Female Tutor

Female students discuss feeling more related to female tutors.

'I think that the, I related slightly more to the female tutors and I thought that they understood when I was getting frustrated more.'

-participant 4, female

'I felt more comfortable when I had female tutors. I loved my maths tutor 'cause my maths tutor was a woman, I just felt like I related a lot to her and she just gave really good tutorials.'

-participant 1, female

Female students gravitate more towards female tutors than male tutors because of affinity bias. Consequently, female students often have a better relationship and increased connection with female tutors. Their need for relatedness is often better supported when they are in tutorials with female tutors, which could lead to better learning outcomes.

Female students describe a greater sense of comfort and amicability with female tutors.

'I definitely felt more comfortable asking questions with female tutors. And there just tended to be a bit more of like a friendly rapport between myself and those tutors, like I just tended to feel a bit more of like a kinship with them, which I found very helpful. I just felt like they wouldn't be biased against me because they were women, so I didn't feel like I was already at a disadvantage and then was having to prove myself, whereas I felt like with other tutors I was consistently trying to prove myself to be a good student, whereas I felt like they [female tutors] already assumed that I was a good student.'

-participant 1, female

'I only ever had one female tutor. The fact that I really liked her, definitely made a huge, huge difference. I mean, all the girls especially really really liked her. Which I think partly was just because she was generally just like a lovely person and was always very, very helpful.'

-participant 8, female

Female students liking their female tutors and having a friendly relationship with them leads to female students having a better affective and cognitive tutorial experience. It allows female students' relatedness to be developed when they also feel that their tutor likes and values them. Furthermore, feeling more comfortable to ask questions with female tutors allows female students to better their understanding. Additionally, it was noted that female students do not feel that they have to prove themselves when in tutorials with female tutors. This improves the affective tutorial experience for female students, reducing their extraneous CL. Reduced extraneous CL allows them to focus more on their understanding which leads to an improved cognitive experience. This is the converse of their experience with male tutors.

However, it is important to remember that women can exhibit unconscious bias towards other women (Phillips et al., 2016). Some female tutors treat female students differently to their male peers. Female participants note that this is sometimes worse than being treated differently by male tutors; they would not expect to be treated differently because of their gender by a female tutor.

'I think because she was a woman, it hit me more than the others, 'cause I would have expected her to understand more than a male tutor and she didn't […] I don't know if she expected more of me because I was a woman or if she was like that with everyone, I don't know. I never saw her acting like that with the others [male students], so maybe it was that she expected more of me or something.'

-participant 7, female

When female students feel that their tutor expects more of them because of their gender, it can lead to a decrease in connection and relatedness with their tutor and adds to their extraneous CL.

4.3.3.3. Female Students and Other Students

Female participants express not having as much room to speak in tutorials as their male peers. This is due to male peers speaking more loudly or over female students and taking up most of the tutorial discussion space.

> *'I do tend to get spoken over by my male peers quite a lot, which is quite annoying […] sometimes when I was giving an answer, they would cut me off and try and explain it before I'd even finished and that just made me frustrated.'*
>
> *-participant 1, female*

> *'They [male peers] spoke louder than me. I spoke quieter than them and that kind of took over the conversation, 'cause I wouldn't speak loud enough and they would just take over everything.'*
>
> *-participant 7, female*

> *'I think I often find I'm not the loudest voice in a tutorial […] in that tute, I'm with two guys, and they are very happy to be pretty open and loud about their answers'*
>
> *-participant 10, female*

Female students not being given space to talk in tutorials leads to them feeling frustrated and having a poorer affective experience. This frustration and fighting to be heard adds to the extraneous CL of female students, taking energy away from their learning. Female students not being able to express themselves academically prevents them from talking through their thoughts and misconceptions with the tutor. This could result in a poorer understanding in the tutorial and a worse cognitive experience for female students. Being spoken over by male peers also decreases female students' sense of relatedness as they do not feel respected by their peers.

Some students describe how the male and female students in their chemistry cohort band together because of their gender.

'I think that there were definitely times when the boys seemed to like band together a little bit and it helps that they were best friends, as well. I would also band together with my [female] friends a bit and we'd, not fight it out but like if you have like specific things you want to get from the tutorial then, it helps to have people backing you up who are on your side and the boys sometimes band together.'

-participant 4, female

'For physical tutorials, it was split by gender. I don't know whether that was on purpose or whether that was just how it happened. But actually, I kind of liked it, I'm not going to lie. I mean, I certainly do really remember enjoying the girls' tutorials quite a lot. I never like felt awkward in those tutorials and it was quite nice having this sort of like girl gang going to do our physical tutorials together. So in that sense, yeah, that was nice. I also definitely felt that there were no elements of showing off in the girls' tutorials, like we're all just there, like, I just want to, you know, understand things, absorb information.'

-participant 8, female

'Something that I've been thinking about is my relationship with the one other girl in our chemistry group of seven. I think we're quite different people and I don't know if she's the kind of person that I would be kind of drawn to naturally, but I realized that I kind of have, maybe because we're the only two girls, I kind of have like this weird, like, protectiveness like towards her. I'm like, we have to, you know, stick together we and I don't know, maybe that's kind of this weird solidarity thing that, you know, there's a few of us.'

-participant 2, female

Students banding together into gendered groups is another example of affinity bias. Within these groups, students can feel more connected to their peers, increasing their sense of relatedness. Participant 8 describes enjoying all-girl tutorials and notes the lack of showing off. Without male students taking up much of the tutorial discussion time, female students have more space to explore their understanding, leading to a more effective cognitive tutorial experience. The participant describes a lack of awkwardness in the tutorial, leading to a more positive affective tutorial experience. Furthermore, feelings of awkwardness are not there to add to the extraneous CL and detract from the learning.

In chemistry cohorts at some colleges, there are very few girls in a year group. This can negatively impact the learning experiences for those female students.

'I've noticed that usually there's only like three women at most usually in the groups that I'm in. I mean, in labs we do them with another college and there's only one girl from their college. I've got, I've been doing a supplementary this year and there's only two girls in our nine people class, so it's always like. It's just something that I've accepted now, that most of the time there will not be like a majority of women or even half women, you know? So it's a bit sad […] I'm glad that it's never just me. I'm glad that there's always at least one other woman in the room 'cause it would be a bit you know, if it was just the feeling of being the only woman in the room.'

-participant 2, female

'I'm the only girl. There's always only one or fewer girls per year in our college. I don't know if they do it specifically with intent, but it's definitely a noticeable pattern that they have. It was almost like a running joke of like, oh, you're the girl in your year. It is difficult to know whether or not they actually do that intentionally, but it's not very promising I don't think […] I think subconsciously it felt like, I was at odds with them [male peers]. I always felt like I was the worst in the year, I also always felt like I was the most stupid one there, even if that wasn't always the case.'

-participant 7, female

Perkin (2016) hypothesised that 'female students may be disadvantaged academically when they are a small minority in their college cohort'. Participant 7 is the only female student out of four and participant 2 is one of two female students in her college cohort of seven. Both female participants note how the lack of other female students in their cohort leads to a more negative affective experience of tutorials. Being part of a small minority of female students in a cohort can lead to feelings of sadness and loneliness. These feelings take up mental space for female students and increase their extraneous CL during tutorials which can negatively impact their understanding. Participant 7 describes feeling that she is the worst at chemistry out of her peers because of her gender. These thoughts once again take up mental space and can prevent female students from fully benefitting from their tutorials. Furthermore, with fewer female peers it is possible that female students in this position feel less relatedness to their peers which could negatively impact learning outcomes.

4.3.3.4. Female Chemist Representation

Participants note the lack of female chemist representation amongst academic staff at Oxford, in particular the lack of female lecturers.

'When you have lectures from mostly males, you know, sometimes that's a bit like, oh ok right where are the women, you know.'
-participant 4, female

'Having more female lecturers would have been nice.'
-participant 3, female

A lack of female chemist representation of lecturers and other staff at Oxford can cause female students to feel like they actively do not belong.

'There was a big thing where in first year I think we had one female lecturer and like we did all point this out, we were like yeah, there's a big lack of female teachers here. It's the people that you see like constantly in terms of interaction, your lecturers tend to very, very rarely be female […] I think it causes a sense of unbelonging'.
-participant 10, female

A sense of unbelonging leads to female students' relatedness not being supported. This makes them less likely to autonomously regulate their extrinsic motivation, leading to poorer leaning outcomes (Niemiec & Ryan, 2009). Furthermore, it can perpetuate feelings of imposter syndrome and add to their extraneous CL, taking thinking space away from their studies.

Female lecturers can act as role models for female students.

'I saw [female lecturer] at the front of the lecture hall and for the first time I kind of understood what representation meant and I was kind of like, oh my God, I can visualize myself being like her, 'cause like most of the other lecturers were all like old white men, basically. I think there was definitely a sense that I was an outlier, until I saw a lecturer was like me.'
-participant 7, female

Role models are more effective when they are of the same gender (Lockwood, 2006). Therefore, female lecturers acting as role models have the potential to increase female students' sense of belonging and relatedness.

Students note the lack of women in senior roles.

'Most of the time, what I find in our day-to-day interactions, like in the lab, you'll have a lot of female teachers, but the higher up you go in terms of like the actual academic staff or like people that are controlling all of these things, there tends to be far fewer women. And I think we notice it, I don't know how much it's internalised or how much it affects like my actual chemistry day-to-day life. But it's definitely something we've all clocked at some point and been like, yeah, that's a thing.'
-participant 10, female

The shortage of women acting as role models in high-profile chemistry positions can signal to female students that they do not belong in the field (Walton & Cohen, 2007). This could diminish female students' sense of belonging and relatedness and increase their feelings of imposter syndrome. This also leads to the perpetuation of the leaky pipeline problem in chemistry (progressive loss of female chemists at each stage of seniority) (Sanford et al., 2020).

4.3.3.5. Male Student Perspective

The two male students in the study feel that the gender of the tutor does not influence their tutorial experience. Instead, the tutorial experience is affected by the tutor's teaching style.

> *'...all of my tutors were male, apart from in second year when one of our tutors went on sabbatical and we had a female organic tutor. I wouldn't say that her gender specifically affected the tutorial, but I didn't enjoy her way of teaching.'*
>
> *-participant 6, male*

It is interesting to note that most of the female participants view the gender of the tutor as impactful on the tutorial experience whereas the male students do not, perhaps suggesting that affinity bias does not always determine participants' relatedness. This could speak to male students feeling valued and respected by tutors of all genders, allowing their relatedness to be supported. Furthermore, male students do not have to battle with thoughts that their tutor thinks less of their chemistry ability because of their gender. This decreases their extraneous CL and allows more mental space for learning and understanding.

Male students are aware of the disparity between male and female chemist representation. Participant 5 discusses that he is aware that most lecturers are male, but this does not affect him personally. The lack of female representation does not affect male students as their gender is not underrepresented. Having good male chemist representation supports male students' relatedness and sense of belonging, leading to improved learning outcomes.

Participant 5 notes that his gender does not affect his experience of learning chemistry at Oxford. This view is shared by participant 6 who has never considered his gender when thinking about his chemistry learning.

'I've never considered the gendered experience part of it [learning chemistry], or like the gender aspects. I mean, I know, there are the statistics and stuff when it comes to finals and things, but I've never really considered it.'

-participant 6, male

Male students are not affected by unconscious gender bias in tutorials, so they do not experience extra negative emotions (such as frustration and self-doubt) associated with being treated differently because of gender. They do not need to consider their gender in tutorials and at other times when they are learning chemistry. This allows more mental space for understanding chemistry and decreases their extraneous CL compared to female students. This could lead to better learning and performance outcomes for male students.

4.3.3.6. Female Students Not Feeling Relatedness: Conclusion

Female students' relatedness is sometimes not supported in tutorials with male tutors. Male tutors can exhibit affinity bias towards male students, and female students may perceive their male tutors as doubtful of their abilities. This impairs female students' tutorial experiences by taking up mental space in the tutorial and increasing their extraneous CL. Female students' relatedness is often better supported in tutorials with female tutors, leading to a more successful tutorial, both affectively and cognitively.

Female students often do not have as much space to speak in tutorials as their male peers. This causes feelings of frustration which adds to the extraneous CL and prevents deeper understanding leading to a poorer affective and cognitive tutorial experience. Female and male students in a cohort often exhibit affinity bias by banding together into gendered groups. Within these groups, students can feel a greater sense of relatedness. However, in some college cohorts there is only one or very few female students in the year. This can lead to low feelings of relatedness for the lone female student, adding to the extraneous CL.

The lack of female chemist representation at Oxford decreases female students' sense of belonging. This does not support relatedness and adds to the extraneous CL of female

students. Female chemists in high-profile roles can act as role models to female students, supporting their relatedness and encouraging them to remain in the field.

Male students are less affected by the gender of the tutor in the tutorial than female students. Male students do not feel that their tutor thinks less of them (or their chemistry ability) based on their gender. This allows their relatedness to be supported and does not add to their extraneous CL, allowing for a more successful cognitive tutorial. Male students are aware of the lack of female representation in chemistry, but this does not affect their learning experience. Male students do not consider their gender when learning chemistry because they do not experience unconscious gender bias. This allows them to have a more positive affective and cognitive tutorial compared with female students and does not add to their extraneous CL. The tutorial experience could be leading to the better learning outcomes for male students, presenting a possible mechanism for the attainment gap at Oxford.

4.4. Limitations

The limitations – especially concerning generalisability – are the same as for Chapter 3.

4.5. Conclusion

Using CTL and relatedness from SDT, this chapter has explored how female students experience chemistry tutorials. Female students have to do extra work in tutorials compared to their male peers. They have to battle imposter syndrome and push themselves to speak up in tutorials. Much of this adds to their extraneous CL, giving them less mental space for deeper understanding of chemistry. Furthermore, they experience a variety of negative emotions during tutorials due to being treated differently because of their gender. Emotions such as anxiety, frustration and loneliness decrease the affective experience of tutorials for female students. Their relatedness is often not supported in tutorials, because of male tutors treating them differently or a lack of representation. All this affects how tutorials are experienced by female students and could lead to learning outcomes differentiated by gender.

Chapter 5: Final Conclusions and Recommendations

5.1. Summary of Findings

The data collected from the qualitative interviews with current MChem students provide a rich insight into the experiences of students in chemistry tutorials at Oxford.

Chapter 3 showed that students of all genders do not always have their autonomy, competence and relatedness supported in tutorials. According to SDT, this could cause students to have less-autonomous motivation, leading to poorer learning outcomes. Some examples of how students' autonomy, competence and relatedness are threatened in tutorials include: smart peers, more students in the tutorial, and tutors not providing useful feedback.

Chapter 4 explored the gendered elements of chemistry tutorials. Female students have extra (hidden) work to do in tutorials compared to their male peers. During tutorials, female students have to: battle imposter syndrome; push themselves to speak up; and deal with negative emotions such as anxiety, frustration and loneliness. Their relatedness is often not supported because of a lack of representation or being treated differently because of their gender. All this extra work adds to their extraneous CL, giving them less mental space for deeper understanding of chemistry. Tutorials are experienced differently by female students, and this might lead to learning outcomes differentiated by gender.

5.2. Importance of Findings

Tutorials are a central pedagogy in the MChem degree. Understanding what makes a tutorial positive or negative is crucial to ensure that they are effective for all students.

Female students have to do more work in tutorials and unconscious gender bias contributes to this extra work. This presents a plausible mechanism for a contribution to the attainment gap in Oxford's MChem degree outcomes between men and women described by Perkin (2016); how female students experience tutorials affects their learning and therefore performance in chemistry exams.

One of the University of Oxford's equality objectives is to 'Eliminate the undergraduate gender attainment gap by 2030', with a target to 'reduce the first-class degree attainment gap between women and men from 8.5% to 4.4% by 2025' (University of Oxford, n.d.). The equality policy states that the university will 'take appropriate steps to meet the particular needs of individuals from protected groups where these are different from the needs of others, and work to eliminate any barriers to their success' (University of Oxford, n.d.).

Female students experience chemistry tutorials differently to male students and have different needs. It is the stated responsibility of the University of Oxford to meet these needs and give female students every chance to succeed. Recommendations can be made from the results of this study to improve the tutorial experience for female students. This could help to narrow the gender attainment gap in MChem, advancing the university's equality objectives.

It is important that tutors and students are aware of the unconscious gender bias that is occurring in chemistry tutorials. Only then can steps be made to reduce it and its effects. This will contribute towards the United Nations' fifth sustainable development goal to 'end all forms of discrimination against all women and girls everywhere' (United Nations, n.d.).

5.3. Recommendations

The data gathered in this study provide specific suggestions for how to improve tutorial experiences for all students and how to make tutorials more effective for female students.

5.3.1. Tutorial Groups and Cohorts

The number of students in the tutorial affects the experience. Students' competence is better supported in tutorials with fewer peers as this encourages greater participation and understanding. Therefore, *wherever possible, tutors should conduct tutorials with fewer students*: two or three students instead of four or five.

Students should be able to choose their own tutorial groups as this enables a more positive affective and cognitive experience. Amongst peers they are comfortable with, students

are more likely to participate and to feel relatedness in the tutorial.

Finally, when female students are a small minority in their college cohort, they experience negative emotions and a lack of relatedness. This adds to their extraneous CL and can cause poorer learning outcomes. *Colleges should be aware of this problem and work to try to ameliorate this situation.* This might involve a working group considering strategic measures (such as improving the application rates of women by improving staff representation and eliminating the gender attainment gap), and structural measures (such as employing female tutors, or more radically, reallocating students post-admission to avoid women being alone in a college cohort).

5.3.2. Tutor Training

Better relationships between tutors and students allow students' relatedness to be supported and enable students to participate more in tutorials. The teaching style of tutors impacts students' experiences of tutorials and how effective they are. *Tutors should receive training on how to teach effectively and how to create relationships with students in which the student feels respected and valued.* This will improve students' affective and cognitive tutorial experiences.

The participants' responses show that unconscious gender bias is currently taking place in tutorials. *Unconscious bias training for tutors for the specific pedagogy of the tutorial should be developed.* This could improve the relationships between tutors and students, making tutorials more effective.

5.3.3. Employing More Female Staff

Oxford's Department of Chemistry academic staff list currently consists of only 22% women. (Department of Chemistry, n.d.) The lack of female representation here threatens female students' sense of belonging and relatedness, perpetuating the leaky pipeline. Furthermore, female students' relatedness is often better supported in tutorials with female tutors.

The department should employ more female academic staff as this could improve the learning experiences of female students. It is important that female academics occupy visible positions of power within the department to mitigate against the leaky pipeline phenomenon and give role models to female students.

5.3.4. Accountability Mechanisms

Sustained accountability is important for understanding and improving women's experience of the MChem at Oxford. *The department should strengthen relevant accountability mechanisms.* This might include prominently publishing relevant gender data (e.g., on attainment and representation) or designing feedback procedures to systematically measure and improve the experiences of diverse demographic groups.

5.3.5. Further Research

This study was limited because of time and transcription resource constraints. Further research could provide a more in depth understanding of unconscious gender bias in chemistry tutorials.

Originally, the design of this study included observations of chemistry tutorials but unfortunately no chemistry tutors volunteered to be observed. The methodology for observations of tutorials to look for unconscious gender bias has been researched and is 'ready to go' (**Appendix C**). Observations provide direct insight into tutorial experiences, complementing students' accounts of the tutorial space.

Participants noted how menstruation affected their tutorial experiences and wider learning of chemistry. For example, one participant described sitting through a tutorial while experiencing considerably pain as they did not want to miss the session, but not wanting to raise this with a male tutor because of the stigmatisation surrounding periods. Menstruation systematically affects a large proportion of the chemistry cohort and further research should be done to review how it impacts their chemistry education.

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Appendix A: Recruitment Flyer

Social dynamics in chemistry tutorials
Ethics Approval Reference: R79438/RE001

VOLUNTEERS NEEDED FOR INTERVIEW

This study explores whether the experience of chemistry tutorials is different for people of different genders and how this affects their study of chemistry.

We are looking for volunteers of all genders to take part in an interview. Participants must be currently on the MChem course and in 1st, 2nd, or 4th year. If selected for interview, you would be invited to an online or in-person session that would take about 30 minutes of your time.

During the interview, you will be asked questions about your experiences during chemistry tutorials. The interview will be with the Part II student researcher, Hannah Bruce (Wadham College).

Participation in the interview is completely voluntary.

The participant information sheet can be accessed through this link: [hyperlink to OneDrive folder]

If you are interested and would like more information, please contact Dr Michael O'Neill on michael.oneill@chem.ox.ac.uk. There is no obligation to take part.

Thank you!

Appendix B: Interview Guide

Introduction

Hi, my name is Hannah. I am a fourth-year chemistry student here at Oxford. I am currently doing my Master's project in chemistry education research. Specifically, I am looking at the social dynamics of chemistry tutorials and how this affects students. I am particularly interested in any potential gender bias during tutorials.

Part of my research is interviewing current MChem students about their experiences during chemistry tutorials and classes. I am interviewing you today because you are a current chemistry student at Oxford and you have agreed to do an interview with me.

This will be a semi-structured interview. I have planned a set of questions to ask you but the interview is relaxed to allow you to freely express your thoughts. I might ask you follow up questions that are not pre-prepared and you are welcome to discuss things you think are relevant that might not have been asked about in the questions. The interview should last about half an hour.

Just to let you know that I might make some notes on a notepad. These are so I can keep track of the interview and write down anything I want to follow up on or if I have new questions to ask. Is that okay with you?

I want to remind you that you can withdraw consent at any point during our conversation. Do you have any questions or anything that you would like to raise before we start?

In person interviews:

I am going to voice record our conversation using a dictaphone. I will then transcribe our conversation using an automated software and amend any errors myself. I will use our conversation for the purposes of my research only. I will not include any information that could directly identify you. I may publish direct anonymised quotes in my research outputs.

I am about to start recording our conversation.

Online interviews:

I am going to voice record our conversation using a dictaphone. I will be using the Microsoft teams automated transcription function, but this won't be recording our conversation. I will use our conversation for the purposes of my research only. I will not include any information that could directly identify you. I may publish direct anonymised quotes in my research outputs.

I am about to start recording our conversation.

Start recording

Questions

Theme 1: Participant's experience of tutorials

Structured question	Possible clarification questions	Possible development questions
What do you think the purpose of a tutorial is?	What do you get out of a tutorial? *Do they make you feel more/less confident about your chemistry?* How do tutorials help with your understanding of chemistry? How do tutorials help to prepare you for exams?	Can you describe a time during a tutorial where you felt you didn't get much out of it? *Why was this?* Can you describe a time during a tutorial where you felt you did get a lot out of it? *Why was this?*
What sorts of emotions do you experience during tutorials?	What kinds of features of a tutorial influence how comfortable or uncomfortable you feel in the session?	Can you describe a time during a tutorial where you felt uncomfortable?

Theme 2: Gender dynamics in a tutorial

Structured question	Possible clarification questions	Possible development questions
How does your chemistry cohort pick tutorial groups? *Who decides? Do you often end up with people of the same gender as you?*	How is your experience affected by the other students in the tutorial? *Does the number of students in the tutorial make a difference?* How is your experience affected by the tutor in the tutorial? *How does the gender of the tutor affect the experience of the tutorial?*	Do you think interruptions happen a lot during tutorials? *Do these affect your experience?*
Thinking back over the things you've just said about picking groups, interacting with students, and the position of the tutor, do you think there is any way that your gender relates to these experiences?	Can you describe a time when you felt that your gender affected your experience during a chemistry tutorial?	

Theme 3: Chemistry

Structured question	Possible clarification questions	Possible development questions
Do the social dynamics of tutorials change between different chemical disciplines (e.g., organic, inorganic etc)? *Is this related to the tutor? Is this related to the scientific content?*	Do you prefer the tutorials for one discipline over the others? *What are the reasons for this? Or do you disfavour the tutorials for one discipline over the others? Why?* Do you think that your grades/performance in each discipline are related to the tutorials for that discipline? *Are they related in any way to the social interactions during the tutorials?*	

Closing

Those are all my questions. Is there anything you wanted to say or add? Perhaps something which came up or something you've thought of during the interview?

Conclusion

Just before I stop recording, I want to confirm that you still consent to the voice-recorded data from our interview being transcribed and used for the purposes of my research only and that I have permission to use direct, anonymised quotes from our conversation?

Stop recording

Thank you so much for your time, I really appreciate it. I will be sending you a short summary of the research findings at the end of Trinity Term.

Appendix C: Observation Checklist

General:

Tutor number	
Male or female tutor	
No. male students	
No. female students	

Time Talk App:

Meeting time	
Total female	
Total male	
% Female	
% Male	

Tutor talk:

	Male student	Female student	Both
Praises/encourages			
Accepts ideas			
Asking questions to specific student			
Asking questions to everyone (who answers)			
Criticising			

Student talk:

	Male student	Female student
Initiation (Talk initiated by student)		

Interruptions:

	Tutor interrupted	Male student interrupted	Female student interrupted
Tutor interrupts			
Male student interrupts			
Female student interrupts			