Methodology and methods

The employment of an appropriate methodology is crucial in that it informs the collection of data, analysis and thus ultimately the degree to which the research questions are effectively addressed (Taber, 2013). Methodology extends beyond the techniques used but can be thought to consist of the "assumptions, postulates, rules, and methods—the blueprint or roadmap—that researchers employ" (Given, 2008, p.516). In this section, the epistemological and ontological assumptions underlying the study will be laid out, as will the research design, validity and reliability. The research instruments to be used as well as ethics will also be discussed. While research in the natural sciences is founded in common principles and notions of reality and knowledge, in the social sciences researchers take a broad range of philosophical positions meaning it is important for the researcher's position to be made explicit in any given study. I justify my position below.

Ontological assumptions

Questions of ontology are concerned with "the nature of the social world", significantly whether there is an external reality to the social world that is separate from those who act within it (Bryman, 2016, p.4). Ontological positions can be seen to exist on a continuum which can shape the methodological approach taken by researchers. Broadly speaking, at one end of this ontological spectrum are realists or objectivists who believe that an external reality exists which is separate from the human observer's understanding, while at the other end of the spectrum are idealists or subjectivists who believe that there is no reality external to that socially constructed by the human mind (Ritchie, Lewis, Nicholls, & Ormston, 2013). Objectivism is an ontological position which has drawn criticism from social scientists as studies taking this standpoint tend to describe social reality in a way which oversimplifies it to causal relationships between isolated variables (Kozhevnikov & Vincent, 2020). In addition, a realist account of social entities such as class and gender draws argument over the degree to which such objects objectively exist or are social constructions (Porta & Keating, 2008). Accounts of the world from a subjectivist standpoint have been considered insufficient as an approach which reduces the reality of the world to that is which is expressed by people and thus makes judging the relative accuracy of differing discourses a challenge (Kozhevnikov & Vincent, 2020).

Critiques of the positions of objectivism and subjectivism such as those presented above has led to a number of more nuanced philosophical positions to be taken by researchers, for example critical realism (Ritchie et al., 2013). Critical realists take the view that while there is a social reality that exists, they also acknowledge that scientists' attempts to understand such reality will be varied and that interpretation is subjective due to being founded in a particular perspective (Bryman, 2016). In short, it could be said that critical realists "retain an ontological realism while accepting a form of epistemological relativism or constructivism" (Maxwell & Mittapalli, 2010, p.8). This is a standpoint that I argue aligns well with this study as critical realism recognises the importance of context - in the sense of the complex processes at play rather than simply the presence or absence of variables - in its explanation of observations and thus its concern is with understanding of particular events or situations rather than general laws (Maxwell & Mittapalli, 2010).

Epistemological assumptions

Epistemology is concerned with "the question of what is (or should be) regarded as acceptable knowledge in a discipline" (Bryman, 2016, p.27). Similarly to ontology, epistemological positions in sociological research have traditionally fallen on a broad spectrum. At one end of the spectrum lies positivism, in which proponents believe the social world can and should be known in the same way that phenomena are known in the natural sciences – through the gathering of facts in a value-free manner in order to provide the basis for laws which describe and predict behaviour (Ritchie et al., 2013). A common critique of this epistemological standpoint when examining the social world is that it reduces all that can be known to all that can be measured and quantified in scientific experiments (Cohen, Manion, & Morrison, 2013). This has been seen as being dehumanising, with such research being seen by Ions as "a branch of mathematics rather than a humane study seeking to explore and elucidate the gritty circumstances of the human condition" (1977, quoted in Cohen et al. 2013, p.17). At the other end of the spectrum lies interpretivism, aligned with constructivism, in which proponents see the social world as fundamentally different to the natural world and thus requiring different ways of knowing (Bryman, 2016). Constructivists would assert that knowledge is constructed as humans interpret the world and that thus different meanings of phenomena arise depending on social and cultural perspectives (Moon & Blackman, 2014). Constructivists would seek to understand human behaviour, rather than to provide laws which explain it, and attempt to "to gain access to people's 'common-sense thinking' and hence to interpret their actions and their social world from their point of view" (Bryman, 2016, p.30).

The constructivist epistemology has attracted criticism, for example in the perception by some researchers that in the absence of a reality external to the observer, all constructions of truth are equally valid (Nola, 1997). However, this concern is largely aimed at relativist forms of constructivism in which all truth is seen to be relative and this position will not be taken in this study. In the form of epistemological constructivism employed when taking a critical realist stance, it is accepted that while our access to social reality is imperfect and socially situated, it does exist outside of one's beliefs about reality and thus knowledge is not reduced to the perceptions of individuals (Kozhevnikov & Vincent, 2020). An interpretivist/constructivist epidemiology is most appropriate for this study as it seeks to gain a deeper understanding of the effects of different classes on attitudes towards science from the point of view of the students and teachers that have experienced them while recognising the importance of the social context in the formation and interpretation of these attitudes.

<u>Mixed-methods case study design</u>

While positions of epistemology and ontology can shape the research design of a study, the methodological approach taken also depends upon the research questions at hand. Below I put forward my justification for the use of a mixed-methods case study design.

In the simplest terms, a case study is a study which "entails the detailed and intensive analysis of a single case" (Bryman, 2016, p.66). Yin (2014, p.16) goes further to define a case study as an inquiry that "investigates a contemporary phenomenon (the "case") in depth and within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident." Case studies have a number of key features, for example the case has boundaries which allow it to be defined and can be characterised temporally and by the individuals or organisations which make them up (Cohen et al., 2013).

Typically the researcher is an integral part of the case at hand and is concerned with understanding the perceptions of those within the case and presenting rich and detailed descriptions and analysis (Cohen et al., 2013). The context I am investigating lends itself to this approach due to its real-world and current nature but due to the inability to control various external variables which means the context cannot be separated from the case, as well as my position as researcher and teacher at the school being studied. The novel context, a year group who have experienced both single-sex and mixed-sex science classes at key stage 4, is also suited to a case study as it presents a unique or extreme case with the potential to find important features of its nature (Bryman, 2016). A common critique of the case study approach concerns the lack of ability to generalise from such research and issues of observer bias and subjectivity (Simons, 2009). However I would argue, in line with Simons (2009), that the concept of generalisation drawn from positivist research traditions does not apply to the case study as the case is studied due to its very uniqueness and not under the assumption that findings could, or should, be generalised to the wider population. This is not to say that comparisons could not be drawn to other cases, just that those comparisons must consider the context-bound nature of the knowledge derived from case study research. Case study research should thus not make claims of generalisability but should present an account which "allows the reader to make an informed comparison between the research context and other contexts where the findings might be considered to apply." (Taber, 2000, p.480). Addressing the issue of observer subjectivity, separating the researcher from the case being studied has been described by Galdas as being "neither possible nor desirable" (2017, p.2) and that researchers should be more concerned with transparency and being reflexive rather than unsuccessfully attempting to demonstrate complete objectivity and neutrality. Reflexivity during data collection and analysis is essential to ensure trustworthiness and rigour in this study, thus a reflexivity statement will be presented later in this chapter.

The case study approach is concerned mainly with the subject of the research and so within that methods must be chosen which are most appropriate for addressing the research question. There is a long-standing divide in the social sciences in terms of approaches to data collection, quantitative approaches which are concerned with gathering quantifiable data such as from surveys are compared to qualitative approaches which place emphasis on words rather than measurement (Bryman, 2016). It has been argued that quantitative and qualitative methods are incompatible due to the perception of being founded in opposing epistemological and ontological philosophies, however mixed-methods research, employing a study design which uses both types of data collection, is increasingly common in sociological research (Bryman, 2003). According to Creswell (2003, p.51) a mixed methods approach is most suitable when "the quantitative or qualitative approach, each by itself, is inadequate to best understand a research problem". I will be seeking to measure students' attitudes towards science and the degree to which students perceive different constructs which make up their attitude towards science have been affected by a change to mixed-sex classes, requiring the use of a quantitative survey instrument in order to examine patterns in attitudes across the cohort. However, to gain a deeper understanding of the issues at hand from the point of view of those that make up the case being studied, qualitative methods such as semi-structured interviews will also need to be used. Yin (2014, pp.17) states that case studies should gather "multiple sources of evidence, with data needing to converge in a triangulating fashion", providing further justification for the employment of

mixed-methods in this research design. Leech and Onwuegbuzie (2009) describe the range of mixed-methods typologies which includes variation around the way in which methods are sequenced, the degree to which mixed-methods are employed across the study and whether there is dominance of quantitative or qualitative methods. Using these guidelines, this study presents a partially mixed-methods sequential dominant design in which the dominant qualitative part of the study follows the initial quantitative part, denoted by the notation quan → QUAL (Leech & Onwuegbuzie, 2009). The quantitative questionnaire will precede the qualitative semi-structured interviews with findings of both methods being integrated during the data analysis phase of the study. The quantitative instrument is used first to provide a general, wider picture of the cohort's attitudes towards science while also allowing for the recruitment and selection of participants for the semi-structured interviews based on their responses to the questionnaire.

Reliability and validity

Concerns of validity and reliability are founded within the natural sciences and traditionally align with quantitative research methodologies. Validity is concerned with whether conclusions drawn from research are sound and is made up of measurement/construct validity (whether measurements accurately measure what they intend to), internal validity (whether conclusions of causality are well-founded), external validity (the extent to which findings are generalisable beyond the research context) and ecological validity (whether the findings are representative of people's everyday environment) (Bryman, 2016). Reliability is concerned with whether repeating a study will yield the same or similar results (Payne & Payne, 2004). In quantitative studies, this concerns whether measures are consistent and would provide the same results on two different occasions and often statistical measures such as Cronbach's alpha are used to assess the degree of reliability of a particular measure (Bryman, 2016). Despite much importance being placed upon reliability in the social sciences, it is rare to see other researchers attempt to recreate studies as seen in the natural sciences (Payne & Payne, 2004). Indeed, as argued by Payne and Payne (2004, p.198) "social life is not repetitive or stable, and so our research perceptions of it cannot be entirely consistent." This has led to some researchers arguing that validity and reliability as described above do not fit well with qualitative methodologies with 'trustworthiness' being proposed as an alternative, made up of the subconstructs of credibility, transferability, dependability and confirmability (Lincoln & Guba, 1985). These concepts maintain a degree of alignment with the criteria associated with quantitative research while showing a greater appreciation for the epistemological and ontological standpoint that underpins much qualitative research. Indeed, it has been argued that too much focus on traditional notions of validity and reliability in qualitative research can be seen as hampering creative approaches in qualitative research (Morse, 1997). Nevertheless, engaging with these issues will be important in ensuring rigour in this study while producing meaningful and trustworthy results.

One justification for mixed-methods designs is to reduce the limitations of each method, particularly relevant to issues of validity and reliability. There has been debate as to the suitability of the term validity in mixed methods research due to the differing ways in which it has been defined (Tashakkori & Teddlie, 2010). However, I would argue that while a 'one-size-fits-all' approach to dealing with issues of validity and reliability across mixed-methods research would not be appropriate due to the diversity of study designs, it is important to

consider these issues in the context of the study in question. The triangulation of data from multiple data sources has been seen as a strategy for increasing validity in research and is particularly relevant to mixed-methods research (Cohen et al., 2013). This can be achieved through the development of convergent lines of inquiry and thus contributes to increasing what has been conceptualised as convergent validity (Mills, Durepos, & Wiebe, 2010). This will be achieved in this study through the concurrent analysis of data from both instruments when identifying themes and patterns. It has also been argued that in mixed-methods research, claims of validity from the critical realist perspective should not simply be concerned with methods and procedures but the inferences made and whether there is closeness of fit with that observed during the study, taking into account the possibility of conflicting interpretations (Tashakkori & Teddlie, 2010). Additionally, as my study is qualitative-dominant it will be important to recognise the relationship between researcher and the case being studied, practicing reflexivity to ensure rigour in conducting the research (Mills et al., 2010). I will take the position of 'empathic neutrality' during the collection and analysis of data, a position that has been described as one that "recognises that research cannot be value free but which advocates that researchers should try to make their assumptions, biases and values transparent, while striving as far as possible to be neutral and non-judgemental in their approach" (Ritchie et al., 2013, p.8). I will further discuss issues of validity and reliability in the context of the method being discussed in each relevant section below.

Reflexivity statement

It is important to recognise the researcher's involvement in research in the social sciences and to appreciate the effects that their position might have on the processes and outcomes of the research, and this a key part of practicing reflexivity (Thorpe and Holt, 2008 ADD REF). Below is a statement which outlines my position with an appreciation for the effects of this on the research:

I am a male science teacher with a Biology background and have been teaching at the school being studied for four years and therefore have experienced the change from single-sex classes to mixed-sex classes myself. I appreciate that my experience and background will, at least in part, shape the way in which data is collected and interpreted. The teachers and students participating in the study are my colleagues and (some of them at least) my former students and therefore it is important to recognise that this might influence the data collection in terms of the responses participants give, my manner during interviews, and my analysis of the data.