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CELEBRITY SCIENCE CULTURE: YOUNG PEOPLE'S INSPIRATION OR ENTERTAINMENT?

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Preface

I declare that the research and writing in this thesis are my own. It has been conducted with the approval of the University of Derby's Research Ethics Committee.

Maria Dent

Abstract

“Celebrity science culture: young people’s inspiration or entertainment?”

This thesis explores the influence of celebrity scientists on the uptake of science by young people, post-GCSE; the phenomenon is based upon media assertions that young people were continuing with science as a result of the increased media presence of scientists: the ‘Brian Cox effect’.

Research design is set within a constructivist-interpretivist paradigm and case study framework, employing a narrative, story-telling approach to data collection and presentation. Narratives require ‘actors’, and as such the ‘lead actors’ in this research are: the conceptual framework; a narrative approach to data presentation; and the sociological perspectives of science capital and habitus. Together they guide development of the ‘bricolaged’ methodology, underpin the innovative script-writing approach to data presentation, which are used to illuminate the phenomenon of celebrity science culture.

Data collection includes two participant groups: eighteen science students (‘A’ Level, undergraduate, and postgraduate), and five celebrity scientists (Sir David Attenborough, Baroness Susan Greenfield, Professor Steve Jones, Professor Mark Miodownik MBE, and Roma Agrawal MBE). Interviews explore science memories and influences, as well as perceptions of the role of celebrity science and scientists.

The rationale and significance of this research lies within two strands: knowledge-based and methodological. It offers new knowledge to the field of celebrity science influence, with the potential to inform science education policy makers, and the methodological bricolage of conceptual framework development and creative narrative practices offer new dimensions to narrative research.

An intrinsic, long-standing ‘passion’ for science was found to be the most influential factor. Advanced subject knowledge of teachers and lecturers, alongside opportunities to work within authentic and meaningful contexts, were highlighted as important in raising aspirations, and building science capital. Celebrity scientists were perceived as having the potential to influence young people, with authentic, inspiring contexts, presented in an entertaining format potentially optimising this influence. Science *per se*, rather than the ‘scientist’ him/herself, was more influential, contrasting with the traditional view of celebrity influence. The perceptions of science students are reflected in the findings from celebrity scientists. Engagement with

children and young people was considered part of their role, not only to raise aspirations, but also to increasingly embed science culturally; their own passion for science the impetus for involvement. Partnership with other stakeholders was recognised as key, especially teachers and parents. ‘Personification’ was also recognised as important, acknowledging the responsibility that brings for their work to be truthful and credible.

The thesis concludes with recommendations for future policy and practice, offering a theoretical framework and bespoke checklist, derived from the data, to support dialogue between stakeholders. This includes exploring use of the narratives as a tool to engage pupils with their own science journeys, with the intention of enhancing their science capital. The concept of “message to a name” is introduced, in contrast to the “name to a message” phenomenon of celebrity influence.

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As with the thesis itself, there has been a bricolage of relationships and support underpinning and enveloping this research; as such it has been particularly influenced by the following:

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The biggest thanks, however, go to my husband, Dave, and our son, Will, who have provided me with a supportive environment for the constant, often all-consuming, work of research, as well as a peaceful place of escape from it. Dave's reading and discussion of this thesis has also clarified and extended my thinking and my writing. It has been their belief, endless encouragement and reassurance throughout my doctoral studies that have made this possible.

Chapter 1: Introduction

1.1 Introduction and Reflexivity

> ‘The Brian Cox effect is a star turn’ (Highfield, 2011)
>
> ‘Big Bang Theory fuels physics boom: Interest in A-level and university course rises as US comedy makes the subject "cool"’ (Townsend, 2011)
>
> ‘We need celebrity scientists to inspire young people, Says Blair’ (Webster, 2006)

These are examples of newspaper headlines alluding to the influence of celebrity scientists on the uptake of science by young people; the media had coined the phrase ‘The Brian Cox Effect’, linking this influence directly to Professor Brian Cox. My initial reaction to these headlines, was one of surprise, and then indignation at the assumption that a celebrity, albeit a celebrity scientist, could be credited with this impact, apparently negating everything that I, as a science educator, and the thousands of like-minded individuals and organisations, had worked hard to do. This assertion was the impetus for my doctoral studies. I began to question what the truth was: Is it true? If so, has it always been true? Did people aspire to science careers in the past because of Einstein, or is this a new phenomenon? Or is this simply a media construct as a result of the celebrity culture in which we live?

There is no doubt that there was increased interest in science at festivals, and in viewing figures for science programmes on television and radio (Highfield, 2011; Thomas, 2012). Plus, the number of young people applying to read physics at the University of Manchester (Paton, 2013), where Brian Cox was a Professor, had also increased significantly; why wouldn’t it? If you wanted to be a physicist, why wouldn’t you apply to be taught by the most famous physicist in the UK? However, it appears that the media had taken the latter, the increased number of applications to study physics at the University of Manchester, and extrapolated it to the science student population as a whole. I was now intrigued. Were celebrity scientists inspiring young people to continue with science, or were they a form of intellectual entertainment? Review of academic literature did not reveal empirical evidence to support this causal relationship, however, if it was true, there was the potential for this phenomenon to be exploited positively to influence young people to pursue science careers.

From the outset of this research, it is important that I am explicit about who I am and why this research is significant to me. My life, career, and indeed vocation, has been committed to promoting and advancing science, including science careers. I worked initially as a Medical

Microbiologist, achieving Fellowship of the Institute of Biomedical Sciences, then moving to Oncology as a research scientist. Having enjoyed the teaching aspects of working in Oncology, I undertook a Postgraduate Certificate in Education (PGCE), and have subsequently worked in both primary and secondary school phases. As well as working as a science teacher in my own school, I achieved Advanced Skills Teacher (AST) status, and worked with the Local Authority developing effective science teaching across a range of primary and secondary schools. I am currently working as a Senior Lecturer at The University of Derby; I am the Primary Science Leader on Initial Teacher Education programmes, and have achieved Chartered Science Teacher status. Science is and always has been my life; one can see, then, why reflexivity was paramount.

The aim of my research was to explore the influences and experiences of science students that shaped their journey towards science careers, ascertaining the role of celebrity scientists in this process. As I had also made this journey I needed to be particularly cognisant of how my influences and experiences might inform how I collected and interpreted those of my participants (Connelly and Clandinin, 1990; Clandinin and Connelly, 2000; Elliot, 2005; Bold, 2011). I decided to write the story of my own science journey in order to explore how my feelings, experiences, perceptions and influences may have emphasised a particular perspective, and therefore a particular bias. This can be found in Appendix 1, and my positionality is further explored in Chapter 3: Methodology. I am not claiming to be objective as a result of this, my experiences shaped my interests, and are actually the lens through which I interpret my own story; indeed my decision to undertake this research relates directly to my own experiences as a science student, scientist, science teacher, and my passion for science (Clandinin and Connelly, 2000; Etherington, 2004). The process of reflexivity not only enabled me to recognise my bias and assumptions, it also informed the methodology employed. By adopting a narrative biographical approach my participants were free to highlight the memories and influences that were important to them, without being led in a particular direction (Elliott, 2005). The interview schedule was also structured to build an appreciation of their perceptions of celebrity scientist influence, rather than being explicit about this focus from the start.

With this appreciation of reflexivity underpinning my work, the remaining sections of this chapter offer an outline of the thesis, summarising key guiding principles and approaches.

1.2 Background and Context

In 2006, the potential of celebrity influence was recognised by the then Prime minister, Tony Blair: "*We need celebrity scientists to inspire young people*" (Webster, 2006); the context for this statement was significant from a political and economic perspective. Since the 1980s, the number of young people continuing with science, post-compulsory age (age 16 or post-GCSE in England) had been decreasing, this was having an impact on the supply of future scientists (European Commission, 2004; HM Treasury, 2006), resulting in the so-called 'Science, Technology, Engineering and Mathematics (STEM) skills-gap' agenda. Educational attainment and scientific skills, as with all STEM skills, are linked to industrial productivity; they underpin innovation, and as such impact on the ability to compete successfully in the global economy (Drori, 2000; CBI, 2012; CBI, 2014). Within the same timeframe as the focus on celebrity scientists, and the decline of STEM-skilled professionals, OECD (2010) showed that England was 16^{th} in the international league table for science, compared to 4^{th} in 2000. This further affirmed the need for deliberate action at Government level, leading to significant investment in a range of initiatives. In the UK, in 2010, there were over 470 initiatives, at a cost of approximately £35 million per year for the larger programmes (DfE/NAO, 2010).

Osborne and Dillon (2008), in their 'Science Education in Europe: Critical Reflections' report to the Nuffield Foundation, not only agreed with these concerns, they also highlighted issues of science teacher recruitment and retention, and the longer term implications on scientific literacy. They argued that as the quality of science teacher is key to student engagement, a key aspect of scientific literacy (OECD, 2006; Holbrook and Rannikmae, 2007; Bybee and McCrae, 2011), lack of specialist science teachers, especially if they have to teach outside their science discipline, could adversely affect continued uptake of science by young people. As an AST for Secondary Science education, I was involved in the delivery of the Secondary National Strategy (SNS); part of the 'Science and Innovation Investment Framework 2004-2014' (HM Treasury/DTI/DfES, 2004). This initiative resulted in curriculum development, with teaching and learning strategies aimed at giving a contemporary focus, promoting science for all, as well as science for scientists (Millar, 2006; Millar, 2012), with an explicit focus on science and citizenship. This was scientific literacy in practice, and interestingly in relation to the celebrity scientist focus of this research, included the use of different media, for example, television, movies, cartoons and news reports. Indeed, I used programmes presented by David Attenborough, Brian Cox, and Mark Miodownik in my teaching.

The perception of the influence of celebrity scientists, the ‘Brian Cox effect’, became an increasing focus of the media (Highfield, 2011; Townsend, 2011); they alluded to a causal relationship between celebrity scientists, and the continued uptake of science, in both school and higher education. The influence of fictional scientists in the United States comedy “Big Bang Theory”, was also included, with one headline in The Observer stating: “Big Bang Theory fuels physics boom: Interest in A-level and university courses rises as US comedy makes the subject ‘cool’” (Townsend, 2011). Data cited by the media, in 2011, appeared to concur with this causal relationship: the number of entries for A-level Biology, Chemistry and Physics saw increases of 7.2%, 9.2% and 6.1% respectively (JCQ, 2011), and in higher education the number of students enrolling onto Biological Science courses increased by 2%, and Physical Science courses (which included chemistry) increased by 3.3% (HESA, 2011). There was an emerging belief, then, that celebrity was important in the popularisation of science and scientific issues, and the subsequent increase in the uptake of science (Highfield, 2011; Thomas, 2012).

The use of celebrities in marketing and advertising is common place, including celebrity advocacy of political, environmental and health agendas (Rojek, 2001; McKinnon, Nascenzi and McBeath, 2008; Boykoff and Goodman, 2009; Marshall, 2014; Kosenko, Binder and Hurley, 2015). Bono, a musician with the rock band U2, having used his celebrity to establish charities addressing world poverty and AIDS, was well aware of the influence his celebrity status offered, noting in an interview in Vogue magazine: “*Celebrity is a bit silly, but it is currency of a kind*” (Singer, 2002). The mechanism, or the power that celebrities have, is to evoke an emotional response, thereby increasing the potential to influence individuals, communities, issues, and organizations, even if they are not favourable (Simonson, 2006; Boykoff and Goodman, 2009; Marshall, 2014). Indeed, Pfau and Parrott (1993) assert that one function of celebrities is to deliberately establish this emotional bond with their audience. Marketing companies, political campaigners, and even aid agencies, all seek to transfer feelings about a celebrity to the agenda for which they are advocating. Of particular relevance to this research, and the purported causal relationship between celebrity scientists and the continued uptake of science by young people, is the recognition that the influence of celebrity over young people is a normal part of their identity development (Giles and Maltby, 2004), and as such are targeted explicitly in terms of product placement by the use of celebrities in the media. Giles and Maltby (2004) suggest that celebrities provide a secondary group of ‘pseudo-friends’ as they become increasingly independent of their parents. Ott and Mack (2014, p.13) go as far as suggesting that the mass media is now the "significant socialising force in contemporary society", rather than the traditional mediation of family and community.

It would seem, then, that the culture of celebrity, through the formation of emotional bonds, in this case with Brian Cox and other celebrity scientists, does theoretically have the potential to influence the career decision-making process of young people.

When considering the feasibility of this potential, however, it is worth considering why this was newsworthy at all. Science in the media was not new: Sir David Attenborough had been presenting since the 1950s, and BBC Radio had consistently included science in its programming schedules. Furthermore, with science competing with celebrity and reality television for viewer ratings and print medium space, and the public trust of scientists being generally considered to be 'shaken', with an anti-science bias in the media (Dillon, 2011), this positive media attention was welcome, but did not fully make sense. Did this indicate that there was truth in their assertions? The media is not a philanthropic organisation; for this sustained focus there must have been some benefit for them. It is difficult to imagine the STEM skills gap agenda sustaining media attention to this extent, even though the message they were portraying to the world was important. It is more likely, then, that the focus of interest was in Brian Cox himself. The media is recognised as ascribing celebrity status to those individuals who have reached a measure few can achieve (Rojek, 2001; Blackmore and Thomson, 2004), this would fit with his rise from being a member of the rock band, 'd:ream', in the 1990s, to an internationally renowned physicist (Professor of Physics, Royal Society University Research Fellow and Chair at the University of Manchester). Perhaps, the media attention on Brian Cox was simply capitalising on this progression from a celebrity musician to physicist, benefitting financially from the skills and talents of this highly mediagenic presenter, with a passion for promoting science with the public.

Nevertheless, there was no doubt that Brian Cox was having an impact on the popularisation of science. The BBCs Stargazing Live programmes received record ratings of 3.8 million at their peak, with thousands of people using Twitter to praise him for making difficult theories more accessible; he was also credited with a 500% increase in telescope sales (Thomas, 2012). Highfield (2011), Editor of New Scientist, recounted a conversation with Cox about how people had "stampeded" to fill the cabaret tent at Glastonbury for a recording of 'The Infinite Monkey Cage'; the show was so crowded, tweeted one of the attendees, that it had been easier to get in to see the band U2. Moreover, he went on to ascribe the "*general thawing in the usual* *cool reception given to science, one that has seen all things geeky become – well, trendy*", and the subsequent increased presence of science debate at specialist and music festivals, to Brian Cox (Highfield, 2011). The question remained though, could his impact be extrapolated to young people choosing science careers? Other scientists were beginning to think so, for example, Haxton (2011) was hoping for a celebrity chemist to promote chemistry. Brian Cox himself, in an interview with The Daily Mail (Thomas, 2012) believed that there had been a "*step change*" in the public's opinion of science: "*I go to schools and I see and hear there are a lot of kids, girls as well as boys, interested in science and engineering.*" Rather than ascribing this directly to himself, Cox suggested that a key factor had been the BBC's decision to make science a more prominent part of its schedule, and put people with academic backgrounds, such as himself, Jim Al-Khalili, Alice Roberts and Adam Rutherford, in presenting roles (Highfield, 2011). A similar point was made by Sir Paul Nurse, President of the Royal Society, in the same newspaper article: "*Brian has been extremely important and is an outstanding lecturer and presenter, but there are also other factors, including the groundwork the Society laid with its 350th anniversary activities, and the BBC's year of science which marked the anniversary.*" He suggested that a "*key element is that science is now cropping up in unexpected contexts*" (Highfield, 2011).

From the perspective of celebrity scientist influence, empirical research was very limited. Three studies refer to celebrity scientists: Sjaastad (2012) explored the notion of 'significant persons' as role models; The Wellcome Trust report (Butt, Clery, Abey, Wardener, and Phillips, 2010) acknowledged the rise of television scientists and science programmes; and Rodd, Reiss and Mujtaba (2013), exploring the rationale for undergraduates choosing to read physics at university, demonstrated the importance of identifying with a key adult, and referred to the 'Brian Cox effect'. Rather than considering the influence of celebrity scientists themselves, research focussed generally on the impact of entertainment-based media, the use of these media in science lessons, exploring their influence on science engagement, and participants' perceptions of science. The influence of the media on children's scientific knowledge has also been considered. The literature review (Chapter 2) explicitly explores the above studies and foci.

In terms of research considering the general influence on the science aspirations of young people, three key projects were relevant to my research: 'The ASPIRES project: Children's science and career aspirations age 10-14' (Archer, DeWitt, Osborne, Dillon, Wong and Willis, 2013a); the Wellcome Trust Monitor Reports, tracking public views on science and biomedical research (Butt *et al*., 2010; Ipsos MORI, 2013); and the ‘Understanding Participation in Mathematics and Physics’ (UPMAP) project (Institute of Education, 2013). These bodies of research, are evaluated and critiqued in Chapter 2, setting them in the context of celebrity influence and the uptake of science by young people.

Drawing these threads together, there was empirical evidence of the influence of celebrity culture on advertising and advocacy (Rojek, 2001; McKinnon *et al*., 2008; Boykoff and Goodman, 2009; Marshall, 2014; Kosenko *et al*., 2015), plus evidence of the more general influences impacting on young people’s career choices (Butt *et al.*, 2010; Archer *et al.*, 2013a; Ipsos MORI, 2013). It was also evident that the media has the potential to determine what is newsworthy, in this case, asserting a causal relationship between the uptake of science and celebrity scientists, going as far as coining the phrase, the ‘Brian Cox effect’. There was, however, limited empirical evidence to support this. The question was then: Was this a media construct, part of the general entertainment offered to attract viewers and readers, or do celebrity scientists indeed have this potential? They certainly entertain, but it is a big leap to extrapolate from this to celebrities influencing career choices.

This was the gap in knowledge, and as such became the research question, the focus of my doctoral researc:

“Celebrity science culture: Young people’s inspiration or entertainment?”

1.3 Research Aims and Objectives

To shed light on this, the following research aims and objectives were addressed:

Aims:

1. To explore the nature of the relationship between celebrity scientists and young people, and the uptake of science;
2. To explore the significant influences on young people’s decisions to pursue a career in science;
3. To develop a conceptual framework to be used as the working tool to explore these influences and relationships;
4. To develop a theoretical framework that will inform future academic research, and with the potential to inform the development of science education policy and the involvement of the media (including celebrity scientists).

Objectives:

- To undertake a small scoping study to facilitate development of the conceptual framework;
- Using the conceptual framework, structure the systematic review of literature and develop an appropriate methodology to explore celebrity scientist influence;
- To explore who or what influences young people to continue with science;
- To explore how young people feel about the media and celebrity culture generally, and celebrity scientists specifically;
- To explore the perceptions of celebrity scientists on their individual roles and influences, and those of celebrity scientists in general;
- Based upon these findings, develop a theoretical framework to inform future research and policy.

1.4 Research Approach

Although the thesis is structured in a traditional fashion, the actual research process was much more iterative, building the story over time, in three distinct phases. The process began with Phase 1: the initial review of literature (presented in the 'Background and Context' above) and a small scoping study underpinned development of the conceptual framework. Once in place, Phase 2 began. Here the experiences and perceptions of eighteen science students were collected through a combination of a narrative biographical approach and semi-structured interviews. Data was analysed using the conceptual framework, and presented narratively in the form of monologues. Alongside this, a second set of literature was reviewed, focussing on the themes that emerged from the development of the conceptual framework; these themes all represented the 'voices' responsible for building science capital and habitus (Archer *et al*., 2013a). Data collected and analysed raised more questions about the influence of celebrity scientists, highlighting the convoluted and complex nature of the decision making process towards a career in science. Thoughts turned towards the celebrity scientists themselves: How did they perceive their role and influence? Did this resonate with what the students and the media were saying? This informed Phase 3, where five celebrity scientists were interviewed, and, continuing with the narrative approach, their data was used to create a 'constructed dialogue'. The creation of the monologues and constructed dialogue are described in Chapter

4: Data analysis, interpretation and presentation of findings, with fully worked examples in Appendix 3.

Three key features of this research were referred to above, and as part of this introductory chapter, I would like to introduce them more formally so as not to lose their importance as the thesis progresses; they are in a real sense, from the perspective of narrative approaches, the 'Lead Actors' in this research, together guiding, revealing and unfolding the story over time:

- the conceptual framework;
- the narrative approach to data presentation; and
- the sociological perspectives of science capital and habitus.

Conceptual Framework development

Conceptual frameworks visually represent the concepts and their relationships within a research question, in order to highlight the variables to be explored (Desjardins, 2010; Miles, Huberman and Saldaña, 2014). With limited empirical evidence of the influence of celebrity science and scientists, development of the conceptual framework was a priority. It was pivotal at all stages of my research, providing connections between theory, methodology, data analysis and presentation of findings (Leshem and Trafford, 2007). This was considered to be a strength, as a criticism of qualitative approaches is the trustworthiness of findings (Simons, 2009; Lincoln, Lynham and Guba, 2011; Bryman, 2012; Edwards and Holland, 2013). The conceptual framework served pluralistic functions, linking both theory with practice, and practice with theory.

Narrative approach to data presentation

The story-telling potential of case study research is recognised (Simons, 2009), thus supporting a narrative approach to data collection and presentation as the most appropriate entry point to exploring and understanding the experiences and influences leading to continued uptake of science, by my participants. Key here is that there does not need to be a problem to solve, or theory to test, it enables an experience of interest to be illuminated (Riessman, 1993; Hinchman and Hinchman, 1997; Leavy, 2009; Saldaña, 2010); essentially, narrative inquiry "begins with experience as lived and told in stories" (Clandinin and Connelly, 2000, p.128). Rich presentation of participant stories through monologues and the constructed dialogue was intended to enable the audiences of my research to "vicariously experience" what was observed (Simons, 2009, p.23), and as such relate to the stories they told.

Sociological Perspective

The sociological lenses underpinning my research were Pierre Bourdieu's theories of capital and habitus (Bourdieu, 1986), considering specifically how these resources and structures informed science career pathways. The ASPIRES report (Archer *et al.,* 2013a) extended Bourdieu's concept of capital into the notion of 'science capital'; a conceptual tool specifically used for understanding the development of science aspirations (Archer and DeWitt, 2017, p.11-12), and clearly relevant to this research. In essence, the more access one has to science capital, the greater one's personal science capital becomes, and the more this is embodied (habitus), the greater the likelihood is of a person choosing a science career. I am assuming that as my participants have all chosen to follow a science pathway, they have a high level of personal science capital and that this is strongly embodied. The conceptual framework developed through the scoping study and literature review (Chapter 2) illustrates the science capital theoretically available to young people, including celebrity scientists. Analysis of data collected illuminated which of these relationships and experiences increased and embedded science capital and habitus effectively, thus leading to their continued uptake of science.

These three features combined provided an interesting and innovative approach to data collection, presentation and analysis; very much in line with the sense of 'bricolage' discussed by Kincheloe, McLaren and Steinberg (2011) in qualitative research. As such they ensured that the research question remained central to the research, and minimised issues of researcher bias.

Summary of Methodology

Asking the research question: "Celebrity science and scientists: Young people's inspiration or entertainment?" required an overarching qualitative approach; I was looking for subjective feelings and perceptions, to illuminate the question, rather than a definitive, more objective, 'yes/no' answer. The epistemological stance was interpretivist, the ontological paradigm social constructionist, and when considering the role of theory, the overarching research paradigm was inductive. Following a small scale scoping study to develop the conceptual framework and subsequent literature review and methodology, the individual influences of young people were captured: their feelings, experiences and perceptions of celebrity scientists and the role they play. This was extended to include the views and perceptions of celebrity scientists themselves, collecting their personal experiences and influences. It was anticipated that the knowledge generated would afford new insights, with the potential to inform educational and media practices. The research employed a qualitative, multiple-case study methodology, with a narrative approach to data collection, presentation and analysis, in order to illustrate this phenomenon of celebrity scientist influence. Participants were purposively selected, and included:

- Phase 1: an initial sample of young people and teachers for the scoping study;
- Phase 2: eighteen young people who had chosen to continue with science, post-GCSE, six from each of three stages of education ('A' level students, university undergraduate students, and post-graduate students);
- Phase 3: five celebrity scientists: Sir David Attenborough, Baroness Susan Greenfield, Professor Steve Jones, Professor Mark Miodownik MBE, and Roma Agrawal MBE.

Research Boundaries

The causal relationship asserted by the media pertained only to the picture in the United Kingdom (UK), and essentially since 2006, when Tony Blair referred to the value of celebrity scientists in raising aspirations of young people for science careers (Webster, 2006). The media did not draw attention to personal, social or cultural differences, including gender and ethnicity. With the aim of exploring the influences on young people to continue with science, the voices of science students were paramount, as were the voices of scientists working in the media. This understanding set the boundaries of this research as follows:

- Review of literature relevant to the UK only, post-2006;
- Personal, social and cultural differences and influences were not included in the analysis and discussion;
- Participant selection: current science students; contemporary celebrity scientists, with a media presence, actively working to promote science.

1.5 Research Assumptions

Table 1.1 shows the beliefs and preconceptions that I held prior to the research, and as such were important in terms of minimising researcher bias; they are based on my experience, background and the initial literature search.

1.6 Significance of the research

From the perspective of influencing young people to continue with science, research has tended to concentrate on issues of inclusion, the curriculum itself, and the role of significant persons (Butt *et al.*, 2010; Sjaastad, 2012; Archer *et al.,* 2013a; Institute of Education, 2013; Ipsos MORI, 2013, Kantar Public, 2017).

Assumption	Example of supporting literature
Young people are influenced by ‘significant persons’ in their lives.	Woelfel and Haller, 1971 Sjaastad, 2012
Teachers are the most influential in terms of encouraging young people to continue with science.	Butt *et al*., 2010 Archer *et al*., 2013 Institute of Education (2013) Ipsos MORI, 2013
An intrinsic interest in science per se is a necessary precursor to potential influence.	Butt *et al*., 2010 Ipsos MORI, 2013
The culture of celebrity, through the formation of emotional bonds with celebrities, is a well-established strategy in advertising and political advocacy.	Rojek, 2001 Simonson, 2006 Boykoff and Goodman, 2009 Kosenko *et al*., 2015
There has been a positive, cultural shift in the public engagement of science.	Dillon, 2011 Highfield, 2011 Thomas, 2012
Theoretically, it is possible for celebrity scientists to be ‘significant persons’ in the lives of young people, encouraging science careers.	Giles and Maltby, 2004 Sjaastad, 2012 Rodd *et al*., 2013

Table 1.1: Research assumptions

Whilst my research was underpinned by the same ideals, that is, to promote the uptake of science by young people, it was significantly different in several ways. Firstly, it considered explicitly the role of celebrity scientists as significant persons with the potential to build science capital and habitus. Secondly, demographic information, such as gender and ethnicity, was not included in data analysis, in order to keep the focus on celebrities themselves. Thirdly, this was a small scale, multiple-case study, focussing in detail on the science journeys of eighteen young people, and the role and perceptions of five celebrities; it was not intended to generalise across a broader population, although the reader might draw comparisons to their own experiences and knowledge. Finally, although the methodology employed the same tool as previous research, that is, interviewing, my work was significantly different in that it required the development of a conceptual framework to guide the process; it included a narrative biographical approach within the interview; and narrative genres were used for the presentation of data.

In essence, then, the rationale and significance of this research can be seen as two strands: knowledge-based and methodological. By contributing new knowledge to the field of celebrity scientist influence, there is the potential to inform science education policy makers, the media, and celebrity scientists themselves, regarding how they could deliberately and effectively engage and communicate with children and young people. This has implications for further reducing the STEM skills-gap in the UK. It is also intended that the monologues created from the data could be used directly with children and young people in school. By introducing them to the science stories of other students, it is hoped that they will relate to them, thereby seeing elements of their own journey within them, and with the possibility that they may see that science is for them. From a methodological perspective, the narrative approach to data collection and creative presentation is offered as a new dimension to general qualitative research practices.

1.7 Structure of the thesis

This research process was a story in itself, and the thesis could have been written chronologically. However, the pragmatic decision was made to present it as outlined below for reasons of conciseness and coherence, avoiding repetition or signposting back and forth through the thesis.

The next chapter (Chapter 2) is a review of relevant research literature. I also present the conceptual framework, outlining what it is; why it was needed; how it was developed; and how it was used. Appendix 2 is a detailed account and exemplification of its development, and includes an evaluation of its role as a tool for analysing the data collected. The main focus of the chapter is to examine literature concerned with the ‘voices of authority’ that emerged from the conceptual framework: one internal, Personal Interest; and four external: Family and Friends; Science Education; Nature of Science and Scientists; and Celebrity Science and Scientists. Whilst a narrative approach is becoming increasingly popular in qualitative research, my review establishes that no one has previously used narrative enquiry in the context of celebrity scientist influence.

Chapter 3 focusses on the background and rationale for the methodology. I explore some of the aspects of qualitative research, setting out the underpinning research paradigms, research design and the specific methods used. I specifically describe my data collection and analysis processes, clarifying use of the conceptual framework and the narrative approach to presentation of findings. Selection of participants is also introduced in this chapter.

In Chapter 4 I present the data analysis, interpretation and presentation of findings. Findings are presented in the form of narrative monologues and a constructed dialogue. Three student monologues are presented, one for each education stage cohort, followed by the constructed dialogue which integrates celebrity scientist quotations around a theme, in conversational style.

Chapter 5 is the Discussion chapter. Here I draw together the findings from data collected. It is organised in line with the five voices of authority that emerged from development of the conceptual framework. The data from student participants and celebrity scientists are discussed concurrently, drawing quotations from the monologues and constructed dialogue to augment the discussion. Limitations of the research methodologies are also discussed, including my own reflexivity. I explain my argument within the context of the relationship between celebrity scientists and the continued uptake of science by young people, taking into account other research and my own reflections.

In Chapter 6 I consider and summarise the array of conclusions and suggestions gleaned from the preceding chapters and synthesise the major findings and recommendations of this research. This includes:

- the original contribution to the fields of celebrity science culture and raising science aspirations, and to knowledge in qualitative research;
- exploration of future implications and applications of my research, both immediate ‘next steps’, and more distal.

Chapter 2: Literature Review

2.1 Overview

The literature review provides both intellectual and methodological insights into the field of celebrity scientist influence on the uptake of science by young people, formed through the synthesis and reworking of theories in this original context. Composition of the literature chosen was distinctive in that it included theoretical perspectives on science career aspirations and the relationship with celebrity influence. This is a strength in that, alongside the scoping study, it enabled not only further development of the unique conceptual framework and bespoke methodology, but together with the findings also provided theoretical perspectives on which to inform policy, and the working relationship between media and science professionals. As discussed in the Introduction (Chapter 1), informing policy and practice is important because of the political and economic implications of the science skills-gap (European Commission, 2004; HM Treasury, 2006), and indeed if the media assertion bears elements of truth, there are implications for the role of celebrity scientists in raising the science aspirations of young people.

The critical review of literature was ongoing throughout the data collection, presentation, analysis, and synthesis phases of the study. The review explores the complexity and interconnectedness of the influences on the uptake of science by young people, and celebrity influence, according to the following two aims:

1. To explore the nature of the relationship between celebrity scientists and young people, and the uptake of science;
2. To explore the significant influences on young people's decisions to pursue a career in science.

This required two major areas of literature to be critically reviewed:

- Science career aspirations;
- Celebrity scientist influence.

In order to establish these theoretical perspectives the following strategic decisions were made regarding choice of literature to be reviewed:

1. Research projects

Central to the review were research projects and influential researchers in the field of science aspirations. Key projects were the Wellcome Trust Monitor Reports (Butt *et al.*, 2010; Ipsos MORI, 2013), tracking public views on science and biomedical research; the 'The ASPIRES project: Children's science and career aspirations age 10-14' (Archer *et al.*, 2013a), and the Understanding Participation rates in post-16 Mathematics and Physics (UPMAP) project (Institute of Education, 2013).

The Wellcome Trust Monitor research (Butt *et al.*, 2010; Ipsos MORI, 2013) measured the public's awareness, interest, knowledge and attitudes towards medical research. The surveys are repeated every three years, and comprise two sample groups: Adults (aged 18 and over) and young people (aged 14 – 18 years). The latter were asked about their attitudes towards, and experiences of science education, and their perceptions about careers in science. Wave 1 findings were reported in 2010, and wave 2 in 2013. In 2016, wave 3 findings focused solely on adults, with a new project emerging, the Wellcome Trust Science Education Tracker (Kantar Public, 2017), to continue research with young people.

The ASPIRES project (Archer *et al*., 2013a) was a five year project, 2009-14, exploring what influences young people to aspire to a science-related career. Their research was based on Bourdieu's work on the interaction of capital, habitus and field, extending the concept of capital into the notion of 'science capital', which they used as a conceptual tool for understanding patterns in the formation and production of children's science aspirations.

The UPMAP project (Institute of Education, 2013) comprised three strands: Strand 1, 'Mapping trajectories of engagement and disenchantment'; Strand 2, 'Investigating subjectivities and school culture' and Strand 3, 'Documenting the reasons for Higher Education choices'.

These three major projects are summarised in Table 2.1, in terms of sample size and methodology; key findings and critical analysis are included within the text of this literature review.

	Year of publication	Participant age range	No. of Participants	Methodology	Implications for this research
Wellcome Trust Monitor Wave 1 (Butt *et al.*, 2010)	2011	14-18 Science and non-science students	374	Face-to face interview	81%: science interesting 81%: science good career choice 44%: Interested in science career Parent and teacher influence important factors.
Wellcome Trust Monitor Wave 2 (Ipsos MORI, 2013)	2013	14-18 Science and non-science students	460	Face-to-face interview	82%: science interesting 82%: science good career choice 41%: Interested in science career Parent and teacher influence important factors. Reference to CSI and Silent Witness influenced forensic science aspiration choice (11%)
Wellcome Trust Science Education Tracker (Kantar Public, 2017)	2017	14-18 Science and non-science students	4081	Survey; online self-completion	68%: Science interesting 62%: Interested in science career Parent and teacher influence important factors.
ASPIRES Project. King's College, London (Archer *et al.*, 2013a)	2013	10-14 Science compulsory subject	Year 6: 9319 Year 8: 5634 Year 9: 4600 83 students and 65 parents	Quantitative online survey Longitudinally tracked via interview	70%: Science interesting 15%: Interested in science career Family science capital important

UPMAP project (Institute of Education, 2013)	2013	Strand 1: 12-14 Strand 2: 15-17 Strand 3: 18-21	Strand 1: 23,000 plus teachers from 140 schools Strand 2: 48 students Strand 3: 50 undergraduate students (mathematics/ physics related programmes	Questionnaires Interviews Longitudinal Interviews Narrative interviews	Young people more likely to continue with mathematics and/or physics after the age of 16 if they have been encouraged to do so by a key adult; Use of narrative interviewing to be explored to collect experiences and perceptions of celebrity scientists
Rodd *et al.,* 2013 UPMAP project data	2013	First-year physics undergraduates	7	Narrative-style interviewing	Significant adult associated with physics important. 'Brian Cox effect' referred to by authors
Wong, 2012 ASPIRES project data	2012	13 Science compulsory subject	2 British Asian girls	Interview (ASPIRES project data)	Family, peers and teachers expectations important
Sjaastad, 2012	2012	15-19 Science and non-science students	114	Questionnaire; psychometric analysis	Interpersonal relationship with significant person important. Development of 'Significant Person Influence on Attitudes towards STEM' (SPIAS)

Table 2.1. Overview of key research projects/research papers

2. Key researchers

Key researchers in raising science aspirations were (in alphabetical order): Louise Archer, Jennifer DeWitt, Justin Dillon, Robin Millar, Jonathan Osborne, Michael Reiss and Billy Wong; and in the field of celebrity and media studies: Daniel Boorstin, P. David Marshall and Chris Rojek. Literature sources included academic journals and texts, professional and policy documentation, as well as media sources, including newspaper articles (a primary source for media perspectives on the 'Brian Cox effect').

3. Key words and phrases

The following key words/phrases allowed access to a breadth of research in both fields: Brian Cox effect, celebrity, celebrity science and scientists, media in education, scientific literacy, science aspirations, career influences; identity as scientists; science capital. Primary readings were used to source secondary research and texts by following references and footnotes; citation indices supported judgements of their standing in the field.

4. Inclusion criteria

Two main inclusion criteria were set: research relevant to the United Kingdom (UK), in line with the media assertion of the causal relationship between celebrity scientists and the uptake of science in the UK; and literature post-2006, the year in which Tony Blair referred to the value of celebrity scientists.

2.2 Literature review and conceptual framework development (Aim 3)

Conceptual frameworks are "logically structured representations of the concepts, variables and relationships … with the purpose of clearly identifying what will be explored, examined and measured or described" (Desjardins, 2010, 1:44 mins); they represent "the current version of the researcher's map of the territory being investigated" (Miles *et al*., 2014, p.20). In essence, they force the researcher to be explicit and selective about what they are doing: 'What are the important features?' 'Which relationships are likely to be important?' and, therefore, 'What data should be collected?' (Robson, 2002). This complements Kuhn's notion of paradigm shifts, in that they move us away from one way of seeing the world to another, modelling possible patterns and relationships (Kuhn, 1970).

Role of the conceptual framework

The conceptual framework in this research played a key role. It was pivotal at all stages, providing "coherence" and "traceable connections" between theory, methodology, data analysis and presentation of findings (Leshem and Trafford, 2007, p.99). This is considered to be a strength, as the trustworthiness of findings can be a criticism of qualitative research (Simons, 2009; Lincoln *et al.*, 2011; Bryman, 2012; Edwards and Holland, 2013).

Specifically, in practice, as well as informing the literature review, the conceptual framework also drew together the theoretical perspectives elicited into an accessible format: the conceptual framework itself (Figure 2.1, P.69); it was used to underpin a robust methodology; it was a means by which the stories, influences, experiences and perceptions of the participants were analysed logically and systematically (explored further in Chapters 3 and 4); it supported an authentic means of presenting the data; it structured the discussion, allowing mirroring with the literature review; and finally, it underpinned development of the theoretical framework (Aim 4) to take forward to inform policy and practice. In essence, then, the role of the conceptual framework was one of transparency, ensuring that the rigorous, logical and systematic research process that it underpinned, would stand up to scrutiny.

Conceptual framework development (Aim 3)

Development of the conceptual framework, therefore, was an essential priority. Conventionally, they emerge from the literature review, and, from the perspective of the more general influences that inform young people's career decision-making, such as the role that schools and families play, the wealth of empirical research made this a possibility (for example, Butt *et al*., 2010; Archer *et al.*, 2013a; Institute of Education, 2013; Ipsos MORI 2013). From the perspective of celebrity science and scientist influence, however, where there was limited empirical evidence, a complementary approach, running alongside the literature review, was also incorporated: a small-scale scoping study.

Scoping study

Participants: There are similarities here with the Delphi technique, in that 'experts' were involved to make subjective collective judgements (Linstone and Turoff, 1975), however, rather than the conventional use of questionnaires, participants who were considered to be 'experts' were interviewed. These were children and people who had, according to the media, been influenced, or are being influenced by celebrity science and scientists, to continue in the field of science post-compulsory age (Townsend, 2011; Paton, 2013). The primary participants in this scoping study were school students (aged 14 and 18), a science teacher, and Bachelor of Education (BEd) Primary trainee teachers (science specialists). The sampling strategy for participation, therefore, was purposive, in that I deliberately chose to interview specific people in order to “illuminate the research question at hand” (Denscombe, 2003, p.16). These participants were more likely to provide relevant and critical data regarding their influences.

Data collection and analysis: Narrative has been defined as: “discourses with a clear sequential order that connects events in a meaningful way for a definite audience and thus offer insights about the world and/or people’s experiences of it” (Hinchman and Hinchman, 1997, p.xvi). Hence, a narrative biographical approach (Clandinin and Connelly, 2000) was designed to allow an appreciation of the participant’s science journey, as well as exploring implicit or subconscious influences. Through a semi-structured interview (see below), participants were asked to name key people or experiences that had influenced their continued uptake of science, and finally, the notion of celebrity was discussed, exploring their experience of celebrity science and scientists, particularly focussing on any perceived influences. Interviews were recorded and transcribed, and initial data analysis took a thematic approach (Saldaña, 2012). This process is explored in detail within this report, and exemplified in Appendix 2.

Interview questions:

Narrative biography:

- Tell me what you remember about science: what are your earliest memories, chronological, through school?
- What were the key influences to make you continue with science?

Semi-structured interview:

- What do I mean by the term ‘celebrity’? What is your understanding?
- Can scientists be celebrities?
- Do you know of any? Male? Female?
- Do they influence? Have they influenced you? Who might they influence?
- [Give my research title] The media is implying a causal relationship – what do you think?

Method

- Initial part allowed you to talk about yourself, to tell your story: did you like that? Positives, negatives?
- Did you like talking about yourself?
- Is there merit in this method? Questionnaire or interview?
- What advice could you give me for future interviews?

Appendix 2 (p.-3-) includes full details of the scoping study, and a description, exemplification and evaluation of how the conceptual framework was strategically developed, thus fulfilling the following aim and objectives of this research:

Aim 3: To develop a conceptual framework to be used as the working tool to explore influences and relationships.

Objectives:

1. To undertake a small scoping study to facilitate development of the conceptual framework;
2. Using the conceptual framework, structure the systematic review of literature and develop an appropriate methodology to explore celebrity scientist influence.

In practice, then, conceptual framework development was an iterative process, combining insights and experiences from the scoping study participants with the academic research reviewed. This conceptualisation of the research, therefore, provided a theoretical overview of my intended research, alongside specific boundaries, allowed reflection on the data collected, to enable insights to emerge incrementally and cumulatively (Hills and Gibson, 1992; Leshem and Trafford, 2007), and supported an authentic means of presenting the data.

To summarise, I believe that this iterative process of conceptual framework development, which commenced from the outset of this research, was a priority for three reasons. Firstly, to ensure that the reader is fully aware of the importance of the conceptual framework as a tool to underpin all stages of the research, offering transparency to the whole research process, and confidence in the findings. Secondly, whilst not an original contribution to research, it is offered as a tool that illustrates how to approach exploration of a research question when empirical research is limited. Thirdly, the scoping study also played an important role in setting boundaries to the literature review, by reducing the range of potential influences down to those considered important to the scoping study participants.

2.3 Structure and sequence of this chapter

The literature review and scoping study together supported development of the conceptual framework (Figure 2.1, p.69), as outlined above and in Appendix 2 (p.-3-). Although the final conceptual framework is not presented in the thesis until the end of this chapter, because of the iterative nature of its development, the categories highlighting the ‘voices’ of influence are used to present the literature review itself: Personal Interest; Family/Friends; Science Education; Nature of Science and Scientists; and Celebrity Science and Scientists.

Throughout the review, I draw attention to important gaps and omissions in the literature relevant to the research. The summary that concludes the chapter is forward focussing, showing how understanding gleaned from the literature contributed to research design.

2.4 Part A(i). Internal voice of influence: Personal Interest

The conceptual framework highlights the following subcategories within 'Personal interest' as influential:

- Personal interest *per se*
- Transformational
    - Make a difference
    - Career in science
- Utilitarian
- Success academically

This combination of science being inherently interesting, transformational and utilitarian, alongside academic achievement, reflects Bruner's (1963) assertion that both the source and reward of learning are part of a person's intrinsic motivation to learn. Indeed, interest is recognised as multifaceted, encompassing both cognitive and emotional elements (Schiefele, 1996; Hidi and Renninger, 2006; Krapp and Prenzel, 2011).

Dewey (1938) was one of the first to recognise the role that interest plays in learning, and as such it has been researched extensively (for example, the work of Hidi, 1990; Schiefele, 1991, are seminal), moreover, Krapp and Prenzel (2011) assert that interest is a precondition of learning, relevant here in terms of appreciating what influences young people to continue with science.

Three forms are distinguished: individual or personal interest, situational interest, and interest as a specific momentary psychological state (the latter two are considered within the notion of 'External voices', p.26).

From the perspective of 'personal interest' *per se*, Silverman (2015) suggests that curiosity, and the desire to explore and understand natural phenomena, are the "strongest incentive[s]" (p.1982) to study science. He suggests that it is the "intrinsic beauty of the subject" (p.1985) that motivates scientists (considered further in 'Science education' (2.5.1) and 'Nature of science and scientists' (2.5.3). This was reflected in the findings of the 'Interests and Recruitment in Science' study (European Commission (2012), a European Union (EU) funded project focussing on science students' experiences and influences, from five EU countries; it found that the intrinsic value of science, that is, "interests, self-realisation and passion for the subject" were "strongly emphasised." Personal interest in science can manifest itself in many ways, with a person building their own science capital through, for example, choosing to read science books, watching science programmes, actively noticing things in nature, collecting artefacts, and so on, so that in a sense they actively put themselves in a position where they learn more than they would have been expected to (Schraw and Lehman, 2001). Although outside the main inclusion criteria of research undertaken within the UK, the work of Maltese and Tai (2010) and Maltese, Melki and Wiebke (2014) in the United States of America (USA), provided interesting insights into children's and young people's experiences that informed their initial interest in STEM. Participants described how it was their innate, intrinsic interest that sparked their initial interest in STEM, and subsequently maintained it; they recounted pre-Kindergarten (Pre-K) experiences of "building/tinkering/taking apart mechanical objects or electronics"; "exposure to media" and "playing or spending time outdoors" (Maltese *et al.*, 2014, p.949). These early informal experiences were recognised as "play[ing] a significant role in initial STEM interest and persistence" (Maltese *et al.*, 2014, p.949).

Individual qualities, such as self-efficacy, identity, and even one's personality, are also recognised as influencing choice, and, therefore, informing personal aspirations (Zeldin and Pajares, 2008; Archer, DeWitt, Osborne, Willis and Wong, 2013b). Bandura's (1982) work on social cognitive theory, asserts that one's "level of perceived self-efficacy correlates positively with range of career options seriously considered and the degree of interest shown in them" (p.136), and as such, this understanding can be ascribed to science aspirations (Archer *et al.*, 2013a). This relates to the 'Being good at science' subcategory of the conceptual framework, where success itself can influence aspirations.

Personal interest is also recognised as being initiated early in a person's life (Maltese and Tai, 2010; Maltese *et al.*, 2014), and as developing over time as they have "constant and consistent interaction" with a context, in this case, with science (Chen, Darst and Pengrazi, 2001, p.384). There is a sense of it evolving, akin to Archer *et al.*'s (2013a) notion of building science capital; one can see how this embedding of science capital and habitus could provide the motivation for continued involvement in learning (Schiefele, 1996; Krapp and Prenzel, 2011), and in the case of this research, influence the continued uptake of science, post-compulsory age.

Of further relevance here is the appreciation that personal interest in general can be stable and difficult to alter (Krapp, 2005; Ainley and Ainley, 2011; Krapp and Prenzel, 2011), so that if a pupil does not have a personal interest in science, this may be difficult to change (Archer *et al.*, 2014b). Moreover, Maltese *et al.* (2014) assert that the later someone becomes interested in science, the less likely it is that they will continue to study it at university. This stability, however, is recognised by Dierks, Höffler, and Parchmann (2014) as having the potential to be used to predict student subject pathways, and indeed, by profiling the interests of science students using Holland's adapted RIASEC-framework (1985), their findings indicated that it could be used to develop effective, appropriately differentiated enrichment activities to raise personal interest, with the intention of raising science aspirations (there may be a role here for celebrity scientists).

Long-term orientation towards something, is described by Schiefele (1996) as latent interest, as opposed to topic-specific, actualised, interest. An example of latent interest can be found in the research of Rodd *et al*. (2013), in that although a participant had a bad teacher, she was described as having "sufficient intrinsic interest herself to keep her motivation up" (p.162) and continue with physics. Schiefele (1991; 1999) further subdivides latent into 'feeling-related' and 'value-related' components. The feeling-related and value-related components are strongly interrelated, even though they contribute differently to maintaining personal interest (Schiefele, 1991; 1999). Interestingly, together these reflect the subcategories of the conceptual framework: positive feelings such as wanting to make a difference, sitting alongside the value-related component of being important to one's long-term goals, such as "the need to fulfil other requirements such as entry to HE, medical school" (Silverman, 2015, p.1984).

Theoretically then, as personal interest is of enduring personal value, built upon pre-existing knowledge, personal experiences and emotions (Schraw, Flowerday and Lehman, 2001; Schraw and Lehman, 2001; Renninger and Hidi, 2011), it can be seen as an important influence in terms of whether someone would choose to continue with science (Maltese and Tai, 2010; European Commission, 2012; Maltese *et al*., 2014), especially acknowledging its inherent stability (Krapp, 2005; Ainley and Ainley, 2011; Krapp and Prenzel, 2011; Archer *et al*., 2014b). This understanding gives confidence in the validity of the 'Personal Interest' category of the conceptual framework, as a tool for exploring the research question.

Does this mean, then, that the issue of young people *not* continuing with science, post-compulsory age, is due simply to lack of interest in science at school? Research from the

Wellcome Trust Monitor (Ipsos MORI, 2013) and the ASPIRES project (Archer *et al*., 2013a) show this not to be the case: 82% of 14-18 year olds (Ipsos MORI, 2013) and 73% of 10-14 year olds (Archer *et al.*, 2013a) found science interesting at school. Some researchers have suggested, however, that this interest and attitudes to science declines through the secondary school phase of their science education (Barmby, Kind and Jones, 2008), and even moving from primary to secondary phase (Galton, 2009). However, Wellcome Trust Monitor (Ipsos MORI, 2013) found that for 83% of pupils science became more interesting at secondary school, and the ASPIRES project found that interest remained largely unchanged between year 6 (age 11) and year 8 (age 13) (Archer *et al*., 2013a). This picture is mixed, possibly due in part to the different ages of participants. Nevertheless, a possible pattern emerged whereby, although pupils were generally positive about school science from Year 6 to year 9, they do seem to enjoy it less; this has been potentially ascribed to the increased emphasis on testing and writing rather than practical work, which may be exacerbated as young people approach GCSEs (Archer *et al*., 2013a). Of course, this may also be true for other curriculum subjects, with examination pressures influencing interest. Therefore, a more helpful marker of interest may be the notion of favourite subject, in terms of enjoyment, but also usefulness for future careers, where subjects are compared directly with each other. In terms of science as a favourite subject, however, findings were again mixed: the 12-13 year olds of the ASPIRES project (Archer *et al.*, 2013a) put science behind English and mathematics, whereas Wellcome Trust Monitor (Ipsos MORI, 2013) (14-18 year olds), and also the BIS/Opinion panel (BIS, 2011) (12-13 year olds) found science to be their favourite subject, more than English and mathematics.

Personal interest, then, whilst complex and difficult to measure, does not appear to be the problem, but this interest is not necessarily translating into science aspirations. Perhaps someone or something else, an external voice, is dissuading pupils from continuing with science, recognising that "Any person who affects the individuals' view of herself or her view of STEM [Science, Technology, Engineering and Mathematics] might contribute to a shift in her attitudes towards STEM" (Sjaastad, 2012, p.1618).

2.5 Part A(ii). External voices of influence

Having explored and validated the influence of personal interest in science, the focus now turns to external voices, and the roles played by situational interest, specific momentary psychological states (Dierks *et al*., 2014), and the notion of significant 'voice' (Sjaastad, 2012).

Situational interest is recognised as a temporary concentration of attention and feelings towards a special situation (Hidi, 1990; Schraw and Lehman, 2001; Wade, 2001; Krapp, 2002). It can be spontaneous (Schiefele, 1999), and often precedes and facilitates the development of personal interest (Krapp, 2005), for example, the situational interest that teachers and parents promote, through the opportunities and experiences they provide, can enhance personal interest. Activities which produce specific, momentary psychological states, such as joy or anger, are recognised as important in deepening interest, but without personal and situational interest, they are unlikely to have a long-term impact on decision-making (Krapp, 2002; Hidi, 2006; Ainley, 2007; Dierks *et al.*, 2014). Nevertheless, their potential impact, alongside situational interest, is also considered within the influence of external voices.

The conceptualisation of significant persons in this research, is built upon Woelfel and Haller's notion of 'significant other' (Woelfel and Haller, 1971); they define a 'significant other' as someone who "exercise[s] major influences over the attitudes of individuals" (p.25), where 'attitude' is the relationship between an understanding of self and their understanding of an 'object'. Whereas Woelfel and Haller (1971) referred to 'significant other', Sjaastad (2012) used 'significant person' to avoid the sexual connotations of 'significant other'. In this research, the term 'significant voice' is used in response to the conceptual framework where influence could be a 'concept' as well as a person, for example, the 'nature of science and scientists' itself was seen to be influential. Intuitively, this notion of 'significant voice' resonates with us, and we could all probably give an example of someone who has inspired us. We talk about the importance of positive role models, but why does a particular 'role model' inspire one person and not another? The mechanism for this is highly complex, but essentially, significant voices act in two ways:

- as 'definers', acting directly with a person to support and guide; and
- as 'models', acting as examples to inspire and motivate (Sjaastad, 2012).

In this way, they influence a person's understanding of 'self' and/or an 'object' (Nauta and Kokaly, 2001; Sjaastad, 2012); in the context of this research, 'self' answers the question "Who am I?", and 'object' answers the question "What is science?" This appreciation leads to four categories of influence: a significant voice can define a person's sense of self; define science careers; model a sense of self; and model science careers (Sjaastad, 2012). In terms of raising science aspirations, when modelling self, the self that is modelled must relate to science; young people need to be able to see themselves as scientists, to have a science identity, if science aspirations are to be raised (Archer *et al.*, 2013a). Sjaastad (2012) refers to this as 'symbolic interactionism', where interacting with another helps us to know ourselves better. Importantly, there is the potential that someone can revise their understanding of themselves through the 'voices' with whom they interact, however, they are not just passive receivers from their significant voices, they can choose to ignore and to pursue their own interests, regardless of quality of input.

Underpinned by this appreciation of the importance of situational interest, specific momentary psychological states, and significant voices in influencing young people to continue with science, the external 'voices' of the conceptual framework are now explored:

- Science education
- Family and friends
- Nature of science and scientists
- Celebrity science and scientists

2.5.1 Science education

The conceptual framework highlighted the following subcategories within 'Science education' as influential:

- Teacher interests, passion for science
- Teacher awareness of student's potential, ability and interests
- Teacher knowledge of science careers
- School/university science curriculum
- School/university links with external science community

Those that we know personally can be expected to be the most influential (Sjaastad, 2012), therefore, it was not unexpected that teachers would be considered to be key significant voices.

Teacher influence:

According to Silverman (2015, p.1983), the "paramount task" of science teachers, regardless of phase of education, should be to nurture the awe and wonder of science. Research literature concurs with this, and vocabulary such as 'expertise', 'confidence', 'enthusiasm', 'skilled' and 'encouraging', are used to exemplify the features of a good teacher (Maltese and Tai, 2010; BIS, 2011; European Commission, 2012; Ipsos MORI, 2013; Logan and Skamp, 2013; DeWitt, Archer and Osborne, 2014; Maltese *et al*., 2014; Silverman, 2015). Indeed, the UPMAP project found that "the encouragement individual students receive from their teachers is the key factor that encourages them to intend to continue with physics post-16" (Mujtaba and Reiss, 2014, p.371).

From the perspective of defining and modelling science and science careers, such that children and young people will be "encouraged" to continue with science (Rodd *et al*., 2013, p.15), teachers are in a position of being able to display science in general, able to raise awareness of the breadth and depth of the subject, and the content of post-compulsory science, including science careers. Mujtaba and Reiss (2013) describe the importance of higher "extrinsic material gain motivation" (p.1824), if young people are to continue with physics. Teachers thus provide situational interest through the provision of hands-on experiences and real-world applications (Hidi, 1990; Krapp, 2002; European Commission, 2012; Sjaastad, 2012; Logan and Skamp, 2013; Dierks *et al*., 2014).

Knowledge of science careers was also highlighted as an aspect of teacher influence through the scoping study. This is contrary to the findings of the Wellcome Trust Monitor (Ipsos MORI, 2013), where although 47% of 14-18 year olds believed teachers were a source of career advice, only 18% believed this to be useful. However, it is of no surprise that the further someone proceeds through their science education, the more they know about the careers available in science, for example, Wellcome Trust Monitor (Ipsos MORI, 2013) found that 78% of 17-18 year old science students knew a great deal, compared to 65% of the 14-16 year olds GCSE students.

Acknowledging that personal interest is stable and resistant to both change and intervention (Krapp, 2005; Ainley and Ainley, 2011; Krapp and Prenzel, 2011; Archer *et al.*, 2014b), if teachers are to be able to give "specific encouragement" (Rodd *et al.*, 2013, p.115), Archer *et al*., (2014b) suggest that the mainstream curriculum should include STEM careers information and knowledge; Mujtaba and Reiss (2013) concur with this. Furthermore, as interest in science is recognised as starting early in a child's life (Munro and Elsom, 2000; Maltese and Tai, 2010; Archer *et al.*, 2012; Maltese *et al*., 2014), it is suggested that teachers begin to define and model science and science careers during the primary phase of education (Sjaastad, 2012; DeWitt, Archer and Osborne, 2013a; Archer *et al.*, 2014b).

The complimentary role of significant voice is to define and model a sense of 'self' (Sjaastad, 2012), and from a science perspective, this is understood to be specifically curriculum and educationally-based (Sjaastad, 2012). However, the conceptual framework does highlight the possible influence of teachers at the more personal levels of being aware of their students' potential, ability and interests. Rodd *et al.* (2013), reflecting on the work of Britzmann (2011), describe how the teacher can be seen as an 'emotional figure', displaying a similar role to parents. In addition, Maltese and Tai (2010) suggest that teacher personality plays a key role in developing an interest in science as they progress through school. As such, teachers as well as parents can bolster self-concept, or self-efficacy in science (Archer *et al.,* 2013b; DeWitt *et al.,* 2013a), and thereby influence subject choices (Cleaves, 2005; Murphy and Whitelegg, 2006; Vidal Rodeiro, 2007), with the potential outcome of raising their science aspirations (Bandura, Babaranelli, Caprara and Pastorelli, 2001). Mujtaba and Reiss (2014) go as far as suggesting that physics aspirations could be enhanced if teachers "actively creat[ed] a more meaningful one-to-one relational dimension within their teaching" (p.388). Involving parents into specific conversations about subject and career choices, as well as their child's academic capability, is also recognised as having the potential to enhance aspirations (Munro and Elsom, 2000).

In summary, those teachers who convey messages about the importance of science and the value of science qualifications for students' future careers, as well as supporting their personal development and self-efficacy as scientists, are recognised as being highly influential in raising aspirations to study science post-compulsory age. This understanding validates teacher 'voice' as influential, validating this conceptual framework subcategory.

Curriculum

In terms of raising aspirations, the conversation around curriculum is generally linked to authenticity, through real, practical, meaningful opportunities (Butt *et al*., 2010; European Commission, 2012; Archer *et al*., 2013a; Ipsos MORI, 2013; Logan and Skamp, 2013; Mujtaba and Reiss, 2013; DeWitt *et al*., 2014; Silverman, 2015).

Active participation in authentic science activities, then, are considered key elements in engaging pupils in science (Ipsos MORI, 2013; Logan and Skamp, 2013), reflecting "the intrinsic activities practised by active scientists themselves" (Silverman, 2015, p.1990). Indeed, Silverman (2015, p.1991) goes as far as saying "to teach science well, one needs to have the attitudes of a scientist … [with the] … classroom reflect[ing] accurately the attributes and activities of a place where real science is done." This is supported by young people themselves, for example, the Wellcome Trust Monitor found that 40% of the 14-18 year olds believed that relevance to real life was important, although they did not want the links to be tenuous or lacking clarity of purpose (Ipsos MORI, 2013). Wanting to be active participants in learning, they also raised concerns that practical work should not be about getting 'fun' into lessons: there should be clear links to theoretical learning (Butt *et al*., 2010; Ipsos MORI, 2013; Logan and Skamp, 2013). Teachers were also in agreement, expressing the concern that 'practicals' could actually be a distraction, if design and implementation were limited (Ipsos MORI, 2013).

Essentially, this requires a curriculum which acknowledges the interests, attitudes and values that pupil's hold. This is in line with Roberts (2007) 'Vision 2', where the curriculum emphasises real life situations, with the potential to influence decision-making regarding socio-scientific issues, in which science plays a part. In contrast, it is recognised that knowledge-based curricula, Roberts (2007) 'Vision 1', do not in themselves necessarily influence decision-making, that is, they do not transform an individual from a passive recipient of information to an active and discerning consumer of information (Laugksch, 1999). However, for someone who already has a strong personal interest, this may not necessarily be true; knowledge *per se* may be all that is required.

The statutory science components of the National Curriculum in England and Wales (DfE, 2013; DfE, 2014), were designed to promote scientific literacy, by deliberately linking the more substantive, knowledge-based elements of science with what it means to work scientifically. To be influential, delivery of the curriculum is expected to include opportunities to explore contemporary science in relevant local and global contexts, making links with the scientific community.

The curriculum itself, then, is recognised as being influential. Silverman (2015) talks about the impact on students of "cookbook laboratory work" that is, the repetition of well-established experiments, on attitudes to science, asserting that it is the investigative side of science, exploring something of personal interest that causes "strongest motivation and deepest satisfaction" for scientists (Silverman, 2015, p.1989).

Links with the scientific community

Informal learning opportunities were also raised in the scoping study as having the potential to be influential. These can include visits to science attractions, such as museums and zoos; visitors and opportunities to work with real scientists in school; and extracurricular activities, such as science clubs, science fairs and festivals.

The Wellcome Trust's 'Science education tracker' (Kantar Public, 2017) found that 57% of young people had visited a science attraction, or been involved in extra-curricular activities at school. When asked about the motivational effects of these opportunities, 40% said they felt inspired to study science further; for the remainder it made no difference. Interestingly, those who did participate in these informal learning experiences were found to be more likely to engage with science through other media, most commonly television, but also via the internet, and books and newspapers (Ipsos MORI, 2013; Kantar Public, 2017). Here, situational interest was promoting personal interest (Hidi, 1990; Krapp, 2002; Dierks *et al*., 2014), thereby building science capital (Archer *et al.,* 2013a).

There are a number of initiatives and schemes bringing scientists and schools together, for example, Researchers in Residence, and STEM Ambassadors, the purpose of which is not only to provide real contexts for their work, but also to show the reality of life as a scientist, thus defining and modelling science *per se*, as well as 'self' as a scientist (Sjaastad, 2012; Archer *et al*., 2014b); indeed, Wellcome Trust wave 2 research found that 53% were interested in hearing more from scientists about their research (Ipsos MORI, 2013). These schemes are mutually beneficial, not only are pupils having access to real scientists working in real contexts, their teachers also gain confidence about the process of science (Bowater and Yeoman, 2013), and have access to advanced, specialist knowledge, and real science equipment; and the scientists themselves have the opportunity to share their work and passion and encourage pupils to follow science pathways (Bowater and Yeoman, 2013).

These schemes, however, do have their limitations. Access to a scientist from a niche field may have the impact of narrowing pupil appreciation of the breadth and depth of science, furthermore, Archer *et al*. (2014b) argue that meeting these scientists may only support pre-existing aspirations, rather than developing new aspirations in pupils who had not previously considered a career in science. Indeed, although all seven physics undergraduates interviewed by Rodd *et al.* (2013) referred to the importance of a significant adult representing physics, that is, physics being personified in some sense, none suggested that an intervention of any sort was influential.

Archer *et al*. (2014b), then, referring to what they call the 'being/doing' divide, in that students like 'doing' science, but they don't want to 'be' a scientist (Archer, DeWitt, Osborne, Dillon, Willis and Wong, 2010), question the initiatives put in place to raise pupil's interest in science, and argue that it may be more effective for teachers to focus on science careers.

In summary, the relationship between attitudes towards school science and aspirations is complex. Negative experiences of school science appear to have a detrimental effect on students continuing with science post-compulsory age, although the opposite is not necessarily true (Cleaves, 2005; Lyons, 2006). Positive experiences can promote interest and enjoyment of science, but do not necessarily translate into pursuing it further (Bennett and Hogarth, 2009; Archer *et al.,* 2014b). Teachers themselves can inspire interest in science through the situational interest they provide, but also their role in defining and modelling a sense of 'self', not just as a scientist, appears to be key (Maltese and Tai, 2010; Rodd *et al.,* 2013; Maltese et al., 2014). Self-concept, self-efficacy and self-confidence can all be bolstered by teachers, and research shows that these attributes are important in maintaining and motivating young people's science aspirations (Archer *et al*., 2013b; DeWitt *et al*., 2013a). This appreciation validates 'Science education' as a significant 'voice'.

2.5.2 Family and friends

Please note, that within the boundaries of this research, 'parent' is used to denote parents, carers and other adults with parental responsibilities.

The conceptual framework highlights the following subcategories within 'Family and friends' as influential:

- Family or friend's personal interest
- Family or friend's experiences of science
- Cultural influences and expectations
- Best interest of young person at heart
- Awareness of their potential, ability and interests

Family

Historically, family has been recognised as the key socialising agents (Bourdieu, 1986; Ott and Mack, 2014). At best, their influence is underpinned by the desire for their children to achieve their potential, therefore, their influence on 'self' is more 'global', more holistic, as parents take the gifts, talents, interests, aspirations, and academic ability of their child into account (Sjaastad, 2012). Here the aim is to support and guide them to be the sort of person they want to be, true to their own self; they shape a child's "sense of themselves and their horizons of possibility" (Archer and DeWitt, 2017, p.77). Family habitus, and the economic, social and cultural capital available to them informs this role (Bourdieu, 1986; Archer *et al*., 2013a). Archer and DeWitt (2017) extended Bourdieu's (1986) concept of habitus from the individual to the family, viewing family habitus as "encompassing families' values, collective dispositions, sense of identity and everyday practices" (p.79). Aschbacher, Li and Roth (2010) refer to these collectively as the family 'micro-climate'.

In terms of career aspirations, family, as a significant voice, generally defines those they have had first-hand knowledge of, so that the careers they display may or may not be related to science (Sjaastad, 2102). The scoping study highlighted the belief that family habitus can shape career aspirations in general, and indeed the Wellcome Trust Monitor (Ipsos MORI, 2013) found that 67% of 14-18 year olds believed family was the most common source of career advice, with 37% suggesting that this was also the most useful; this is significantly higher than teacher influence.

Regarding science aspirations, family is recognised as highly influential, both positively and negatively (Butt *et al*., 2010; Maltese and Tai, 2010; Archer *et al.,* 2012; DeWitt *et al.,* 2013a; Ipsos MORI, 2013; Archer, DeWitt and Dillon, 2014a; Maltese *et al*., 2014). When specifically considering family science capital (Archer *et al.,* 2012; Archer *et al.*, 2014a), research in general found that affluent, middle-class university educated parents tended to display high levels of science capital and this resulted in their child being more likely to study science, post-compulsory age, with the intention of pursuing a career in science (Archer *et al.,* 2014b; Kantar Public, 2017). Even where only one parent was interested in science, 47% of the 14-18 year olds were themselves interested, compared to 35% where parents were not (Kantar Public, 2017). Data from the ASPIRES study also reflected this (Archer *et al*. 2013a) with 81% of adults agreeing that living with someone with a science background improved career prospects in science, compared with 67% who did not.

From a practical perspective, children of families with high science capital had not only been advised about science careers, but their parents had also facilitated science-related work experience (Kantar Public, 2017). Furthermore, parents, older siblings and the wider family can act as advisors for younger siblings, offering first-hand experience and knowledge of specific science fields (Morrow, 1999; Wong, 2012). Wong (2012) exemplifies this through 'Samantha', whose parents and members of her extended family viewed careers in the fields of medicine and law as desirable professions; these high aspirations were normal within her family habitus and available social and cultural capitals, and as such she was highly motivated to pursue science further.

Friends

DeWitt, Osborne, Archer, Dillon, Willis and Wong (2013b) did not find peer attitudes to science to be closely related to student aspirations in science. The influence of specific friends, however, is less certain, with research suggesting that even if attitudes and aspirations are influenced by peers (Francis, 2000; Mendick and Francis, 2012), young people may not actually be aware (Springate, Harland, Lord and Wilkin, 2008; DeWitt *et al*., 2013b). Wong (2012), again taking 'Samantha' as an example, noted that although her close group of friends aspired to different professions, the fact that they were all in the 'top set' was "mutually beneficial" (p.53). Furthermore, Samantha's peers also recognised her as scientific, with her and her friends being regarded as geeks and nerds. Wong (2012) suggests that this may have been beneficial to Samantha and her identification with science, in that they "laugh[ed] it off as a compliment", a strategy recognised by Nayak and Kehily (2006). Both groups of close friends and peers appeared to be playing a role in embedding her science aspirations.

In summary, family and friends are recognised as having the potential to influence science aspirations. Family habitus is recognised as having the potential to make science "known, thinkable, desirable and achievable" (Archer and DeWitt, 2017, p.97). The relationship with friends, however, is less clear (DeWitt *et al.,* 2013b). This understanding validates the 'Family and friends' subcategories of the conceptual framework.

2.5.3 Nature of science and scientists

Is science itself an influencing factor? If so, is it the knowledge and understanding itself, and the exploratory nature, problem-solving aspects of science? Or is it linked to the personal aspects of wanting to make a difference, and thereby being willing to engage in science, in real contexts?

The conceptual framework highlighted the following subcategories within the 'Nature of science and scientists' as influential:

- Scientific literacy: knowledge, understanding and scientific process
- Scientific literacy: willingness to engage in science
- Scientific literacy: 'real' contexts
- Science communication and engagement

The Science Council (2019) defines science as "the pursuit and application of knowledge and understanding of the natural and social world following a systematic methodology based on evidence", and a scientist as someone who "systematically gathers and uses research and evidence, making a hypothesis and testing it, to gain and share understanding and knowledge." Whilst this sounds dispassionate, they do go on to assert that "**all** scientists are united by their relentless curiosity and systematic approach to assuaging it." (Author's emphasis) (Science Council, 2019).

In a sense, however, these latter sentiments could be applied to other curriculum subjects and career pathways, so what is it about the nature of science that has the potential to influence young people to continue with it, post-compulsory age?

Brake (2010) identifies five characteristics of science: "science as an institution; science as a method; science as a body of knowledge; science as the key driver of the economy; and science as a worldview" (p.13). Interestingly, these mirror the subcategories of the conceptual framework, and as such are helpful as a structure to explore the influential 'Nature of science and scientists', and to validate the conceptual framework itself; Brake's (2010) characteristics have been re-ordered in line with the subcategories of the conceptual framework.

Science as a body of knowledge:

Brake (2010) describes science as a "living body of knowledge … it is progressive, building on previous knowledge … [and the] … net outcome of all its endeavours up to that date" (p.18). Essentially, science evolves, it is dynamic, reflecting the vocabulary used by the Science Council (2019) cited previously, such as systematic, evidence-based, pursuit of knowledge. Is this what interests young people and inspires them to continue with science? The 'Personal interest' section of the conceptual framework would have us think so. The Science Council (2019) also uses the word 'creative' to describe the work of scientists, however, this notion of creativity in science can be contentious, with a dichotomy seen between the sciences and arts, as discussed in the seminal text 'Two Cultures' by C.P. Snow (1959); if science is not seen as creative, young people who see themselves as creative may not aspire to a career in science.

Silverman (2015, p.1985) asserts that when research scientists are asked what it is that:

> "fascinates them, impels them to pursue it, and rewards them for the countless hours spent at it", the general sentiment is that "science is intellectually exciting, a challenge to one's mental skills; that there is beauty to science, whether in an artful experimental solution to a seemingly insurmountable problem or in the remarkable predictive power of a set of equations." (p.1985)

Silverman (2015) cites two sources in support of this (Sreenivasan, 2004; Conover, 2015), but there are many others, for example, the 'icould' campaign (https://icould.com/), includes a video of Maggie Aderin-Pocock, describing her fascination with science, and her reasons for wanting to be a scientist. Silverman (2015) also notes that being able to work scientifically "inspires personal confidence to handle problems outside the laboratory as well" (p.1985). It is interesting that research shows that young people believe that science helps them even if they do not want to be scientists (Ipsos MORI, 2013), as described earlier.

Silverman (2015) uses the word "beauty" to describe science, and this is also the sentiment of Professor Marcus du Sautoy (2008) on taking up his new appointment as the Charles Simonyi Chair in the Public Understanding of Science at the University of Oxford in 2008, as he asserted that scientific literacy is fundamental to the way we understand the world.

Science as a method:

Brake (2010) describes this at its simplest as "experiment and observation" (p.16). In the 'Science education' category of the conceptual framework, it has already been noted that practical science can be influential, if meaningful, and preferably linked to real contexts (Butt *et al*., 2010; Ipsos MORI, 2013). One of the misconceptions of science is that scientists work in isolation, and that relationships are not important, however, for most scientists, planning tends to be collective and collaborative (Brake, 2010, p.17). du Sautoy (2008) again, asserted, with the notion of collaboration in mind, that science is about communication, in that "a scientific discovery barely exists until it is communicated and brought to life in the minds of others." Is it the opportunity to collaborate, to build networks and relationships that influences young people to continue with science? This social nature of science is a key driver of the economy, especially in terms of recruitment. Fundamentally, science is a learned vocation, communicated and disseminated through journals and books.

Science as a key driver of the economy:

According to Brake (2010), science's role as a key driver of the economy includes "the creation of wealth, goods, food and comfort" (p.20). The 'Personal interest' category of the conceptual framework has already shown that this is indeed an important influencing factor: young people want to make a difference to the world in which they live, and as such they viewed science as 'transformational'. It is important to note, however, that progress in science is not generally accidental, it tends to be in response to some economic need (Brake, 2010). In this way, advances in science develop as a result of the direct benefit it provides for particular people, in a specific context. This is important for young people to realise, that science is dynamic and responsive, not simply learning facts and repeating well-established experiments (Silverman, 2015).

Science is also often abstract in nature, and the notion of scientists as 'brainy' and of 'otherness' (considered below) have also potentially contributed to young people seeing science as "not for them" (Jenkins and Nelson, 2005; DeWitt *et al*., 2013a). This may have led to a situation where the job of science was restricted to a minority of people, leading to an "elite profession" (Brake, 2010, p.22), potentially resulting in the current skills-gap. These could be potential barriers, but equally returning to the social nature of science considered to be important in recruitment (Brake, 2010), could it be the notion of 'Science as an institution' that is influential?

Science as an institution:

Science is part of the establishment and as an institution employs thousands of scientists across a range of disciplines (Brake, 2010). The scoping study and subsequent conceptual framework highlights the potential for scientists themselves to be influential, and in the context of this research, to be significant voices (Sjaastad, 2012). An essential prerequisite, however, is that the perceptions of science and scientists held by young people, their teachers and families is accurate, and that scientists are perceived in a positive way (Springate *et al.*, 2008; DeWitt *et al*., 2013a; Archer *et al.*, 2014b). Science aspirations, then, are shaped by the ability to identify oneself as a scientist, and be able to imagine oneself in a particular occupation (Archer *et al*., 2013b; DeWitt *et al.*, 2013a). As such, negative stereotypes and misconceptions of science and scientists can act as a barrier to identification (Archer *et al*., 2010; DeWitt *et al*., 2013a; Archer *et al*., 2014b), such that a career in science may not be seen as "for me" (Jenkins and Nelson, 2005; DeWitt *et al*., 2013a).

Traditional perceptions of scientists have included 'geeks', 'nerds' and Einstein-like images, who are often white, middle-class males (Archer *et al*., 2010); indeed, a recognised way of gaining insight into the perceptions people hold of scientists is the 'draw a scientist' test (Chambers, 1983), where respondents consistently draw an 'Einstein-type' scientist surrounded by test-tubes, wearing a lab coat and goggles.

Whilst acknowledging the significance of the relationships between 'gender, ethnicity and social class' and 'science and scientist stereotypes', this is not a specific aim within this research. The phenomenon of 'Celebrity Science Culture' is explored from the perspective of a generic celebrity scientist, considering how they might influence young people, rather than the impact of their gender, ethnicity and social class. The small-scale nature of this research would not allow meaningful data to emerge from these perspectives, especially considering that I have asked participants to self-identify as scientists, regardless of their personal biographical details.

So what are children's and young people's perceptions of scientists? Wellcome Trust Monitor wave 2 research (Ipsos MORI, 2013) found that 72% of young people believed that scientists come from a range of social backgrounds, and not an elite group, as Brake (2010) feared. The ASPIRES project data (Archer *et al.,* 2013a) found that pupils believed that scientists were well paid (56%) and had interesting work (55%), however, when considering their opportunities and their reputation, figures dropped to between 38–44%, with only 6% believing that science was a "cool" career. One might think, then, that these findings confirm that the stereotype of 'geeky' scientists may be dissuading students, but this was not the case: only 21% said that scientists were 'geeks', and only 14% said they were 'odd'. Although this stereotypical 'geek' scientist was prevalent in the research of DeWitt *et al*. (2013a), focussing on the perceptions of Year 6 (age 11) children, interestingly, participants frequently "did not subscribe" to it, and some "refuted it explicitly" (p.1471). Furthermore, DeWitt *et al.* (2013a) found that Year 6 children perceived scientists to be 'normal' or "no different from you and me" (p.1468), some parents, however, did hold the contrary view. Although these Year 6 children also recognised the "scientist as specialist" (DeWitt *et al.,* 2013a, p.1472), they were not at this age seen as 'other'. In addition, Archer *et al.*'s (2014b) intervention to promote science careers, whilst not revealing an association between perceptions of scientists and science aspirations, their qualitative data did show an impact, in that the higher attaining girls felt that their previous stereotypes of scientists had been challenged, they 'seemed normal' (p.45), with two of the girls noting that by meeting scientists, their "pre-existing medical aspirations" had been "confirmed and bolstered" (Archer *et al*., 2014b, p.42).

Interestingly, those students who identify themselves as scientists may be stereotyped by their peers as 'geeks', with the often associated personality trait of being socially awkward (Mendick and Francis, 2012; Wong, 2012; DeWitt *et al*., 2013a; Wong, 2016); this is exemplified and exacerbated by the media through characters such as Dr. Sheldon Cooper in the 'Big Bang Theory', one of the programmes credited by the media with the increased uptake of science by young people.

Another potential barrier is the perception that scientists are "deeply intertwined with notions of 'otherness' and 'cleverness'" (Archer *et al*., 2014b, p.45), with the outcome again that science could be seen as "not for me" (Jenkins and Nelson, 2005; DeWitt *et al.,* 2013a). The

ASPIRES project (Archer *et al.*, 2013a) found that 79% of Year 9 pupils perceived scientists as 'brainy' or 'clever', with science seen as 'specialist', and careers in science potentially perceived as unachievable, for the "exceptional" (p.18); this is recognised as especially true of physics as a high status subject (Francis, 2000; Bourdieu, 2004; Bleazby, 2015). Indeed, Rodd, Mujtaba and Reiss (2014) found that those young people who defend themselves against anxieties, giving the example of 'Robin' who defended himself against not being good enough, were less likely to continue with physics. This 'Einstein' image described above, further highlights the perception of science as a hard subject, and associated with being clever.

For some pupils, however, the association of being 'clever' or 'brainy' may be regarded as a positive attribute. In Wong's (2012) research, Samantha's 'triple science status' was a "desirable identity because it represents cleverness and academic status" (p.52); for her science was "positively constructed" (p.52). Nevertheless, it has been suggested that holding a positive image of scientists may not be enough to influence continued uptake of science; they may still perceive them as 'not like me' and therefore 'not for them' (Jenkins and Nelson, 2005; DeWitt *et al*., 2013a). Furthermore, if scientists are perceived as naturally intelligent (Wong, 2016), such that cleverness is "inborn, rather than acquired" (DeWitt *et al*., 2013a, p.1471), this may reinforce any perceptions that scientists are not 'normal' people (Wong, 2016), and if this is the case, DeWitt *et al.* (2013a) suggest that this is "likely to act against student openness and willingness to take up a science identity" (p.1472). Indeed, for some young people, it is just the "recognition of being clever" that they want, and as science is associated with 'cleverness' it can act as a "symbolic marker" of their intelligence (Wong, 2016, p.85). Butler (2006) describes this identification with science as the performativity of intelligence. These students may not even have aspirations, or even an interest, in science. Wong (2016) describes this as an extrinsic motivation for science, in that it will diminish when its purpose has been fulfilled, for example, once access to higher education or a particular job has been secured; I have referred to this as 'utilitarian' influence in the 'Science Education' category of the conceptual framework (Figure 2.1, p.69).

Acknowledging then, that a young person's perception of scientists can have a positive or negative influence, it is important that the scientists with whom they inter-relate build a positive image of science and of themselves. This links to the final characteristic of 'Science as a worldview'.

Science as a worldview:

Brake (2010) asserts that science is "one of the most powerful influences shaping beliefs and attitudes to the Universe and man" (p.25); its aim, therefore, is to communicate science so that the public "appreciate the status of science and scientists" (p.26). From the perspective of this research, if the public does "appreciate" science and scientists, this could impact on the science aspirations of young people as they engage directly with scientists, and indirectly through the influence and situational interest provided by teachers and families.

Traditionally, science communication and engagement was a top-down, 'Public understanding of science' (PUS) approach, that is, scientists decided what the public needed to know (Russell, 2010). However, in the last thirty years, there has been a move towards a bottom-up 'Public engagement in science and technology' (PEST) approach. The Third Report of the House of Lords Select Committee on Science and Technology, 'Science and Society' (Parliament. House of Lords, 2000), asserted the importance of the general public's attitudes and values being "recognized, respected and weighed", if they were to be supportive of science policy. The PEST model recognises the importance of two-way engagement between scientists and the public to increase trust and confidence in science (Whitmarsh, Kean, Peacock, Russell and Haste, 2005).

The scientific community is committed to promoting science with the general public, For example, the partnership organisations of 'Science Community Representing Education' (SCORE) (Association for Science Education, Institute of Physics, Royal Society, Royal Society of Chemistry and Society of Biology) all hold an annual science event; there are festivals such as that promoted by the British Science Association, and the Cheltenham Science festival. The Association of Science and Discovery Centres (ASDC, 2010) represents over 100 science centres and discovery centres in museums, botanic gardens, aquariums, and zoos. Science museums have become more innovative in terms of the audience they want to attract. For example, in London, the Science Museum's "Lates" programme is for adults only and has attracted young adults who would not have traditionally visited the museum; it has been referred to as a combination of "science and snogging."

It is clear then that there has been a wealth of strategies and initiatives designed to engage the public in science, and to popularise science, and indeed, 'popular science' is now a literary genre in its own right, with a range of authors writing to engage the public in science, through a range of publications, for example, New Scientist, Nature, BBC Focus, and books by

Professor Brian Cox, Professor Stephen Hawking, Baroness Susan Greenfield, and Sir David Attenborough. Whilst the general public still does not have access to academic journals, it is possible to engage with contemporary science and scientists issues through these publications. These carry the potential to increase the science capital of families and teachers, and as such raise the science aspirations of young people.

The 'Nature of science and scientists', then, bringing together the aspects of scientific literacy and science communication and engagement, appear to have the potential to influence the continued uptake of science, post-compulsory age, either directly or indirectly, and as such is validated as a category within the conceptual framework.

2.5.4 Part A: Summary

The review of literature so far, has validated inclusion of 'Personal interest', 'Science education', 'Family and friends', and the 'Nature of science and scientists' as categories within the conceptual framework (Figure 2.1, p.69).

Previous research (Archer *et al.,* 2013a; Ipsos MORI, 2013; Kantar Public, 2017) has shown that personal interest is not the issue when considering young people's science aspirations to continue with science. Science was found to be enjoyable, and seen as valuable, even if a science career is not followed (Archer *et al*., 2014b). Young people do value real and relevant contexts, and opportunities for practical work, where appropriate (Butt *et al*., 2010; European Commission, 2012; Ipsos MORI, 2013). Nevertheless, the relationship between young people and their experiences of school science is complex, with positive experiences not necessarily translating into continued uptake (Cleaves, 2005; Bennett and Hogarth, 2009). Teachers are seen as key people in this process, able to inspire interest through the opportunities they provide, and the knowledge they have of careers in the field (Maltese and Tai, 2010; Archer *et al*., 2013a; Ipsos MORI, 2013; Logan and Skamp, 2013; Maltese *et al*., 2014). In addition, they can also inspire through the relationships they build (Sjaastad, 2012; Maltese *et al.*, 2014); this is akin to the role of family and friends, wanting the best for their child. Furthermore, a family's habitus and science capital are recognised as being potentially powerful in raising aspirations (Archer *et al.*, 2012), whereas the influence of friends is seen as less critical (DeWitt *et al*., 2014).The nature of science and scientists also has the potential to raise aspirations, either through direct contact with scientists and their work, or indirectly, through the situational opportunities provided by teachers and parents.

2.6 Part B: Celebrity science and scientists.

The rationale for including this category of the conceptual framework as a separate part is to not lose sight of the focus of this research: "Celebrity science culture: young people's inspiration or entertainment?" The format of the sections within Part A are not appropriate here, because whilst the scoping study highlighted the role of the other voices as influential, this was not the case for celebrity scientists. Only two participants of the scoping study referred to science in the media, one in general commenting that they watch science documentaries, and a second more specifically talking about wanting to be a marine biologist after seeing one on the television. For the other participants, although they themselves were not influenced, they could see the potential, and this category of the conceptual framework was based upon their perceptions of what this influence might look like:

- Inspire to continue with science
- Raise awareness of opportunities within science
- Raise general interest in science
- Entertain

Literature in this section is structured as follows: firstly, exploration of 'Science as an institution' and 'Science as a worldview' (Brake, 2010) are continued from the perspective of media involvement; this situates the focus of this research away from the more mainstream considerations of raising science aspirations, towards celebrity scientist involvement, the originality of my research. Secondly, the notion of celebrity *per se* is explored, including the definition of 'celebrity', how someone becomes a celebrity, and the mechanism by which they influence. Not only will this provide a vocabulary through which to explore celebrity scientist influence, but will also underpin the development of the theoretical framework (Aim 4) to be used for wider dissemination to the different stakeholders. Having established an understanding of celebrity influence, the remaining sections consider the influence of celebrity non-scientists and scientists; the perceptions of young people; the perspectives of celebrity scientists themselves on their individual roles; and a synthesis of the findings of Part B using the notion of the 'Brian Cox effect' itself.

As a proviso, I am not claiming to be a media studies expert, so that the insights explored are very much from a layperson's perspective, with knowledge gleaned from recommended key texts. Whilst there is a danger of "mission creep" (Hyde, 2009, p.2), a notion whereby someone moves from their recognised field into an area outside their realm of expertise, I have attempted to keep the knowledge relevant by linking it with how it relates to the notion of celebrity scientists.

2.6.1 Science and the media

'Science as an institution' and 'Science as a worldview' (Brake, 2010) were introduced in Part A as characteristics of the 'Nature of science and scientists'. This discussion now continues with a specific focus on the media. Here, the term 'media' is used to include a range of genre, for example, television, radio, print media and web-based media.

Many British science organizations have specialist press teams to help get messages about their work into the media, with a view to building trust and confidence in both science and the scientists themselves (Russell, 2010; Bowater and Yeoman, 2013). Indeed these organisations encourage scientists to actively contribute to the media, to communicate their work, and to interact with the public (Bucchi, 2011). Science undergraduate degree courses now offer modules in science communication, including working with the media, so that these expectations and skills are established prior to beginning careers as scientists in the workplace. The Science Media Centre (SMC) (2012) is an organisation deliberately created to promote a balanced and accurate portrayal of scientific issues in the media. In the same way that celebrities are offered media training, the SMC also offers scientists media training and guidance, so that they can communicate with clarity and confidence.

Bucchi (2011) describes Cloître and Shinn's (1985) model of the four main stages of science communication: intraspecialist; interspecialist; pedagogical; and popular. As such, scientists can plan to simultaneously communicate their work at different levels, by publishing and presenting in both specialist and popular scenarios; Brian Cox is an example of a scientist who has been very successful at this. One can see that credibility as a scientist is the starting point, before engaging and communicating with schools and the general public. Having confidence in scientists and the science portrayed has implications in terms of public perceptions and engagement; here there is a potential impact on how parents, teachers and young people themselves view science, and therefore on young people's science aspirations.

An interesting paradox here, in terms of credibility, is the so-called 'Sagan effect', a derogatory term directed initially at Carl Sagan; Sagan was a renowned astronomer, cosmologist, astrophysicist and astrobiologist, as well as author, television presenter and science populariser. Here, credibility in the eyes of fellow scientists was deemed to be inversely proportional to their popularity with the general public (Shermer, 1999; Jensen, Rouquier, Kreimer and

Croissant, 2008; Fahy, 2015). It was based on the premise that if they were spending too much time engaging and communicating with the public, the quality of their work must be diminished. For Sagan this was unfair, but, nevertheless, he paid the price for his media presence, and was denied membership of the National Academy of Science (NAS) in the USA; the equivalent of membership of the Royal Society in the UK. Although the 'Sagan effect' has now been discredited, in the 1980s it was a concern for those scientists who wanted to engage with the public (Shermer, 1999; Jensen, Rouquier, Kreimer and Croissant, 2008; Fahy, 2015). Of relevance to this research is the importance that Brian Cox places on Sagan and his television series 'Cosmos'. As guest on the BBC radio 4 programme 'Great Lives' (*Great Lives, Series 21, Carl Sagan*, 2010), Cox chose to talk about Carl Sagan, and asserted that it was he who convinced him that he should be a scientist. He went on to describe Sagan as the "*benchmark*" for anyone who wanted to popularise science. It is interesting, however, that Keay Davidson, Sagan's biographer, asserts in this same radio programme, that it was Carl Sagan's mother who "launched" him into his scientific career. This highlights the complexity of the relationships with significant voices and raising science aspirations.

Acknowledging then that scientists today are actively looking to be involved in the media, there are implications in how they and their work are represented. In 2010, the BBC Trust commissioned a 'Review of impartiality and accuracy of the BBC's coverage of science'; Professor Steve Jones (Jones, 2011, 2012; BBC Trust, 2014), Emeritus Professor, University College London, undertook the review. His report (Jones, 2011) described BBC science content as "exemplary" (p.3), acknowledging its high quality and that it was a "thriving and improving genre of programming" (p.3), however, three main shortcomings were noted. Firstly, there was concern over the 'due impartiality' guidelines, with Jones asserting that "there should be no attempt to give equal weight to opinion and to evidence" (p.7) and that a "false balance" (p.8) between well-established fact and opinion must be avoided. Secondly, gender imbalance, as less than a third of contributors and presenters were women; and thirdly, there was a preponderance of interviews given by scientists from the "golden triangle" (p.82) of science institutions (delineated by Oxford, Cambridge and London).

By the time the review was concluded in 2014 (BBC Trust, 2014), under the guidance of the new science editor David Shukman, several initiatives were in place to address these. Nearly 200 senior staff had attended workshops exploring issues around impartiality and giving 'due weight' to science coverage, and there had been a significant shift in the number of women involved, with strategies in place to extend this further. The BBC had also expanded its use of interviewees from across the UK in order to reflect the breadth of research activity, acknowledging that this was vital as part of the “UK’s contribution to the world” (p.3-4), mirroring concerns regarding the STEM skills-gap, and science’s contribution to the UK’s economy. Interestingly, from the perspective of this research, the intended outcome of these measures was to “bring stories to a wide audience that may inspire and educate and inform the next generation of scientists” (p.4). Looking to the future, the newly formed BBC Science Forum introduced new audience research, ‘Audience Insights’, to track the performance of BBC science every six months.

Science on television and radio, of course, is not new. Sir David Attenborough has been presenting since the 1950s, and the television programme, ‘Horizon’ has been running from 1964 to the present day. In the context of science capital and celebrity involvement, an interesting example of an early science programme is ‘Science in the Making: Right Hand, Left Hand’, broadcast in 1953 (McManus, Moore, Freegard and Rawles, 2010). It explored right- and left-handedness, with a group of current celebrities (and a chimpanzee), and involved its viewers by asking them to complete a questionnaire published in the Radio Times, and return it to the BBC for analysis; today, we would call this ‘citizen science’, a strategy involving the public directly in scientific research with the outcome of building science capital and developing scientific literacy.

Documentary-style science programming, however, began to decline on all terrestrial channels (Russell, 2010), with programmers claiming changes in audience expectations made science programming a gamble, with the more committed independent producers believing that serious science programmes could no longer be made. Concern was raised that this was leading to a “dumbing down” (Russell, 2010, p.145), with the obvious implications on how science was perceived by the public. Moreover, this contradicts the approach of Renzulli (1998) to gifted and talented education, where focussing on enrichment and high order thinking was recognised as having the potential to build knowledge and understanding of all learners; he uses the metaphor “A rising tide lifts all ships” to promote this thinking. Table 2.2 includes examples of science television programmes categorised according to three genres: Entertainment, Natural history, and Current science developments; it is acknowledged that there is cross-over between the different genres.

Two different approaches to portraying science in the media began to emerge, alongside documentaries, with the focus more on entertainment; important in this research in terms of the role of celebrity scientists on young people's engagement in science. Firstly, the media began to use a number of presenters not directly involved in science research, for example, Richard Hammond co-hosted 'Brainiac: Science abuse'; some presenters, however, did have credibility by having a background in science, as in the cases of Dara Ó Briain and James May (Russell, 2010). Secondly, fictional television programmes and the film industry have increasingly played an important role in the way science is represented, with Russell (2010) asserting that how science and scientists in fiction are treated is a "key factor in the culture of science, in the making of scientists and in the forming of attitudes towards science by other professionals and by the public" (p.xvii). An example is the radio soap opera 'The Archers', where even though fictional, it played a significant role in informing the farming community of new ideas, techniques and markets after the Second World War (Russell, 2010). Indeed, Futuyama (2007), as the then President of The American Institute of Biological Sciences (AIBS), asserted: "The biggest challenge to biology and to science is not to achieve deeper understanding of genomes or ecosystems or black holes .... The challenge that matters now is to make sure that science is taken seriously" (p.3), and as such, he promoted the use of movies to clarify and deepen the public understanding of science.

Although formal education is the traditional route through which knowledge and understanding in science is gained, the media itself was now facilitating links between scientists and the public (Bucchi, 2011). It had taken on the role of "informal science educators" (Miller, 2004, p.290) where "mass media professionals are regarded as key actors in fostering people's scientific literacy and thus their engagement in scientific processes and decisions" (Weinmann, Löb, Mattheiß and Vorderer, 2013, p.150); these professionals include script writers, producers and directors. Interestingly, noting that the research question is asking whether celebrity scientists inspire or entertain, as a science communication strategy, this is known as 'Entertainment-Education' (Singhal and Rogers, 2002; Singhal, Cody, Rogers and Sabido, 2004; Lacayo and Singhal, 2008). 'The Archers', referred to above, is an example of this.

'Entertainment-Education', often abbreviated to 'Edutainment' (Lacayo and Singhal, 2008), is defined as "the intentional placement of educational content in entertainment messages" (Singhal and Rogers, 2002, p.117). It aims to influence the knowledge, attitudes and overt behaviour of an audience by incorporating a specific message in an entertaining format, such as soap opera or movie (Papa, Singhal, Law, Pant, Sood, Rogers and Shefner-Rogers, 2000; Singhal and Rogers, 2002).

Genre	No. of series	No. of episodes	Timeframe	Presenters
Entertainment				
Brainiac: Science abuse	6	58	2003-2008	Richard Hammond: 2003-06 Vic Reeves: 2007-08
Springwatch			2005-present	Bill Oddie Simon King Kate Humble Chris Packham Martin Hughes-Games Michaela Strachan Gillian Burke Iolo Williams
Embarrassing Bodies & Embarrassing Bodies: Live from the Clinic	12	142	2007-2015	Christian Jessen Dawn Harper Pixie McKenna
Bang goes the theory	8	67	2009-2014	Liz Bonnin Jem Stansfield Dallas Campbell Yan Wong Maggie Philbin
Dara Ó Briain's Science Club	2	12	2012-2013	Dara Ó Briain Alok Jha Mark Miodownik Helen Czerski
Chef vs Science			2016	Mark Miodownik Marcus Waring
Natural History				
The Life series		9	1979-2008	David Attenborough
Other TV programmes (examples below)		39	1954-2019	David Attenborough
• *Zoo Quest*			*1954*	David Attenborough
• *The Blue Planet*			*2001*	David Attenborough
• *Planet Earth*			*2006*	David Attenborough
• *Frozen Planet*			*2011*	David Attenborough
• *Planet Earth II*			*2016*	David Attenborough
• *Blue Planet II*			*2017*	David Attenborough
• *Climate Change – The Facts*			*2019*	David Attenborough
Stargazing Live	6		2011-present	Brian Cox

Other TV programmes (examples below)				Brian Cox
• *Wonders of the Universe*			2011	Brian Cox
• *Wonders of Life*			2013	Brian Cox
• *Forces of Nature*			2016	Brian Cox
• *The Planets*			2019	Brian Cox
How it Works			2012	Mark Miodownik
Genius of Invention			2013	Mark Miodownik
Everyday Miracles			2015	Mark Miodownik
Secrets of the Super Elements			2017	Mark Miodownik
Current Science Developments				
Horizon	55	1200	1964-2019	Numerous, including Brian Cox (6 episodes, 2005-09)
Tomorrow's World		1400	1965-2003 2017-date	Numerous
The Sky at Night		794	1957-present	Patrick Moore (1957-2013) Chris Lintott (2013-present) Lucie Green (2013) Maggie Aderin-Pocock (2013-present) Mark Miodownik (2014) Brian May (1998, 2011, 2012)

Table 2.2. Examples of science television programmes

It is not a theory of communication, it is a communication strategy to bring about social change (Singhal and Rogers, 2004), and can occur at the level of the individual, community or society. Entertainment-Education is not restricted to television and radio, it includes mobile phone applications, games (physical and web-based), theatre, and even "crafts, art, textiles, murals, toys and creative expression" (Singhal and Rogers, 2004, p.18). Farah Karimi (2008), Executive Director of Oxfam Novib, in her Foreword to the 'Pop culture with a purpose: using edutainment for social change' (Lacayo and Singhal, 2008), asserted:

> *"Edutainment strategies have an impressive record in modelling new collective social norms, mobilizing communities, changing the mindsets of individuals,*

> *influencing public discourse and setting political agendas. It opens the minds and hearts of people and encourages them to make positive changes in their lives."*

Entertainment-Education has been used successfully to bring about social change, for example, reducing social exclusion and violence, and to address health-related issues, such as smoking and vaccine-promotion (see, for example, Singhal and Rogers, 2002; Singhal, Cody, Rogers and Sabido, 2004; Lacayo and Singhal, 2008). Soap operas, such as the BBCs 'Eastenders', will often have a disclaimer after an episode offering a point of contact if an audience member has been affected by a particular storyline.

According to Lacayo and Singhal (2008), Entertainment-Education has at least four advantages (p.9):

- Audience popularity (if they're good!);
- They provide effective emotional identification and role-modelling;
- They allow complex and layered treatment of multiple themes (like sexual abuse and machismo, or abortion and the emergency contraception pill) through intertwined and on-going storylines;
- Long-term, repeated exposure to different aspects of the same theme.

The latter is important from the perspective of raising science aspirations, in that the more messages people are exposed to, and the longer the time-frame over which this occurs, the more likely they are to have a "positive attitude toward an issue and be motivated to change" (Lacayo and Singhal, 2008, p.9). Perhaps there is a need for 'soap opera' type programmes, with science topics featuring scientists as main characters that are aimed at primary school-age children.

Entertainment-Education is regarded as a strategy which connects and applies the components and assumptions proposed by Bandura's social cognitive theory (Bandura, 2004). It assumes that people gain knowledge and plan their behaviour by observing others, that is, role models, in their social environment. In Entertainment-Education, mass media actors are role models for viewers, offering the possibility of social change; in this research, the continued uptake of science. Ideally, media models should conform to "vicarious motivators" (Bandura, 2004, p.84), displaying the benefits of this change; from a science perspective, it is important that these role models are positive, as previously discussed. With regard to the viewers, Bandura (2004) stresses their "attentional involvement" (p.84) as being crucial to extend an Entertainment-Education message's impact. This links with the 'Elaboration Likelihood Model, created by Petty and Cacioppa (1986), which focusses on persuasion and how messages are transmitted to different audiences, in order to change their attitude (Lacayo and Singhal, 2008). The focus here is on the concept of transportation, in that being transported or 'lost' in a storyline may allow its persuasive message to be absorbed. As such, identification with a media character comes into play, with the potential that the viewer 'becomes' the media character, again linking to self-efficacy (Bandura, 2004). Enjoyment is also important when engaging with a media product; these are referred to as hedonic entertainment experiences (Wirth, Hofer, & Schramm, 2012).

Weinmann *et al*. (2013) studied the potential of Entertainment-Education for promoting engagement with a science issue, focussing on the three key elements: enjoyment, transportation and identification; this involved surveying 111 undergraduate students after they had watched a movie about genetics. Their results suggested that the more viewers experienced these elements, the more they actually felt informed about scientific issues, providing them with the "ability to integrate them in their daily lives" (p.156); this has implications for developing scientific literacy and enhancing the science capital of the viewing public.

Appreciation is a further aspect of 'Entertainment-Education', defined as "the quality or perceived artistic value of the media content under consideration" (Oliver & Bartsch, 2010, p. 56). It draws upon cognitive processing by the audience, rather than on emotional engagement (Oliver and Bartsch, 2010). Weinmann *et al*. (2013) noted a perceived link by the audience between high quality media content and their belief that they had learned something. Whilst they did not measure 'appreciation', the cognitive dimension of media entertainment, in their study, they assert that both enjoyment and appreciation, that is, emotional involvement and cognitive processing, are important aspects of 'Entertainment-Education' media (Weinmann *et al.*, 2013), and as such they advocate their use to convey scientific information more often. However, there is an issue that "perceived knowledge should not be mistaken for actual knowledge gain" (Weinmann *et al*., 2013, p.157), in that scientific facts and ideas may be misrepresented for the purpose of entertainment, with advances in technology typically outpacing the public's understanding of the underlying science (Russell, 2010). How scientists themselves are portrayed can also be an issue, for example, in the BBC series 'Silent Witness', the pathologists become investigators, and can be seen to exclude the police. These scientists are sometimes portrayed as too busy, their work life-consuming, in strained personal relationships (Russell, 2010); a potential negative effect on how scientists are perceived.

Whilst there has been some criticism of Entertainment-Education in terms of its potential 'top down' approach (Dutta, 2006; Obregon and Tufte, 2014), Wang and Singhal (2018) assert that its purpose is "to show what is possible, i.e. to expand the solution space for audience members, and not to tell them what they should do" (p.178). Does this have the potential to raise science aspirations? The media believes that it does by its construct of the 'Brian Cox effect', and indeed, the 'CSI effect' (Kim, Barak and Shelton, 2009; Hook and Brake, 2010) is a recognised cultural phenomenon where young people embark on forensic science courses at university, because of television programmes like '*CSI: Crime Scene Investigator'*. The same phenomenon was observed on nursing courses after the BBC programme '*Call the Midwives'* and Channel 4s '*One Born Every Minute'* were screened (Cullen, 2016). The issue here is that programmes do not necessarily show the reality of these careers, including career opportunities, with a potentially negative effect on perceptions of science by the public. The inclusion of science advisors, credited alongside the production team, is one way that the media and science community can work together to ensure science is represented accurately.

It is clear then that the media plays an important role as an "informal science educator" (Miller, 2004, p.290), and that 'Entertainment-Education' through emotional and cognitive engagement has been shown to influence the perceptions of the public towards science (Oliver and Bartsch, 2011; Weinmann *et al*., 2013). It is possible that parents, for example, as a significant voice, by engaging with these programmes, may be subconsciously increasing the science capital of their family, thereby potentially raising the science aspirations of their children (Archer *et al.,* 2012; Archer *et al*., 2013a; Archer *et al.,* 2014a). As such, if in some way they identify with the celebrities as themselves (Marshall, 2014), they may recognise their daughter/son as being like her/him (Morgan, 2011). This may also be true of teachers, and their personal television viewing, however, teachers are also in a position to deliberately include entertainment-based media as part of the curriculum, and certainly over the last two decades this has been increasingly the case. Indeed, Millar (2006), critiquing the implementation of the 'Science in the 21st Century' GCSE course, supported the use of entertainment-based media to engage students in contemporary issues, and to generally develop their scientific literacy (Millar, 2006; Osborne and Dillon, 2008; Millar, 2012). This is not the same as using a documentary-style television programme, newsprint or science programme deliberately created for use in schools; here pedagogical resources are produced by science organisations and publishers to support the use of such media, for example, the indexing of David Attenborough's Planet Earth series by the BBC, allowing teachers to make direct links with the curriculum.

2.6.2 Role of the media in science education *per se*

In terms of empirical, peer-reviewed research, the focus has been on the use of these entertainment-based media in science lessons, rather than on the scientists and presenters themselves. Indeed, the Wellcome Trust Monitor (Ipso MORI, 2013), although it acknowledges the rise of television scientists and science programmes that have helped teachers provide different examples that young people may be more familiar with, for example, astronomy (Butt *et al*., 2010), there was no mention of the scientists themselves having an influence.

Rutter (2011) and Orthia, Dobos, Guy, Kan, Keys, Nekvapil and Ngu (2012), for example, described the use of The Simpsons to teach forensic science. There has also been a focus on the influence of media on children's scientific knowledge, for example, again, forensic science programmes and understanding of genetics (Donovan and Venville, 2012); they acknowledged the potential for misconceptions to arise due to the presentation of inaccurate scientific knowledge. Christensen (2011) 'blamed' the mass media for these misunderstandings. Genetic fingerprinting is an example of science that appears frequently in the news media, and on crime television dramas to identify culprits, however, there is limited focus on the underlying science, nor on its limitations and reliability (Russell, 2010). There is the potential for a negative impact on young people and their science aspirations if the science presented is not credible and trustworthy.

Having acknowledged the importance, then, of Entertainment-Education (Singhal *et al*., 2004; Lacayo and Singhal, 2008; Weinmann *et al.,* 2013), as informal science educators, this review now considers the celebrity scientists and non-scientists presenting or being portrayed. It begins with a consideration of the notion of celebrity itself.

2.6.3 Definition of celebrity

The traditional definition of a celebrity is generally ascribed to Boorstin (1961, p.57), as someone who is "well-known for their well-knownness." Marshall (2014, p.57) asserts that celebrities are "given heightened cultural significance within the social world"; they are "highly visible… at national or international level" (Fitzgerald and Savage, 2014, p.46). Of course, there are many people in the world for whom this definition would apply, for example, politicians, however the significant difference between someone who is well-known and someone who is a celebrity appears to be based on how they come to prominence. Celebrities are essentially a media construct, described by Boorstin (1961, p.57) as "counterfeit people whose identities are staged and scripted"; they are "social and cultural fabrications" (Rojek, 2001, p.10), "shaped, presented and disseminated" (Fitzgerald and Savage, 2014, p.56) by the media. The media then directs public attention to the celebrity, thereby reinforcing their celebrity status (Rindova, Pollack, Hayward, 2006). Here already is a paradox: for Brian Cox, this would appear to be a derogatory statement, he is certainly not a counterfeit person, having an impressive *curriculum vitae* in the world of particle physics; perhaps the 'counterfeit' refers to the celebrity status itself.

It is also worth acknowledging that fictional characters can also become celebrities. Rojek (2001) refers to them as 'celeactors'; they are media-created, and recognised as having the potential to influence social and cultural agendas, operating as "models for emulation, embody desire and galvanize issues in popular culture, dramatize prejudice, affect public opinion and contribute to identity formation" (p.26). An example relevant to this research is 'Dr. Sheldon Cooper' of the US television programme, 'The Big Bang Theory'; this series has also been credited with influencing the increased uptake of science (Townsend, 2011), perhaps acting as a significant voice, albeit fictional, modelling and defining what it means to be a scientist. Interestingly, Jim Parsons, the actor who plays Sheldon Cooper, has also advertised for Hewlett Packard portraying the same character; an example of "mission creep" (Hyde, 2009, p.2) and the power of celebrity endorsement.

Celebrity influence is derived from two domains: "the realm of individual identity and the realm of the supporting group or followers" (Marshall, 2014, p.25). In terms of individual identity, Chouliaraki (2012) refers to two important characteristics: recognisability of their work and accomplishments; and associated capacity which provides the media with a "name to a message" (p.3); she exemplifies these through the humanitarian efforts and work with the United Nations of Audrey Hepburn and Angelina Jolie. Hyde (2009) and Kosenko *et al*. (2015) also refer to Angelina Jolie and her role in raising breast cancer awareness. Associated capacity further enhances the celebrity's public image and recognisability, and therefore the potential to expand their network of influence, further embedding their celebrity status (Marshall, 2014). Within the context of this research, Brian Cox was originally recognised as a member of the music band 'd:ream', and this is often referred to by the media; it is not difficult to see how for Brian Cox the notions of recognisability and associated capacity have worked in tandem to create a "name to a message" (Chouliaraki, 2012, p.3) for the world of physics; he has personified physics (Bucchi, 2011; Fahy, 2015), or become "science incarnate" (Fahy, 2015, p.207). This has enabled him to expand his network of influence and to present biology-based programmes and work on children's television.

Marshall's (2014, p.25) second domain of celebrity influence, the audience, is recognised as playing an important role in reinforcing celebrity status (Rojek, 2001; Marshall, 2004; Rindova, *et al.*, 2006), so that whilst the media fabricates them, it is the audience who "embed them culturally" by engaging with their publications, programmes and by generally talking about them (Boorstin, 1961, p.57). The media facilitates this audience engagement by a "technique of inclusion" (Marshall, 2014, p.124) where on live television the viewer is spoken to and looked at directly; for example, Brian Cox, as the host of Stargazing Live, talks to the live and television audiences in this way, and as such they are included in the program. A sense of familiarity, of 'knowing' the celebrity is created, even though it is actually a one-dimensional, "asymmetrical … lopsided relationship" (Ferris, 2010, p.393). Today, social media plays a role in further embedding this asymmetrical relationship, in that, by following celebrities on Twitter, for example, a perception of closeness is created (Marshall, 2014); Rojek (2001) refers to this as an "illusion of intimacy" (p.19). In effect, it feels as though we can share a bond with celebrities through common knowledge of their lives and activities (Ferris, 2010); they are perceived as "people like us" (Fitzgerald and Savage, 2013, p.46); as such reflecting the aspirations of the science community that young people should see science as "for them" (Jenkins and Nelson, 2005; DeWitt *et al*., 2013a).

Of further relevance here is the concept of the "pseudo-event", a term introduced by Boorstin (1961) to describe events that are "deliberately planned for the immediate purpose of being reported or reproduced, thereby bringing new facts into being" (p.35). Recognising that the "underlying reality of the situation can be ambiguous" (Boorstin, 1961, p.11), akin to today's political agenda of 'fake news', could it be possible, then, that that the Brian Cox effect was a 'pseudo-event'? If so, why would the media do this? Clearly, they are not philanthropic organisations, they need to be profitable, and the concept of celebrity is a proven strategy that governs the content of the media (Ott and Mack, 2014), recognising that "audiences will pay to consume virtually anything that features celebrity personalities" (p.42). As the "significant socialising force in contemporary society", a role that traditionally belonged to family and community (Ott and Mack, 2014, p.13), the media has the potential to determine the social agenda, informed by what is newsworthy and, supported by stories of those who have reached "measures only a few can reach" (Blackmore and Thomson, 2004, p.304). Marshall (2014) contends that celebrities have transformational power, by identifying them as men and women "from the people" (p.43), who, according to Rojek (2001), have "dramatically made good" (p.38); Brian Cox can clearly be seen as someone who has "dramatically made good", from a minor celebrity in the band 'd-ream' to a Professor of Physics.

Interestingly, Sutcliffe (2010), writing for the Independent newspaper, talking about 'Wonders of the Universe', questions whether the series was created not because the BBC urgently felt that cosmology needed addressing, but because they needed to find something for Brian Cox to do. Nevertheless, regardless of whether or not this was a pseudo-event (Boorstin, 1961), the fact remains that Brian Cox has been credited with the increased uptake of science.

This aligns with McLuhan's (1964) famous dictum: "The medium is the message", where Brian Cox is both the medium, the personification of physics (Bucchi, 2011; Fahy, 2015), and the message, "be like me, a scientist." As such he provided the media with a "name to a message" (Chouliaraki, 2012, p.3), he was Marshall's "media form" (2014, p.xxix); this concept is considered below.

2.6.4 The role and influence of celebrities

Businesses and organisations frequently use celebrity endorsement as a marketing tool to create brand awareness, whether it be a political, charitable or commercial cause. Indeed there are marketing companies who explicitly work to attract celebrities to these causes, offering advice on how to articulate their "philanthropic interests to the media, contributors and policy decision-makers" (Hyde, 2009, p.230).

By asserting a causal relationship, the media is essentially promoting a view that Brian Cox is 'selling' science, raising brand awareness. This section of the literature review considers how the phenomenon of celebrity culture is capitalised upon to further political causes and to sell products. Entertainers originally entertained, but they are now involved in advertising and advocacy.

Marshall (2014) argues that celebrities serve a political function by "*attempt[ing]* to contain the mass" (emphasis in the original) (p.243); or as Rojek (2001) asserts, they "shepherd the populace into imitative consumption" (p.34). Bourdieu (1996) raised concern about the power of celebrities, in that "they are always telling us what we 'should think' about what they call 'social problems'" (p.46) noting that this includes influencing the setting of life goals; of relevance to this research. Hyde (2009) suggests that celebrities, by offering their 'voices' to these social problems, such as politics and charity support, have "vastly exceeded their mandate" as entertainers; she refers to this as "mission creep" (p.2), citing Michael Douglas, who was invited to speak to British MPs about risks of nuclear proliferation. As a result celebrities have become opinion leaders: "people who influence the opinions, attitudes, beliefs, motivations, and behaviours of others" (Valente and Pumpuang, 2007, p.881), and this appears to be underpinning the media's assertion of a causal relationship between celebrity scientists and the uptake of science.

2.6.5 Influence of celebrity non-scientists

If advertising, politics and popular culture are all be influenced by celebrity culture, then it is not an unreasonable assertion to expect this influence to extend to the field of science, even if the celebrity is not a scientist. For example, "I'm not a doctor, but I play one on TV" is the opening line of a successful advertisement for aspirin, in the 1960s and 1970s; the actor was Robert Young, star of Marcus Welby MD. This formula of celebrity endorsement has been utilised repeatedly, and Hyde (2009) goes as far as saying: "An entertainer saying 'it works for me' trumps any damning study that the scientific community can come up with" (p.146). Robert Young's advertisement was not controversial in that aspirin is a *bone fide* medication, however, some endorsements lie within the realm of pseudo-science, for example, Suzi Quatro (rock singer) using colon cleansers to prevent sore throats, an uncomfortable, but not particularly harmful claim, to Gisele Bunchen (Brazilian fashion model) not using sunscreen, as she believes it is poisonous, putting herself and any followers at risk of sunburn and melanoma (Sense About Science, 2011).

In addition, Taylor Smith (2012) draws attention to the dangers of celebrity endorsement and unproven medical conditions, citing the rock band Foo Fighters support of Christine Maggiore and her 'Alive and Well AIDS Alternatives Foundation'. Maggiore believed that AIDS was not caused by HIV, but by malnutrition, and encouraged HIV positive pregnant women to avoid antiretroviral drugs. This belief ultimately led to the death of her daughter, and then herself: both deaths were HIV-related. Essentially, the Foo Fighters chose to ignore twenty years of research in favour of Maggiore's strong beliefs.

Interestingly, these endorsements are not always initiated by the celebrities themselves, there are agencies deliberately connecting celebrities with diseases, even if they have not suffered from it personally (Lerner, 2009).

Non-scientist celebrity advocacy and endorsement, however, is not all negative, and indeed can positively promote health issues (Lerner, 2009; Kosenko *et al.*, 2015; Caulfield and Fahy, 2016). Lerner (2009) cites Michael J Fox for raising the profile of Parkinson's disease, and

Kylie Minogue, breast cancer awareness, and again Angelina Jolie who is fastidious about referring people back to their doctors.

Why is this relevant to this research? Non-scientist celebrity endorsement has the potential to raise the profile of science and scientific issues in the eyes of the public (Lerner, 2009; Kosenko *et al.*, 2015; Caulfield and Fahy, 2016). However, if they are promoting pseudo-science, or are used to manipulate scientific opinion, rather than seeking to promote accurate scientific knowledge, this may add to the public scepticism about science (Dillon, 2011). If science is not seen as credible and trustworthy, this has the potential to impact negatively on raising the science aspirations of young people, in that rather than identifying with scientists as significant voices, as "people like us" (Fitzgerald and Savage, 2013, p.46), they may see science as "not for me" (Jenkins and Nelson, 2005; DeWitt *et al.*, 2013a).

These pseudo-scientific claims made by non-scientist celebrities are being monitored, refuted and addressed by the scientific community. Two examples are the organisation 'Sense about Science' (Sense about Science, 2011) and Dr. Ben Goldacre, (Goldacre, 2008; Goldacre, 2013) through his publications and newspaper columns devoted to 'Bad Science'.

2.6.6 Mechanism of celebrity influence

Literature on celebrity advocacy and endorsement centres around the importance, not only of identifying with the celebrity, but also that a personal connection is required leading to the formation of what the media calls 'emotional bonds', 'para-social bonds', 'para-social interactions' or 'pseudo-intimacy' (Merton, 1946; Lazarsfeld and Merton, 1948; Horton and Wohl, 1956; Rojek, 2001; Ferris, 2010; Marshall, 2014). Pfau and Parrott (1993) suggest that by establishing an emotional bond with the audience, campaigners seek to transfer feelings about the celebrity to the issue advocated. Merton (1946) illustrated this phenomenon by evaluating the influence a radio host had on persuading Eisenhower to stand for President of the USA, noting that fans felt a personal connection to the host: "You'd think she was a personal friend" and "I feel she's talking to me".

Furthermore, Merton and Lazarsfeld, in their seminal work on mass communication in the 1940s (Merton, 1946; Lazarsfeld and Merton, 1948), developed the notion of "status conferral function," where the media "enhance[s] the social standing of the issues, persons, organizations, and movements they cover, even if they are not favourable" (Simonson, 2006, p.111). Boykoff and Goodman (2009, p.396) exemplified this in the field of science by highlighting an 'emergent climate science-policy-celebrity complex', considering how non-scientist celebrities are used to create emotional bonds with the public, thereby promoting climate change and stem cell agendas.

Two specific theories of celebrity influence, based on the formation of emotional bonds, are exemplification theory and attention economics.

Exemplification theory includes two important heuristics: availability of the celebrity, and how representative the celebrity is to the target population (Yoo, 2016). If the celebrity is representative, that is, has the "characteristics of the target population" (p.57), this 'population' will be able to identify with the celebrity, leading to the development of para-social bonds (Van Norel, Kommer, Van Hoof and Verhoeven, 2014). As such, they are more likely to notice them in the media, and in a sense, the celebrity becomes more 'available' to them. With exemplification theory, then, the key to raising science aspirations relies on both the availability and credibility of the celebrity scientist, and the ability of the young person to identify with them, that is, there must be a "perceived fit" between the endorser and the product (Fink, Parker, Cunningham and Connen, 2013, p.21). This goes some way to explain the influence of Brian Cox on those students already interested in physics: there is a perceived fit, they have physics in common.

There are implications here, in that celebrity scientists may only have an influence on those who already have science aspirations, so that the heuristics of exemplification theory have the potential to enhance the formation of para-social bonds, thereby further embedding their desire for science careers.

Attention economics (Simon, 1993) is based upon the premise that we can pay attention to, and absorb, only so much information, disregarding the rest; the more information available, the less able we are to cognitively process, and the less attentive we become. Processing large amounts of information requires cognitive shortcuts, and one such shortcut is to attach decisions to someone else, someone with whom we have developed para-social bonds. From the perspective of this research, the scoping study and literature review have both shown that these are more likely to be teachers and family (Butt *et al.*, 2010; Archer *et al.*, 2013a; Ipsos MORI, 2013; Logan and Skamp, 3013). Simon (1993) describes this as "docility" (p.xxviii), that is, "the tendency to depend on suggestions, recommendations, persuasion, and information obtained through social channels as a major basis for choice" (Simon, 1993, p.156). He is not suggesting that people become passive, they do make decisions, but they engage with a "limited pool of information in a limited way" (p.xxviii). It is also important to recognise that the influence of celebrity over young people is a normal part of identity development (Giles and Maltby, 2004), and they are, therefore, often targeted explicitly in terms of product placement by the use of celebrities. Giles and Maltby's (2004) findings, based on 'Celebrity attitude scales', suggested that celebrities provide a secondary group of 'pseudo-friends' as they become increasingly independent of their parents. In terms of science aspirations and career choice, young people may see celebrities as pseudo-friends, and may rely on cognitive shortcuts, such as deferring to the suggestions and guidance of significant voices; this may include celebrity scientists, as the media asserted.

2.6.7 Celebrity: a young person's perspective

Three potential issues were raised in the previous section **(2.6.6)**:

i) Exemplification theory requires that a young person is able to identify with the celebrity, that is, there needs to be a "perceived fit" between the endorser and the producer (Fink *et al*., 2015, p.21);

ii) Celebrity influence is a normal part of identity development (Giles and Maltby, 2004);

iii) Pseudo-friendships (Giles and Maltby, 2004) based upon para-social bonds may be formed (Horton and Wohl, 1956)), and this may result in celebrities having a degree of influence on the choices and decisions made by young people; Simons (1993) attention economics.

The work of Mendick, Allen, Harvey and Ahmad: "The role of celebrity in young people's classed and gendered aspirations" (CelebYouth, 2014) raises interesting insights regarding the issues above, as pertinent to my doctoral research. The study was conducted in England, 2012-2014, and involved 148 secondary school students, aged 14-17 years, and through individual and group interviews, the researchers used how young people talked about celebrities (celebrity talk) as a vehicle to explore their own identity. Their work considers how this intersected with gender and social class. From the perspective of my research, this understanding is less critical; my participants had already chosen to continue with science, post-compulsory age, and were looking back at who/what had influenced their decision-making, attention was not drawn to their gender, ethnicity or social class. It will, however, have relevance in future research when engaging with children and young people looking to promote science pathways.

Identity work is defined as "the ongoing processes through which people come to understand their place in the world" (Allen and Mendick, 2015, p.16), recognising that it is not fixed and therefore can be shaped by the complexity of personal contexts and relationships; this may or may not include celebrity science culture. In essence, Mendick *et al*.'s research (CelebYouth, 2014) looked at "how ways of talking and knowing about celebrity (and individual celebrities) form some of the ways that young people think about themselves and others" (Allen and Mendick, 2015, p.16). Through their initial studies, twelve celebrities were found to generate the most discussion amongst participants and these were then used to focus subsequent stages of research; this list did not include a celebrity scientist. They noted that as young people talked about celebrities, and the work they did, they were "saying something about themselves, using celebrity talk to construct and perform an imagined future self in work" (p.17). Celebrity, then, was found to play a role in the way young people think about their future work.

It is not unusual for celebrity culture, however, to be referred to as a potential 'corrupting' influence on young people's aspirations by the media (Allen and Mendick, 2013a), and indeed even by politicians. For example, after the 2011 riots across England, the then Works and Pensions Secretary, Iain Duncan-Smith, blamed a "'get rich quick' celebrity culture exemplified by The X Factor and the dysfunctional lives of footballers as having created a society 'out of balance'" (Wintour and Lewis, 2011). This is contrary to the stance taken by Tony Blair (Webster, 2006), and subsequent policy makers and stakeholders in science education, advocating the need for more celebrity scientists to inspire young people to continue with science.

The website CelebYouth.org (CelebYouth, 2014) developed by Mendick and colleagues, in a section called 'Mythbusters', summarises and redresses some of these perceptions that people hold regarding young people and celebrity culture. The following insights are relevant in terms of celebrity scientist influence.

Firstly, one such myth raised is the danger that young people might want to be a celebrity rather than a scientist, however, Mendick *et al*. (CelebYouth, 2014) found that a general aspiration to becoming a celebrity was not the case, rather they aspired to a range of careers. Indeed some expressed doubt about a celebrity lifestyle, concerned about issues of privacy and pressures of appearance. They were not obsessed with celebrity culture, they did not want to marry a footballer, be a glamour model, or a Reality TV star (Allen and Mendick, 2013b; Allen, Harvey and Mendick, 2014). Their research also found that young people were not influenced more than older members of the public, nor was there a gender difference. Fame in itself, however, was not dismissed where it occurred as a reward of a successful career, where it was based upon recognition for achievements (CelebYouth, 2014). Indeed, people like Bill Gates, founder of 'Microsoft', one of the twelve celebrities underpinning their research, were described as 'deserving celebrities' (Mendick, Allen and Harvey, 2015), people who had achieved success for the 'right' reasons and through the 'right' routes, based on their intelligence, skills and passion; their fame and wealth were seen as "deserved by-products" (Mendick *et al.,* 2015, p.71).

Bill Gates was one of a number of celebrities who were grouped together into the specific genre, the 'geek celebrity'; these were from business and technological fields, and also included Richard Branson and Mark Zuckerman, admiring them for "their talent, innovation and wealth creation (Allen and Mendick, 2015, p.17). However, no women were included in this group and as such it was "aligned with masculinity, combining business success, celebrity status and geekiness" (Mendick, Allen and Harvey, 2016, p.204). Here there is resonance from the perspective of 'Science as an Institution' (Brake, 2010) and the issues of 'cleverness' and 'white, middle-class male scientists', discussed previously (Section 2.5.3). Mendick, Allen and Harvey (2016) argue that 'geek celebrity' is an emerging figure in young people's imaginations, as an aspirational and inspirational 'role model'; this is something to consider in future research when working with young people themselves.

In contrast to this, celebrities were described with derision if they were "devoid of effort or talent" (CelebYouth, 2014). The adjectives 'inauthentic', 'improper', and 'undeserving' were used to describe those celebrities who lacked talent, did not work hard, and became famous for nothing (Allen and Mendick, 2013b; Allen *et al.*, 2014; Mendick *et al.*, 2015). 'Celebrity chavs', or Reality TV stars in, for example, X Factor or Big Brother, were described as "lack[ing] moral and economic value" and achieved their celebrity status "through luck, manipulation or proximity to other celebrities" Allen and Mendick, 2013b, p.79). They wanted to feel that the success celebrities achieved was deserved and earned, and that they were doing a job that was valued by society and enjoyable. The notion of 'authenticity' was recognised as important, again reflecting the insights in 'Science as an Institution' (Brake, 2010), where when scientists engage with the public and young people, the science they present needs to be authentic.

Mendick *et al.* (2016) also found that their participants were critical of those who "earned excessive salaries, wasted their money and were too motivated by wealth" (p.212), however, they were highly regarded if they ‘gave back’ to society financially, through philanthropic work, with the proviso that again this was authentic and not just for publicity.

In terms of career aspirations, Allen and Mendick (2015) propose that “celebrity culture can provide a source that prompts young people to investigate careers of which they were not otherwise aware of or think were possible for ‘someone like me’” (p.17). This general view mirrors the science community’s approach to raising science aspirations, where avoiding young people seeing science as “not for me” (Jenkins and Nelson, 2005; DeWitt *et al.*, 2013a) is paramount. This sounds very positive, and reflects the notions of celebrity advocacy and marketing already discussed, however, Allen and Mendick (2015) warn that “celebrity culture is not an unproblematic resource within young people’s identity work” (p.18), in that, celebrity success stories have the potential to “close down” opportunities as well as “open up” (p.18); they assert, therefore, that the celebrities with whom young people will engage, are chosen carefully and critically, in the “pursuit of social justice” (p.18). Authenticity appears to be a key factor, resonating with insights from ‘Science as an Institution’ (Brake, 2010).

The next section takes this forward by considering the role of celebrity scientists themselves.

2.6.8 Influence of celebrity scientists

The notion of celebrities evoking an emotional response, and therefore having the potential to enhance the social standing of issues, persons, organizations, and movements, even if they are not favourable, is recognised (Giles and Maltby, 2004; Simonson, 2006; McKinnon *et al*., 2008; Boykoff and Goodman, 2009; Taylor Smith, 2012), and there is the potential for this to extend to celebrity scientists.

The media asserted a causal relationship between Brian Cox and the increase in the uptake of science by young people, post-compulsory age (Highfield, 2011; Townsend, 2011), however, there was limited empirical evidence to support this; most evidence is anecdotal, presented by the media, based essentially on evidence from television viewing figures, book sales, telescope sales, and attendance at festivals. As discussed in the introduction, in terms of entry to physics courses at university, yes, the number did increase, but was this as a result of the influence of Brian Cox? Joe Winters, Institute of Physics (Townsend, 2011), whilst acknowledging the lack of “hard evidence”, argues that anecdotally they were confident that Brian Cox had been a “major driver of increasing interest levels in the subject.” In addition, Professor Regan, a physicist at the University of Surrey, believed it may be true, suggesting that as a child he had no knowledge of science professions, therefore “having [him] on TV probably helps open people's eyes to that" (Falk, 2015). Brian Cox, in an interview with Falk (2015), believed that peer-reviewed research was necessary to determine the truth of the theory. Furthermore, Imran Khan, director of the Campaign for Science and Engineering in the UK (CaSE) was more pragmatic referring to the issue of timing (Falk, 2015). Acknowledging the increased uptake in science and maths, Khan draws attention to the fact that these young people needed the right GCSEs and 'A'-levels, and that these decisions were made four or five years previously. He argues that the science organisations and institutions involved in promoting science careers are not given due credit, and that it is dangerous to ascribe these changes to one person.

As previously discussed, empirical evidence is very limited. The Wellcome Trust report (Butt *et al*., 2010) acknowledges the rise of television scientists and science programmes, indicating that they may have helped some teachers provide different contexts for education that young people may be more familiar with, for example astronomy; the scientists themselves are not referred to. Interestingly, Rodd *et al*., (2013) note the potential existing in the imagination, and that this could be a television science presenter, referring explicitly to the "Brian Cox effect."

The final aspect of this literature review is to consider the role of the celebrity scientists themselves. For young people to continue with science, the development of their scientific literacy and raising of their science aspirations is essential. This leads to an exploration of the role that celebrity scientists themselves have to play.

Where are celebrity scientists currently seen?

There are a number of television and radio programmes presented or contributed to by scientists that have the potential to influence the general public's attitudes and behaviours towards ourselves and the natural world: for example, '*Embarrassing Bodies'*; '*Springwatch*'; '*Stargazing Live'*; '*Sky at Night'*; '*Dara Ó Briain's Science Club'*; and scientists are even seen on '*Countryfile*'. Radio programmes include '*The Infinite Monkey Cage'*; '*Life Scientific'*; '*In our time*'; and '*Inside Science'*. Table 2.2 highlights examples of science television programmes.

Scientists also present at book and science festivals, and like Brian Cox, conduct speaking tours. Real scientists can also be seen in fictional programmes, such as Big Bang Theory, as previously discussed. Does their presence add authenticity to the programme? Is this likely to influence uptake of science?

The question remains, do these celebrity scientists have an influence on young people? What do the scientists themselves have to say?

2.6.9 What do scientists say?

What follows are examples of what celebrity scientists themselves are saying about science in the media today, and their role within it. Their perceptions and insights are not taken from academic research, rather they are from 'grey' literature, that is, newspapers, magazines and popular radio and television programmes. In the absence of academic research, their perceptions and insights are intended to inform further development of the conceptual framework, and subsequent methodology, from the perspective of celebrity science culture.

Brian Cox, in an interview with Life Scientific (Al-Khalili, 2014) referred to the broad base of academics in public life, that they are part of the fabric of society, and that this should be celebrated: "*science is too important not to be part of popular culture.*" He acknowledged that there is a new kind of celebrity, a scientist, one that is "*snapped up by paparazzi*", aware that "*popular culture is a fickle thing*" but arguing "*why shouldn't we be … more important than footballers?*" He goes on to say that being an academic, teaching and researching, inspires people, and that universities should take this seriously, however, he warns that "*our job is not to produce 'cannon fodder' for the economy*," rather "*we want people to care about science*." Whilst acknowledging the importance of scientists in popular culture, Cox asserts that it is the science that is important, not the economy or the celebrity status. In Falk's (2015) biography, Brian Cox acknowledged that "*admissions into physics are going up at universities, so if that's true and I played a little part in it, then Brilliant!"* (p.207), but again he believed that peer-reviewed consensus is the way to determine whether the theory was correct.

Dara Ó Briain, although a comedian, and not a practicing scientist, has a Degree in mathematics and theoretical physics from University College Dublin. At the time of this interview in the Observer (Lewis, 2013), he was presenting three television franchises: 'Stargazing live' with Brian Cox, 'Dara Ó Briain: School of mathematics' with Marcus du Sautoy setting mathematics problems; and 'Dara Ó Briain's Science Club' with Mark Miodownik. Whilst he recognised that he was 'a big draw' for audiences and networks, he was keen to downplay his significance: "*My role is just as a conduit. I don't deserve to be included alongside people like Jim Al-Khalili and Alice Roberts, because I am not a scientist, I'm not presenting any work I've done.*" In the interview he commented on his stubborn refusal to talk down to viewers, to dumb down the science in a sense, referring to the negative notion of 'geek' now being the more positive 'geek chic'. Ó Briain suggested this was a golden age for science, with a new generation of communicators, such as Brian Cox and Alice Roberts. He referred to these scientists as passionate about their subject, and curious about each other's work, and "*just generally funny and nice people to talk to ... they actually know stuff. It's great*."

Alice Roberts, as the new President of the Association for Science Education (ASE), in an interview by the Times Higher Education (Elmes, 2014), suggested that science role models are important, and that the BBC has "*moved away from celebrities presenting science towards academics with broad expertise in various areas of science*." When asked what advice she would give to scientists and public engagement, she said that "*plenty of colleagues say they've found public engagement to be personally enriching, sometimes scientifically challenging, even to help spark new ideas*." Here, as well as benefitting the general public and young people, she was aware of a benefit for the scientists themselves. In an interview for Cotswold Life (Jarvis, 2010), talking about Cheltenham Science Festival, she explains that "*the festival is another way of giving people the tools to make decisions … I don't think people can be too informed or too engaged*." She was also very keen for young people to take up science, but not to specialise too early, because it *"encourages them to think of themselves as either scientific or creative – one or the other*", whereas, "*the best scientists are incredibly creative*." On her appointment as Professor of Public Engagement at Birmingham University, she was interviewed by the LSE Impact blog team (LSE, 2012). On describing her new role, she said that she hoped that her appointment would show that "*it's also acceptable to be an academic and be on television … it can be an incredibly powerful means of opening up those channels of communication – reaching out to a much wider audience than you might think*." She raised the importance of having a scientifically literate population, and that the best people to engage with the public are the scientists themselves. She was also asked about her involvement in the BBC production, 'Coast'; she described the importance of making science "*part of the mix, part of the culture of the series, rather than separating it out as a 'special case*'", referring to C.P. Snow and science and the arts being falsely separated. Furthermore, she was very clear that the programme did not 'dumb down' the science, technical language was explained, the presenters all had expert backgrounds, there were top experts in their fields as contributors, asserting "*that is essential – and that's why it's so important that universities don't disregard or denigrate television. As a medium it can be such a beautiful, visual way of disseminating science to a very wide audience indeed*." She is also aware of the value of new media, such as blogs and Twitter, as *"rapid and responsive means of sharing research and views."*

Alom Shaha, in his Guardian blog (Shaha, 2010), asks the question: "Where is the female Brian Cox?" Although his blog is focussing specifically on the lack of women scientists on television, he is aware of the power of ‘celebrity’. Whilst acknowledging that he is “*some kind of role model as well*”, he suspects that “*most of my students are more impressed by the fact that I am friends with Professor Brian Cox than anything else, [and that he is] … looking forward to the additional kudos I will get at school when my students realise that Mark Miodownik is a friend of mine*.” He also links the words ‘Golden Age’ with science on television, suggesting that “*the likes of Brian Cox, Jim Al-Khalili and Adam Rutherford are presenting some of the best science programmes ever made*.”

Jim Al-Khalili, when asked about his role (Davies, 2012), said: “*We stress the career benefits … but students are not mainly choosing the subject for vocational reasons, it is because it is fascinating*.” He said that applications for physics at Surrey had increased by 40%, and that candidates were citing Cox’s shows as their inspiration, as well as the Large Hadron Collider at CERN, and the television programme, ‘Big Bang Theory’.

Synthesising this information, they collectively believe that:

- science is in a ‘Golden Age’ of involvement with the media;
- science is a beautiful, creative subject;
- the scientists are engaging but it is the science that matters;
- public engagement is essential;
- there should be no ‘dumbing down’;
- science is inspiring as well as entertaining.

The following bullet point links with what I believe to be the most relevant quote for this research from Alice Roberts (LSE, 2012):

> *“I think that the enduring appeal and success of television documentaries shows that people really want this medium to inform and educate – as well as entertain. I think the main lesson for television producers is that they should never underestimate that desire for knowledge, nor underestimate the intelligence of viewers. As a member of the public, I enjoy being challenged by documentaries.”*

2.6.10 Part B: Summary

In summary, celebrity advocacy and endorsement are powerful and well established influences, and are recognised as an important part of young people's identity formation. The mechanism involves formation of emotional, para-social bonds. Celebrity non-scientists are recognised as influencing the general public in terms of scientific attitudes and behaviours, and the potential of celebrity scientists to influence young people is recognised. Whilst this might be true, the question still remains as to whether they influence young people's decision to continue with science, post-compulsory age, that is, as *per* the research question: Celebrity science culture: Young people's inspiration or entertainment?

2.7 Conclusion

This literature recombined with scoping study findings, enabled the final conceptual framework (Figure 2.1, p.69) to be established (Aim 3), and as such was used to underpin the methodology, including data analysis, interpretation and presentation of findings.

Methodological implications

Review of the literature and scoping study findings raised methodological implications for this research.

Age and experience of participants: The research projects reviewed (Butt *et al*., 2010; Ipsos MORI, 2013; Archer *et al*., 2013a; Kantar Public, 2017) were based upon student participants aged 10-18 years old, with limited delineation of those who had chosen to continue with science post-compulsory age. The exception was Strand 3 of the UPMAP project (Rodd *et al*., 2013), which studied undergraduates studying mathematics and physics-based programmes. In order to explore the role and influence of celebrity science and scientists on the uptake of science, this research includes only participants who had decided to continue with science, exploring who or what influenced these decisions.

Method: Review of literature highlighted studies that included narrative interviewing (Clandinin and Connelly, 2000; Bold, 2011), enabling detailed stories of participant influences to be collected. The work of Maltese and Tai (2010), Maltese *et al.*, (2014), and findings from the IRIS project (European Commission (2012), highlighted the importance of asking participants to recount their science stories, and to explicitly ask who/what influenced them to continue with science. This approach was also explored in the scoping study of this research, allowing implicit as well as explicit influences to be ascertained. However, the scoping study

Nature of science and scientists

- Scientific literacy: knowledge, understanding and scientific processes
- Scientific literacy: willingness to engage in science
- Scientific literacy: real contexts
- Science communication and engagement

Family and friends

- Family or friend’s personal interest
- Family or friend’s experiences of science
- Cultural influences and expectations
- Best interest of young person at heart
- Awareness of their potential, ability and interests

Influences on Young People

Personal interest

- Interest in science *per se*
- Transformational:
  - Wanting to make a difference
  - Wanting a career in science
- Utilitarian
- Success academically

Celebrity science and scientists

- Inspire to continue with science
- Raise awareness of opportunities within science
- Raise general interest in science
- Entertain

Science education

- Teacher interests, passion for science
- Teacher awareness of student’s potential, ability and interests
- Teacher knowledge of science careers
- School/university science curriculum
- School/university links with external science community

Figure 2.1 Final conceptual framework also highlighted the importance of semi-structured interviewing, in that data would have been missed without it (Appendix 2, Table 2). In addition, the work of Mendick *et al*. (CelebYouth, 2014) confirmed the importance of gaining participants' experiences and perceptions of celebrity *per se*, and to listen to the language and examples chosen to demonstrate this. This research, then, included a narrative biographical strand and semi-structured interviewing to explore both implicit and explicit influences.

Role of celebrity scientists: academic literature reviewed did not explore the role of celebrity scientists directly; their influence was alluded to. Furthermore, the insights and perceptions of celebrity scientists themselves were only available through 'grey' literature, in the form of newspaper and magazine articles, both paper-based and electronic, rather than empirical, academic data. In this research, then, celebrity scientists were invited to be participants, with a view to explicitly exploring what they perceive their role to be.

This is fully elucidated in Chapter 3. Methodology.

Chapter 3 Methodology

3.1 Introduction

Encompassing Kvale's (2007) metaphor of qualitative research being like a journey, and the interviewer a traveller, this chapter elucidates the philosophical, paradigmatic stances, and the practicalities of reaching the research destination. From reading this chapter, the reader might think that this was a straightforward, linear and logical journey, however, it was far from that, and, as such, I have tried to include some of the dead-ends and diversions along the way. However, in order for the reader to appreciate the integrity of this journey (Wellington, Bathmaker, Hunt, McCulloch and Sikes, 2012), and to be confident in the rigour of the processes described, it is presented logically, with one decision informing the next. The starting point was 'me', a positivist, objectivist researcher in oncology, travelling to a final destination as a social scientist. The destination for this study was as follows: The overarching approach was qualitative; epistemological and ontological paradigms were interpretivist and constructionist; and when considering the role of theory, the data was generally explored inductively, although deduction and abduction had a role to play. The research employed a multiple-case study framework, utilising qualitative interviewing to generate data; this encompassed a narrative biographical approach and semi-structured interviewing. Analysis and presentation utilised the conceptual framework and narrative approaches. The notion of 'bricolage' (Kincheloe, 2001; Kincheloe, 2005; Kincheloe *et al*., 2011) is a particularly helpful metaphor, as I describe how I have chosen and woven together a range of approaches to create a bespoke methodology and subsequent methods; one of the originality claims of this research.

3.2 Paradigmatic stance

Whilst all four aims were crucial, at the heart of the research question were two specific aims:

1. To explore the nature of the relationship between celebrity scientists and young people, and the uptake of science;
2. To explore the significant influences on young people's decisions to pursue a career in science.

To shed light on these, I wanted to capture the science memories and stories of young people: how and why they had chosen to engage with science? Were there any indicators from an early age? Who else was involved in this journey? Were celebrity scientists part of this journey? Essentially, I was looking for descriptive details of their influences, specific events in their lives, and particular experiences and perceptions of their social and cultural worlds that had informed this journey through science education. These ‘thick’ descriptions (Geertz, 1973; Flyvberg, 2011), elicited with the purpose of building explanations, could not be collected through any quantitative means, therefore the general orientation of my research, that is, the research strategy, was qualitative.

Of particular relevance for my research is the tendency of qualitative researchers to view social life in terms of processes. Pettigrew (1997, p.338) defines this as “a sequence of individual and collective events, actions and activities unfolding over time in context.” I wanted my participants to reflect on the processes leading to their decisions to continue with science, post-GCSE; in essence I wanted to show how events and patterns unfolded over time (Bryman, 2012).

The difference between quantitative and qualitative approaches are not simply about the presence or absence of quantification, there are fundamental differences in terms of epistemological and ontological perspectives, human nature and agency, and the role of theory (Lincoln *et al.*, 2011; Bryman, 2012). The paradigm thus adopted for my research approach depended, then, on the meta-theoretical assumptions that I held towards these in the context of the “nature of social science and the nature of society” (Burrell and Morgan, 1979, p.viii, reprinted 2016).

Epistemological Assumptions

Epistemology is the theory of knowledge, and epistemological assumptions are concerned with what constitutes acceptable knowledge (Lincoln *et al*., 2011; Green and Thorogood, 2014), not only in terms of the knowledge *per se*, but also in how it is communicated. This required justification of a particular epistemological stance: positivism or interpretivist.

According to Lofland, Snow, Anderson and Lofland (2006), the epistemology underlying qualitative research involves the central tenet that “face-to-face interaction is potentially the fullest condition for achieving intimate familiarity with the actions and orientations of other human beings” (p.15). At the level of epistemology, then, qualitative researchers are more influenced by interpretivism, looking to view events and the social world through the eyes of the people they study (Lincoln *et al*., 2011; Bryman, 2012; Green and Thorogood, 2014). This social world must be interpreted from the perspective of these people, believing that they are capable of their own reflections on their own social worlds. Here, I was looking to view the continuing uptake of science directly through the eyes of young people who had already embarked on this journey. From this perspective, by default, I am assuming that the young people have had free will, that they have had some choice in how they acted, able to choose their own career pathways; that is I am working from an anti-deterministic perspective. The determinist approach proposes that all behaviour is caused by preceding factors and is thus predictable (McLeod, 2013); the causal laws of determinism form the basis of science. I acknowledge, however, that there may be a ‘soft’ determinism, where people do have a choice, but this may be impacted on by biological or environmental pressure (McLeod, 2013). So that, for example, by belonging to a ‘science family’ (Archer *et al.,* 2012), with high science capital and habitus, choosing a science career may be an expectation.

As a former research scientist, I was familiar with working within a positivist epistemology, with an emphasis on objective, falsifiable, empirical data, and the notion that phenomena are observable only through experiment and confirmed by the senses (Bryman, 2012). The subjects of my previous research on bacteria and cancer cells did not “make sense of their place in the world”, as people do (Green and Thorogood, 2014, p.12). The perceptions and experiences of young people are clearly complex and inter-related, and whilst there is a place for viewing these objectively, in the field of psychology, for example, in this research I was looking for a more subjective account. I was not seeking a single ‘truth’, falsifiability was not required; I was not working within the hard science paradigm referred to by Lincoln *et al*., (2011), and as such a different epistemology was required. An interpretivist stance would allow the complexity and inter-relatedness to be captured through an “empathic understanding” (Bryman, 2012, p.28) where my understanding of social reality, that is the influences on young people to continue with science, is based on the understanding and interpretations of others, the young people themselves, acting within their social world (Bryman, 2012; Green and Thorogood, 2014).

Furthermore, a positivist approach includes a distinct separation between ‘researcher’ and ‘researched’, the ‘discrete dualism’ of the knower and known (Lincoln and Guba, 1985, p.37), whereas in this research I was seeking understanding through joint exploration with both sets of participants, the science students and celebrity scientists.

The question of meanings and values is also central to this discussion. The positivist ideal of value-free research is particularly untenable in a study involving perceptions and experiences: every aspect from the initial stimulus by the media, and choice of research question onwards, was inherently value-laden, including my position as a science teacher/educator.

This understanding led convincingly to an epistemological stance of interpretivism, where subjective understanding of experiences and perceptions was sought, and where interpretations were elicited and placed into the social reality framework. This subjectivity was also relevant when considering my ontological position.

Ontological Assumptions

Ontology is concerned with the nature of being, becoming, existence, or reality. My research is concerned with the nature of social reality pertaining to the influences on young people to continue with science. The ontological question here regarding social reality is two-fold: does it have an objective reality, external to the participants, beyond influence (objectivism), or is it socially constructed, produced through social interactions between individuals, and in a constant state of revision (constructionism)? (Blaikie, 2009; Lincoln *et al.,* 2011; Bryman, 2012). My ontological position of social reality from the perspective of the research question, was that things can change and develop, evolve, and are as such constructionist. With constructionism, social reality, as well as being socially constructed, is subjectively experienced (Lincoln *et al*., 2011; Bryman, 2012). From this position it was necessary to collect subjective accounts that explained how the world was experienced and constructed by the people who lived in it, at that time, in this case how their world of continued uptake of science, that is, their science journey, was experienced and perceived. Constructionism also suggests that the categories people construct to understand the natural and social world are also social products. Of further importance was the notion that social reality is the result of human thought expressed as language, that is, it displays a concern with the language that is employed to present categories in particular ways. It suggests that the social world and its categories are not external to us, but are built up and constituted in and through interaction. As Potter (1998, p.3) observed: 'The world … is constituted in one way or another as people talk it, write it and argue it." This is especially relevant when considering how data is generated, analysed and presented.

It is important at this point to clarify why this research was not objective in nature, especially as objectivism is a classic way of conceptualising organisations and cultures (Bryman, 2012), and clearly I was exploring the influence of specific organisations (schools and universities, scientific world) and cultures (celebrity science/scientists, family, peers, schools and universities culture of learning). However, instead of choosing to see organisations and cultures from this perspective, from a realist ontology where objective reality exists, that is outside the influence of actors/participants external to them, and is divisible into examinable parts (Guba and Lincoln, 1981; Guba and Lincoln, 1988), they were seen as emergent realities, in a constant state of change through the active participation of particular people (Strauss, Schatzman, Ehrich, Bucher, and Shabshin, 1973). It is based on a relativist ontology that a multiplicity of realities are constructed by people and exist through their perceptions (Guba and Lincoln, 1981; Guba and Lincoln, 1988). These realities are plural, personal, and that changing the individual changes the reality (Lincoln *et al*., 2011). Organisations and cultures may shape perspectives, but they are not inert objective realities that possess only a sense of constraint, and indeed, they are interpreted differently by different actors within them: they may act as points of reference, but they are always in the process of being formed (Strauss *et al*., 1973). This implies a sense of freedom as well as constraint in the internalisation of systems, beliefs and values, that is, they can be seen as constructionist in nature, and this was my stance.

Thus, the ontological paradigm adopted was constructionist, in that I was considering the ways in which social reality was an ongoing accomplishment of my participants, rather than something external and constraining.

Assumptions concerning human nature and agency

Assumptions concerning human nature and agency are essentially based upon the ways people are believed to be able to act in the world (Wellington *et al.*, 2012), that is, do they have choice, or are their actions predetermined? According to Wellington *et al.* (2012, p.103), "most people would probably put themselves somewhere in the middle", and this I believed to be true for my student participants, a soft-determinism, as discussed previously (McLeod, 2013). They had been able to make some choices in terms of subjects, but they were also possibly constrained by environmental factors, such as the breadth of subject choice, or indeed family expectations. In terms of social power and agency, the recognition that "the more [social power] you have, the more you can choose what to do" (Wellington *et al.,* 2012, p.103) is especially relevant to this research, in that by exploring how much they 'have', that is, their science capital (Archer *et al.,* 2013a), it was hoped to illuminate how this influenced their choices.

These assumptions had implications in terms of methodology and methods, in that if the actions of my student participants were believed to be predetermined, experiments would have been suitable, however, as I believe that they had been able to make choices, methods exploring their experiences and perceptions, seeking explanations and understanding were required (Wellington *et al.,* 2012). This further supported an interpretivist, social constructionist approach to data generation.

Role of Theory: Inductive, Deductive and Abductive approaches

When considering the role of theory, the fundamental philosophical question was whether I intended to test a theory, that is, a deductive approach where theory generates research, or to construct and develop theory, that is, inductive where the research generates theory (Bryman, 2012; Miles *et al*., 2014).

The research pathway was iterative, with movement between theory and data through the different phases, so that at times deductive approaches came to the fore, and others, inductive. An example of a deductive phase was the empirical scrutiny of the literature to initially 'test' the media's working hypothesis of the 'Brian Cox effect', and an example of an inductive phase was where the scoping study data was used to develop the conceptual framework. It was helpful, then, to think of inductive and deductive as "tendencies" rather than a hard-and-fast distinction (Bryman, 2012, p.27); they are not "mutually exclusive research procedures" (Miles *et al.*, 2014, p.238).

Moreover, my research paradigm can also be considered as being in line with abductive reasoning (Blaikie, 2009; Bryman, 2012). With abduction, the researcher "grounds social scientific accounts of social worlds in the perspectives and meanings of participants in those social worlds" (Bryman, 2012, p.709). Here, 'social world' refers to their experiences and perceptions of science education and celebrity influence. This was especially pertinent to how their data, the narrative accounts of this social world, was presented using narrative genres, so that having collected data in order to understood their social world, it must be presented from the participants' perspectives; the narratives produced "must not lose touch with the world as they see it" (Bryman, 2012, p.401). A key question will be: are the monologues and constructed dialogue authentic and plausible accounts that reflect participants' perspectives of their social world of science education and celebrity influence?

Overall, the general tendency was towards an inductive paradigm, distinguished by virtue of its reliance on explanation and understanding of my participants' perceptions, with the development and construction of theory.

In Summary

To summarise, an interpretivist, constructionist stance, and a belief that my participants had been able to choose their educational and career pathways, required methods that would allow understanding of the complexity and inter-relatedness of their experiences and perceptions. These methods would enable me to begin to construct a 'social world' from their perspectives, that is, an appreciation of the influences pertaining to continued uptake of science, alongside the role of, and relationship with, celebrity scientists. As empirical evidence was very limited, an interplay between deductive and inductive approaches was required to facilitate initial development of theory, and a working conceptual framework, so that this could be used inductively to construct and develop theory further. An abductive approach was required to ensure that the voices of the participants were established and maintained; this was also the role of the conceptual framework.

The research paradigms adopted prescribed methodological boundaries to my research, that is, they provided direction and guidance. Without them, methods can become “meaningless congeries of mindless choices and procedures” (Guba and Lincoln, 1988, p.114). The practical implications of this are explored below.

3.3 Research Design

Based on the paradigmatic stances outlined above, the next step was to establish the framework that would scaffold the elicitation of the unique experiences, memories, roles and perceptions of the participants.

In social science research, frameworks include: experimental and related designs; cross-sectional or survey design; longitudinal design; comparative design; and case study design (Blaikie, 2009; Bryman, 2012; Silverman, 2013). Decisions of appropriateness are based upon issues surrounding causality, generalisation, understanding behaviour in social contexts, and temporality (Bryman, 2012).

An interpretivist, constructionist paradigmatic stance ruled out experimental approaches in that they generally measure the impact of an initiative or policy, requiring manipulation of variables (Bryman, 2012). Although this research was considering the influence of celebrity scientists, and was inspired by the media asserting a causal relationship between celebrity scientists and the continued uptake of science, my intention was not to prove or disprove this assertion, in a quantifiable manner. As an essentially positivist, objectivist paradigm, this framework could not capture the complexity of decision-making, plus there would be ethical implications in terms of control groups. Qualitative approaches also exclude cross-sectional design, in that researchers collect quantitative or quantifiable data, from multiple cases at a single point in time, in order to elicit “patterns of association” (Bryman, 2012, p.58). They are known as nomothetic, in that they are concerned with “generating statements that apply regardless of time and place” (Bryman, 2012, p.69). Although I collected data from multiple cases, I was not seeking to generalise, rather, within a qualitative paradigm, I was seeking to collect the experiences and perceptions of participants to generate ‘thick’ descriptions (Geertz, 1973; Flyvberg, 2011). Longitudinal design was not relevant as it looks to map change over time; here data collected was historical, the participants were already scientists. Comparative design, which considers multiple contrasting cases, was also inappropriate: participants were selected on the basis that they had chosen to continue with science, post-compulsory age, they were not being compared to those who had not.

Case study design was the framework of choice, seeking to understand behaviour in social contexts (Bassey, 1999; Simons, 2009; Yin, 2009; Flyvberg, 2011; Bryman, 2012), and is explored below.

Case study framework

Simons (2009, p.21) defines case study as “an in-depth exploration from multiple perspectives of the complexity and uniqueness of a particular project … in a ‘real-life’ context … The primary purpose is to generate in-depth understanding of a specific topic.” Although it is acknowledged that all research could be considered to be a case study (Bryman, 2012), it is generally distinguished by its concern to elucidate the unique features of the case: an idiographic approach (Bryman, 2012). This was the intention of my research within an interpretivist, constructivist stance, to elicit the unique experiences and perceptions of science students and celebrity scientists, and to explore the complexity of this, within the context of the uptake of science.

The rationale for a case study approach is further supported by the understanding that its scope is “an empirical enquiry that

- *investigates a contemporary phenomenon in depth and within its real-life context, especially when*
- *the boundaries between phenomenon and context are not clearly evident.”*

(Yin, 2009, p.18)

The ‘contemporary phenomenon’ here was ‘celebrity influence’, in the context of ‘uptake of science’, and it was these localised boundaries that were being explored (Bassey, 1999). Celebrity influence regarding advertising and endorsement was an established paradigm (Giles and Maltby, 2004; Simonson, 2006; McKinnon *et al*., 2008; Boykoff and Goodman, 2009; Taylor Smith, 2012), whereas celebrity influence on the uptake of science was not; the boundaries were “not clearly evident” (Yin, 2009, p.18).

In addition, an important strength of case study is that it has the potential to involve participants in the research process itself, recognizing the value of co-constructing data; also important in a narrative approach (Simons, 2009; Flyvberg, 2011). This essentially shifts the power base, and enables the researcher to take a "self-reflexive approach to understanding the case and themselves" (Simons, 2009, p.23); important in this research in terms of eliciting key influences. Moreover, through the use of accessible language, vignettes, cameos, and direct observations, for example, audiences of case study reports can "vicariously experience" (Simons, 2009, p.23) what was observed and utilize their tacit knowledge in understanding its significance. And indeed, data collected was presented as monologues and a constructed dialogue to allow the reader to "vicariously experience" (Simons, 2009, p.23) the stories and perceptions of my participants, and so appreciate the complexity and significance of their experiences and insights.

Considerations of a case study framework

In terms of rigour, it is important to consider the implications of a case study framework on generalisability, participant selection and choice of specific methods.

Generalisability

A standard criticism of case study research is the issue of generalisability or external validation (Simons, 2009; Flyvberg, 2011; Bryman, 2012). Clearly, from the perspective of theory creation or 'statistical generalization' (Yin, 2009), generalisation from a single case is not possible, and even if a number of cases are used, similarities and differences cannot easily be established; each case will have unique aspects, even if typical traits are evident (Blaikie, 2009; Bryman, 2012). However, Aims 3 and 4 of this research require that findings are generalised in some form in order to develop both a conceptual framework as a working tool for exploring influences and relationships (Aim 3), and a theoretical framework to enable dissemination to stakeholders with a view to informing policy and practice (Aim 4).

The perspectives of different scholars in the field have been helpful here and are summarised as follows. Bryman (2012, p.50) suggests that the crucial question is not whether the findings can be generalised but "how well the researcher generates theory out of the findings." This is akin to Yin's (2009) 'analytic generalization', where theory provides the link between cases. In addition, Williams (2000) asserts that generalisations are supported by referring to the findings of other researchers.

Stake (1995) describes three different types of generalisation in case study: petite, where generalisations are made between very similar situations; naturalistic, which are based upon rich understanding of the context and to enable application; and grand, akin to the positivist, objectivist generalisations of the natural sciences.

Lincoln and Guba (1985) refer to ‘transferability’, also highlighting the importance of contexts, advocating that sufficient information of the context is provided so that the audience can judge the relevance of findings to another context. This resonates with what Bassey (1981, p.85) calls ‘relatability’, where researchers provide ‘thick descriptions’ (Geertz, 1973; Flyvberg, 2011) of their cases, again to enable others to make decisions. Similarly, Simons (2009, p.24) refers to Stake’s (1995) ‘particularisation’, where the researcher presents a “rich portrayal of a single setting to inform practice, establish the value of the case and/or add to knowledge of a specific topic. Naturalistic generalisation (Stake, 1995) is key here, so that the context of the research sample needed to be explicit and articulated clearly, supporting the reader in seeing how the findings could be applied outside of this research.

This understanding of generalisability informed the research design, aware that “the strategic choice of case may greatly add to the generalisability of a case study” (Flyvberg, 2011, p.304). By seeking to explore the complexity and uniqueness of my participants’ experiences and perceptions, with the intention of providing in-depth elucidation of how these influenced science aspirations, the following decisions were made:

- Information on contexts included: the education phase of the student participants, and a brief biography of the celebrity scientists;
- ‘Thick’ descriptions (Geertz, 1973; Flyvberg, 2011) are provided by: recording the interviews and transcribing them verbatim; using the conceptual framework to analyse data collected; and by ensuring that all quotations used in the monologues and constructed dialogue can be traced back to the original transcript;
- Each participant would be considered as a single case, a ‘single setting’, that is, a focus of interest in their own right. This research, then, can be seen as a multiple case study;
- Participants would be selected according to the ‘typical’ strands of phase of education (students), and a presence in the media (celebrity scientists) as well as acknowledging their uniqueness;

- The conceptual framework would underpin data collection, analysis and presentation, in order to draw the typical strands together, whilst at the same time enabling outlying data to be collated;
- Findings would be critiqued against research in the field, that is, theory will provide a link between the cases and the findings of other researchers;
- Respondent validation will play a key role in supporting trustworthiness and authenticity of the data. All participants will be given: a copy of their recording; the verbatim transcript; a section of one of the monologues or constructed dialogue as an example of how data is being presented. Participants will be invited to add to or remove any data, from their personal transcripts.

3.4 Research method

How does this translate into specific methods for data collection, analysis and presentation? From the perspective of the multiple-case study framework, it is recognised that it is not "constrained by method", whatever is most appropriate is used (Simons, 2009, p.23), however, decisions must be made knowledgably. In the context of the research question: "Celebrity science culture: Young people's inspiration or entertainment?", I was looking to see if celebrity scientists played a part in influencing a young person's decision to continue with science, that is, were they part of how they made sense of their life story.

Bryman (2012, p.472) suggests that researchers ask themselves, "What do I need to know in order to answer each of the research questions I'm interested in?"; in this case, how do I capture the role played by celebrity scientists in the lives of young people? The specific research objectives are helpful here:

1. To explore who or what influences young people to continue with science;
2. To explore how young people feel about the media and celebrity culture generally, and celebrity scientists specifically;
3. To explore the perceptions of celebrity scientists on their individual roles and influences, and those of celebrity scientists in general.

This first could have been addressed by simply asking the students outright, however, as I believed that it was unlikely that the notion of celebrity scientist influence would arise, I needed a method that would allow any influence to be elicited naturally, if indeed there had been any influence. Furthermore, I did not want to put the notion of celebrity scientist influence into the student participant's consciousness until I had explicitly elicited their individual influences.

Allowing the students to recount their memories of their science journey was considered to be a viable means of capturing this knowledge, specifically listening for celebrity scientist influence. Simons (2009, p.4) refers to the 'authenticated anecdote' which "captures the idiosyncrasy of the particular, the need to provide evidence (an unauthenticated fragment will not do) and the inherent story-telling potential in the case study approach."

Objectives 2 and 3 focus the research onto the perceptions and insights surrounding the role of celebrity scientists and their influence on the uptake of science. Direct questioning was appropriate, including directly asking the participants if they themselves had been influenced by celebrity scientists.

The research explores the experiences and perceptions of students and celebrity scientists regarding the influences that underpin continued uptake of science, and their thoughts about the role that celebrity scientists may play, or indeed have played, to promote science and science careers. Methods were required, then, that would allow both implicit and explicit influences to be elicited, and that would allow meaning-making. Collecting the stories of lived science experiences of the student participants, alongside direct questioning to elicit their perceptions of celebrity science culture, would accomplish this. The insights of celebrity scientist participants would also enable an exploration of how they may be effectively 'used' to model and define what it means to be a scientist. The underlying question is: What can we learn from each other's unique perspective? This required the prudent choice of cases to exemplify the phenomenon in question.

In summary, this bricolaged framework of an interpretative, constructionist paradigmatic stance, and multiple case study approach, provided the basis for the choice and design of the bespoke research method employed in this study, that is, qualitative interviewing encompassing narrative enquiry and subsequent semi-structured interviewing. I was seeking to explore the complexity and uniqueness of each of my participants and their perceptions of celebrity scientists, through detailed and rigorous analysis using the conceptual framework, via these multiple perspectives of narrative inquiry and semi-structured interviews, with the intention of providing in-depth elucidation of how their experiences and perceptions have influenced decision-making. This is explored below.

3.4.1 Qualitative interviewing

Qualitative interviewing is concerned with understanding social phenomena from the perspective of those involved (Rubin and Rubin, 2005; Kvale, 2007; Edwards and Holland, 2013). It is based on conversation, and whilst its "structure and purpose" is determined by the interviewer (Kvale, 2007, p.7), the emphasis is on the participant's viewpoint, allowing them to share what they perceive as relevant to the conversation, even if that means moving off the interview schedule. Flexibility is key, if the researcher is to elicit "rich, detailed answers" (Bryman, 2012, p.470).

Mason (2002) lists the strengths of qualitative interviewing as being able to explore:

1. the texture and weave of everyday life;
2. the understandings, experiences and imaginings of research participants;
3. how social processes, institutions, discourses or relationships work; and
4. the significance of the meanings they generate.

These link directly with the focus of this research, in that both celebrity culture and young people choosing careers are aspects of everyday life (1); the focus is to explore science memories and influences, and the perceptions held towards celebrity scientists (2); it explores how families and friends, schools and universities, and the notion of celebrity culture, influence career pathways (3); and to allow participants to make sense of their journeys (4).

Nevertheless, there are challenges as qualitative interviewing has been criticised as being: "anecdotal, illustrative, descriptive, lacks rigour, is unsystematic, biased, impossible to replicate, and not generalizable" (Edwards and Holland, 2013, p.91). These have been discussed previously within the case study framework, however, it is important to reiterate that my research process must be made as transparent as possible, and rigour ensured through a systematic approach. This includes explicitly focussing on reflexivity, and the potential for researcher bias (Alvesson and Sköldberg, 2009; Cousin, 2010; Etherington, 2013). Qualitative interviewing must also be underpinned by a strong philosophical and paradigmatic position (Kvale, 2007), as is the case in this research.

Within this qualitative interviewing approach, two specific methods were required: one to elicit the science stories and influences of the student participants, and another to elicit the perceptions of the role and influence of celebrity scientists, of both the students and celebrity scientist participants. These methods were an initial narrative biographical approach (for the science students) and semi-structured interviewing of all participants; the rationale for why these were the most theoretically resonant is considered below.

3.4.2 Narrative biographical approach

Acknowledging the “story-telling potential” (Simons, 2009, p.4) of a case study framework, a narrative biographical approach to part of the data collection process was taken; narrative approaches also underpinned data analysis and presentation, and these are considered in Chapter 4. As narrative inquiry is recognised as a contested, complex field in which there are no fixed definitions, meaning and practices (Sikes and Gale, 2006; Squire, 2008; Chase, 2011), I needed to engage with these approaches in order to design and apply the most appropriate method for my research. What follows is the rationale and theoretical underpinning for this choice of method, highlighting the issues to be considered.

Narrative inquiry is qualitative research that uses and tells stories (Polkinghorne, 1988; Clandinin and Connelly, 2000; Elliott, 2005; Sikes and Gale, 2006; Bold, 2011), taking the story itself as the focus of exploration (Riessman, 2003). It is case-centred (Riessman, 2002), and these cases can illuminate complex phenomena and relationships between people, events, and outcomes (Shulman, 1986; Clandinin and Connelly, 2000; Goldenberg, 2004; Sikes and Gale, 2006); in relation to my research, exploring the influences on young people to continue with science, including celebrity scientists.

It is based on the premise that people organise their experiences of the world into narratives, and tell a story in which they and others are characters (Connelly and Clandinin, 1990; Moen, 2006; Hardy, Gregory and Ramjeet, 2009). Gubrium and Holstein (1998, p.166) refer to these as “texts of experience.” Narrative methods do not usually set out to test a hypothesis (Riessman, 1993), rather they tend to begin with “experience as lived and told in stories” (Clandinin and Connelly, 2000, p.128), and this is what I was looking for. Dewey (1938) described experience as being personal and social, asserting that people must be understood in terms of their relationships and social context; the notion of context is very important and has been raised previously in terms of generalisability.

By eliciting the science stories of the student participants, the narrative biographical approach was a way of understanding how their experiences and influences informed their career subject choices (Clandinin and Connelly, 2000; Sikes and Gale, 2006), especially as experiences grow out of other experiences and lead to future experiences (Dewey, 1938). This is essentially ‘meaning-making’ or ‘sense-making, exploring why something happened and its impact (Hinchman and Hinchman, 1997; Elliot, 2005; Sikes and Gale, 2006; De Fina and Georgakopoulou, 2012). Indeed, Flory and Iglesias (2010) call them ‘looking back products’ constructed to make sense of life, and Polkinghorne (1988) goes as far as stating that narrative is regarded as the primary scheme by which human existence is rendered meaningful.

Considerations

A consideration with narrative inquiry is that there is no specific guidance regarding "suitable materials or modes of investigation, or the best level at which to study stories" (Andrews, Squire and Tamboukou, 2008, p.1); the challenge, then, was to design and justify my particular approach (Bold, 2011). Specifically, in this study, it was 'experience-centred' (Squire, 2008), in that it focusses on making meaning from the stories told. This assumes that narratives are "sequential (in time) and meaningful; are definitively human; 're-present' experience, reconstituting it, as well as expressing it; and display transformation or change" (Squire, 2008, p.42). This was what I was looking for from my participants: the unfolding of their science journey overtime.

Having said that, elements of an 'event-centred' approach (Labov, 1972) will be present, in that participants will be asked to tell their stories chronologically. However, rather than their stories representing events, I was looking to make meaning of their experiences as they pertain to the continued uptake of science; that is, they are defined by theme rather than structure (Squire, 2008). Interestingly, they may go beyond past-tense narrating to include present and future stories (Squire, 2008), potentially relevant as by reflecting on their science pathway so far, they may look ahead to future possibilities.

Narrative approaches are important in terms of identity and a sense of self (Holland, Lachicotte, Skinner and Cain, 1989; Bold, 2011), and indeed our stories help us to understand ourselves (Andrews *et al.,* 2008; Bold, 2011). By eliciting their influences, participants had the opportunity to understand how and why they had pursued their science careers so far; they would potentially see the complexity for themselves. Furthermore, when interviewed, the participants were still in the midst of their stories and experiences; their journey had not ended. Bold's (2011, p.23) notion of "narrative as transformation" was acknowledged, in that, future decisions could be influenced by recounting their stories. As all participants had self-identified as scientists, this was unlikely to be an issue. Nevertheless, the ethical decision was made not to engage in conversation with the students about potential career opportunities.

The stories participants tell are multivoiced (Polkinghorne, 1988), consisting of the "micro/macro narratives" (Andrews, 2012) of, for example, friends, parents, teachers. This 'multivoicedness' (Polkinghorne, 1988) results in multiple stories occurring simultaneously in the lives of participants, which cannot be separated from their context and social relationships (Mishler, 1991; Elliott, 2005; Moen, 2006; Squire, 2008; Kear, 2012). This has implications for the interview process, recognising that we take our audience into consideration and adapt what we say and how we say it accordingly (Denzin 1989; Hinchman and Hinchman, 1997; Elliott, 2005); if participants were to tell the same story to a parent or friend, it was likely to be different. Asking participants to share their stories and their experiences and perceptions required trust and respect for all involved (Clandinin and Connelly, 2000; Glesne, 2011).

When conducting narrative biographical interviews, the notion of co-construction of the narrative is important (Andrews *et al*., 2008; Bold, 2011). During an interview, both parties are involved in determining story development and negotiating meaning (Mishler, 1991; Squire, 2008). Squire (2008) asserts that the researcher needs to be strategic in their approach. Processes, therefore, needed to be in place to avoid unwittingly influencing the content of the narrative, and potentially place more emphasis on certain influences. To mitigate issues of memory affecting our interpretation of events over time (Bold, 2011), and to limit my need to intervene and prompt, student participants knew in advance that they would be asked to tell me their science story and who/what influenced their decision to continue with science. I structured the interview so that my participants were able to share their experiences and perspectives and perceptions without interruption; guidance was given prior to the interview in order that they could prepare fully. During the interview, subsidiary questions were used to clarify points made, and to explicitly ask the participants to affirm who or what had been their key influences. As Riessman (1993), I wanted to collect the stories that emerged naturally by allowing participants to take responsibility for what they wanted to tell. I was conscious of not interrupting participants so as not to disrupt the opportunity for narratives to emerge naturally from conversations (Elliott, 2005).

In summary, it can be seen that narrative is not "an objective reconstruction of life – it is a rendition of how it is perceived" (Webster and Mertova, 2007, p.3); it is tentative and cannot provide certainties (Polkinghorne, 1988; Elliott, 2005; Bold, 2011). Bold (2011, p.31) argues that "the point in time and the context in which the narrative is collected serve to make it unique." So that, according to Squire (2008), narrative inquiry is "almost always subjectively true", of meaning to the person telling it. The stories that I would elicit, then, would represent one version of truth, and furthermore, would be shaped by how I interpreted and presented their stories (Kincheloe, 2005, Van Niekerk and Savin-Baden, 2010; Bold, 2011).

3.4.3 Semi-structured interviews

With semi-structured interviews, the researcher has a list of questions, but there is flexibility in how and when they are asked; responses can be pursued, so that a dialogue may ensue (Gillham, 2005; Kvale, 2007; Bryman, 2012). They allow space for participants to respond in their own way, but they also offer some structure against which the responses of different participants can be compared (Bryman, 2012; Edwards and Holland, 2013).

Quality interviewing requires a quality interviewer. Kvale (2007) offers a list of characteristics of a quality interview which includes active listening, flexibility and being non-judgemental, whilst Bryman (2012) adds being balanced and ethically sensitive. My response was to ensure that my positionality did not influence the responses collected, and to treat participants with respect and dignity (Birch and Miller, 2002; Etherington, 2004; Josselson, 2007; Duncan and Watson, 2011). These are considered more fully in 'Ethics and Reflexivity', section 3.5.

Qualitative researchers generally agree that interview questions need to be open-ended (Elliott, 2005; Merriam, 2009; Glesne, 2011). As such the interview schedule included different types of question, including direct, probing and interpreting (Kvale, 2007; Bryman, 2012), to draw out insights, perceptions and feelings about the role and influence of celebrity scientists. Questions were ordered so that they flowed well, framed using everyday and common language that was comprehensible and relevant to the participants (Elliot, 2005; Merriam, 2009; Glesne, 2011).

Phase 2: Student participants

For student participants, following the narrative biographical phase, the interview moved towards a semi-structured interview format considering the nature of science, the notion of celebrity *per se*, participants' experiences and perceptions of the role and influence of celebrity scientists, and their perceptions of the 'Brian Cox effect.' The semi-structured interview was structured to avoid students knowing the focus on celebrity scientists from the outset. I did not want student participants to know the focus of the research until part way through the interview, therefore, the order of questions was in strict order.

As with all research, the notions of power and emotional dynamics were important here, and therefore the interviews took place in a setting in which I hoped the participants would feel comfortable; it is recognised that a sense of rapport would be beneficial to the interview (Edwards and Holland, 2013). Nevertheless, it is acknowledged that there were asymmetries of power; I, as the interviewer, was defining the interview context, the questions and the course of the interview (Gillham, 2005; Kvale, 2007). This is explored more fully in the ‘Ethics and Reflexivity’ section 3.5 below.

Phase 3: Celebrity scientist participants

For the celebrity scientist participants, the interview was entirely semi-structured. The celebrity scientists received the interview schedule prior to interview, and to some degree the interviews were intended to be a conversation with the questions as prompts.

From my personal perspective, the power and emotional dynamics of interviewing were especially relevant as I interviewed members of an elite group, that is, celebrity scientists. In order to minimise this status imbalance (Gillham, 2005; Kvale, 2007; Edwards and Holland, 2013), I ensured that I was well-prepared, that I knew their background and research interests, and their activities in the media. I kept a professional but friendly persona. I wanted to position myself as someone who could be considered equal in terms of situated knowledge (Edwards and Holland, 2013). The advantage was that these people were used to being interviewed, and familiar with being asked their opinion (Kvale, 2007).

3.5 Ethics and Reflexivity

3.5.1 Statement of Ethics

The ethical statement is “a thoughtful reflection on the real impact of the research on the lives of people and their situations”; it is “not simply a declaration that permissions have been sought and granted” (Bold, 2011, p.70). The notions of respect and responsibility are paramount (Birch and Miller, 2002; Duncan and Watson, 2011), with the promotion of benefits (beneficence), and the reduction of harm (maleficence) as key ethical tenets (Kvale, 2007; Bold, 2011).

Participants voluntarily agree to ‘give away’ their data to the researcher, and it is the researcher’s obligation to treat participants respectfully. Indeed, Josselson (2007) asserts that researchers have an ethical duty to protect the privacy and dignity of participants; as Miles *et al*. (2014, p.56) implore: “First, do no harm.” With narrative approaches, the researcher and participants construct understanding together, and, therefore, ethics can be thought of in terms of relational matters (Clandinin and Connelly, 2000; Cohen *et al*., 2007). In this research, moral relationships in terms of harm, respect and duty towards others, but also social relationships, where creating a new body of knowledge has the potential to improve the social world, come to the fore (Bold, 2011). Simons (2009, p.97) refers to “relational ethics”, where awareness of potential harm and the potential of the research process to “contribute positively to participants’ experience” are drawn together. Through this relational approach to ethics, it was not only my intention to limit potential harm, I also intended that this research would 'do some good', that is, both maleficence and beneficence were paramount in my thinking.

Ethical guidelines

Encouraging respondents to become more active participants in the research process, especially the narrative approach, where they were able to share what they believed to be the most important aspects of their science journey, did not automatically result in a more ethical methodology and indeed required a greater sensitivity to the ethical issues raised (Elliott, 2005). The "openness and intimacy" of qualitative research can be "seductive", potentially leading participants to divulge information they may later regret (Kvale and Brinkmann, 2009, p.73), such that the potential for exploitation was just as great as it would have been in structured interviews and survey approaches.

Throughout this research, then, I was cognisant of the ethical responsibilities towards all the participants, which were undertaken with due consideration, working within the University of Derby's 'Research Ethics: Code of Practice' (2013) and the British Educational Research Association's (BERA) (2018). The main areas of ethical concerns in this research related to:

- Positionality of the researcher (considered in Reflexivity, section 3.5.2);
- Access to participants;
- Beneficence and maleficence to participants;
- Informed consent; invasion of privacy – anonymity and confidentiality;
- Potential impact on the context or to others in the context;
- Storing data;
- Reporting outcomes (representing participants' voices).

(Etherington, 2004; Elliott, 2005; Kvale, 2007; Duncan and Watson, 2010; Bryman, 2012)

The ethical approval process included developing a propensity towards understanding the needs of the participants; it did not stop when approval had been granted by the University of Derby Ethics Committee, it was a continuous process throughout the research.

Ethical considerations (see Appendices 4 and 5, Ethical Approval documentation)

Access to participants: A statement was provided outlining the research intentions, including the purpose and process of the research (Clandinin and Connelly, 2000; Elliott, 2005). It explained why participation was necessary, why it was beneficial, how it was to be used, and how and to whom it was going to be reported. Participatory ethics generally focusses on identifying a suitable sample and considering whether participants can find the time or personal resources to engage effectively in the research (Bold, 2011). With the science student participants, it was important that they did not feel pressurised by their Head of Sixth Form, or University Programme Leaders; to this end, following receipt of my invitation to participate, they were asked to self-refer. For the celebrity scientists, participatory ethics was especially relevant in the case of identifying a suitable sample. As well as time or a willingness to engage with the research, the issue of access was complex; celebrities protect their privacy. Nevertheless, a strategy was formed (see 3.6 Data collection) and agreement from five celebrity scientists was gained.

Beneficence of this research was primarily to allow student participants to engage with their science journey, and to reflect and explore the nature of the influences that informed that journey. By exploring their perceptions of the role of celebrity scientists, they had the potential to inform future policy thus impacting on the opportunities made available to other children and young people. For celebrity scientists the beneficence was primarily to give them a ‘voice’ regarding their role and influence on the uptake of science by young people, post-GCSE. This allowed comparison with the perceptions of the science students, with a view to informing the way they work with young people and schools.

In terms of maleficence, student participants may have been reflecting on an area of their lives not explicitly thought about before (Elliott, 2005), and even though the focus was not of a sensitive nature, once they were given the opportunity to talk about their experiences and feelings, some unexpected negative accounts, as well as positives, may have emerged. If something of a personal nature had been disclosed, raising a safeguarding issue, correct procedures were in place (DfE, 2018), and a statement was included in the consent form relating to the researcher’s need to breach confidentiality (BERA, 2018). I am highly experienced in terms of safeguarding and child protection, and am Disclosure and Barring Service (DBS) checked. There was also the potential that participants may benefit from being able to talk about themselves, especially if they felt that the research was worthwhile, however, it was difficult to predict in advance what issues might arise (Elliott, 2005). There was potential for the research to be a transformative experience, for example, influencing future decision-making into specific science careers; the research statement clarified that this was not the intention (Elliott, 2005). In addition, a scoping study was used to consider issues such as time commitment and appropriateness of questions. As an outsider researcher, I had no authority over the participants, and as such posed no threat; I was also not in a position to offer advice. Any indication of discomfort and the interview would be stopped.

Informed consent: Smythe and Murray (2000) suggest that consent is an ongoing process throughout the research, therefore, participants were assured of their right to withdraw prior to final integration of the data and dissemination; a final date was given. Permission to contact the school students was granted by the Headteacher of the school, and the invitation to participate was disseminated by the Head of Sixth Form. University students were contacted via their Programme Leaders. Consent was granted by the individual participants as all were aged seventeen plus.

Confidentiality: Student participants were assured that interviews were confidential and that measures would be taken to ensure that they would not be identifiable following dissemination, however, because there was the possibility that they may be identifiable by those who know them, even if details were changed and a pseudonym used, dissemination of the research was discussed with the participants involved (Elliott, 2005). Use of direct quotations required prior consent from the participants, and I remained alert to issues participants wanted to keep confidential. From the perspective of the celebrity scientists, it was desirable that data collected could be attributed to the individual scientists, recognising that it would be very difficult to ensure that participants were not identifiable, if anonymity was requested. Therefore, consent to attribute data, including direct quotations, was requested. The safeguards of respondent validation of transcripts, and discussion regarding dissemination of the research took place in order to protect their privacy and to ensure that their views were accurately represented.

Potential impact on the context or to others in the context: During the interviews, participants may have described other people, potentially affecting relationships post-dissemination. As I had a responsibility to protect these people as well as the participants (Clandinin and Connelly, 2000), I retained the right to censor and anonymise those referred to.

Storing data: Data was stored securely in order to uphold the ethical tenets of respect and responsibility (Bold, 2011). Ethical issues arise from the harm that might occur should the materials be misappropriated or misused in some way (Bold, 2011). In order to protect the privacy and dignity of participants (Birch and Miller, 2002; Josselson, 2007), data was stored in accordance with the Data Protection Act (2018) and GDPR regulations (European Commission, 2018). A password protected USB stick was used to store mp3 files and transcripts, monologues and constructed dialogue, and consent forms were stored in a locked filing cabinet. Only I had access to the raw data.

Reporting outcomes (representing participants' voices): Personal narratives are linked to personal identity (Elliott, 2005), therefore, interpretation and analysis must be performed with integrity (BERA, 2018). Researcher bias was acknowledged and every effort was made to accurately portray the data. Respondent validation of transcripts took place, and they retained the right to edit or expand their data prior to final integration and dissemination. Transparency of my approach was essential: participants needed to know not only the purpose of my research, and what I intended to do with it, but also to be reassured that the story I was telling was the one that they wanted to tell (Bold, 2011).

In summary

Ethical considerations for this specific case study research, in line with recommended guidelines were:

- My positionality was explicit;
- The participants were informed of the purpose and beneficence of the research;
- Informed consent was gained from each person interviewed;
- Interview transcripts: Student participant transcripts were anonymised and remained confidential; celebrity scientist participants' transcripts were not anonymised, however, attention was paid to those statements requested to be kept confidential;
- Participants had opportunity to review their transcripts and extracts from the monologues and constructed dialogue;
- Inclusion of direct quotations required explicit permission of the participant;

(Connelly and Clandinin, 2000; Elliott, 2005; Kvale and Brinkmann, 2009; Simons, 2009; Duncan and Watson, 2010; Bold, 2011)

With respect and responsibility in mind, I believe that I "adopt[ed] a sensitive approach" (Bold, 2011, p.66) throughout the processes of data collection, analysis and presentation described below (Section 3.6), to ensure participants were not harmed, and that through this rigorous approach an account was produced that did not lend itself to misinterpretation (Bold, 2011). There was a high level of transparency.

3.5.2 Reflexivity

As a positivist researcher, I was very familiar with the notion of ‘reflective’ practice, a *post facto* process, where evidence is analysed before taking the next step; as an oncologist, for example, this might have been the success or failure of oncogenic drugs. It is future-focussed but remains connected to completed stages (Bryman, 2012). Social researchers, using qualitative methods on the other hand, focus on reflexivity; here the ‘self’ is more transparent (Etherington, 2004). As with reflection, this is also proactive; it is a process of introspection which raises the researcher’s awareness of their assumptions and biases, in order to monitor their impact on the research process and outcome. It is more than a simple acknowledgement of its influence.

In practice, this reflexivity was not only about the implications of my assumptions, biases and decisions, but also on how I interpreted the data collected, that is, it impacted on the knowledge and understanding of the social world that I was generating (Bryman, 2012). Alvesson and Sköldberg (2009) refer to reflexive interpretation, and the importance of a self-critical eye during the process of interpretation and authorship. I needed to interpret my own interpretations, and look at my own perspectives, in order to avoid my authorship “silencing the voices of others” (Alvesson and Sköldberg, 2009, p.199).

A key tenet of reflexivity then is that it informs interaction with participants before the researcher and participants react to each other. Interestingly, it is also an exploration of how participants impact on the researcher, so that “You learn about yourself … as well as the case” (Simons, 2009, p.4). Thus the trustworthiness of the findings and outcomes of the research is enhanced (Etherington, 2004).

Reflexive considerations:

Positionality: As a reflexive practitioner, I needed to ask myself how I might influence the research at all stages of the process (Yow, 1997; Alvesson and Sköldberg, 2009; Cousin, 2010). Having acknowledged my subjectivity, I collected and analysed data with this position accounted for (Bold, 2011).

The first step was to make my positionality explicit in terms of personal predilections, interests and my background as a scientist and science teacher/educator (Etherington, 2004; Wellington *et al*., 2012). Indeed, my motive for starting this research emerged from my interests and experiences, so that “stories of us are with us as we move from field to field text to research text” (Clandinin and Connelly, 2000, p.177); this was very much the case for me.

Narrative research emphasizes the importance of the researcher exploring their own personal narratives (Clandinin and Connelly, 2000; Phillion, 2002), and in order to be cognizant of the potential tensions between my experiences and those of my participants, that is what I did: I wrote my own science story, discerned my own assumptions of celebrity scientist influence, and reflected on how these experiences and perceptions compared with those of my participants (see Appendix 1). This clarity provided me with a strong basis on which to design and conduct rigorous work that I could justify, and which would stand up to scrutiny (Wellington *et al*., 2012).

Intersubjectivity: Alongside my personal subjectivity, I was also aware of monitoring my intersubjectivity. I was conscious of not only my own bias, but also that of my participants and how our interactions might impact the research process and data generated (Glesne, 2011). I therefore asked each participant if there was anything else they wanted to say that we had not discussed; I was interested to see if there was something that I had missed in my literature review and interview processes.

Participant reactivity: The responses of my participants are likely to be affected by the characteristics of me as the researcher. They knew that I was a scientist and a science teacher/educator.

Researcher reactivity: The question of researcher reactivity is also important (Bold, 2011). Reactivity is usually thought of in terms of participants' reactions to the research context, not the researcher's reactions, however, it is inevitable that different relationships will be formed with each participant (Bold, 2011). Yow (1997) questions whether this might affect the researcher's reaction to the experience of hearing participants' stories and perhaps not pursuing issues that might be controversial. From my perspective, this was especially important when contacting and interviewing celebrity scientists: would I be able to question and probe responses, even if something controversial arose? In line with Simons (2009) guidelines, this reactivity was monitored and reflected upon, and any conscious biases or issues were documented post-interview. The potential for this can be illustrated from the outset, in that even receiving a response back from David Attenborough, being asked to ring him, filled me with excitement, which was exacerbated by the response of peers and friends.

Ethics of writing: Rhodes (2000) adopts the metaphor of 'ghostwriters' as a term for how researchers can understand their role within the production of textual representations of the data they collect. This approach requires continuous reflexivity, allowing the researcher to account for their position in the textual production; acknowledging that "stories are shaped by their listeners" (Andrews *et al*., 2008, p.6). My methodology resulted in narratives that were derived directly from the data collected; I was attentive to questions of "voice." Skinner (2003, p.527) refers to this as the "ethics of writing," where a balance is found between the writer's voice and the voices of the participants. Merriam (2009, p.23) describes the process stating, "The overall interpretation will be the researcher's understanding of the participants' understanding of the phenomenon of interest." Here, respondent validation was paramount: as the monologues and constructed dialogue were created using direct quotations, confidence that these were accurate was essential. This rigorous approach avoided including only the 'juicy stuff' (Saldaña, 1998, p181); this is explored further in Chapter 4.

Fluidity of reflexivity: According to Etherington (2004, p.30), "Reflexivity implies a difference in how we view the 'self': as a 'real' entity to be 'discovered' and 'actualised', or as a constantly changing sense of ourselves within the context of our changing world." She suggests that reflexivity, then, is "fluid and changing" (p.32). Here was beneficence for me as researcher, as someone deeply familiar with the cultural, political and social contexts of this study, and by appreciating that 'knowledge' from a reflexive position is always a reflection of the researcher's location in time and social space, I was likely to be challenged to see different perspectives and perceptions as the research unfolded (Clandinin and Connelly, 2000).

In summary

All research can be seen as autobiographical, growing out of the researcher's interests and experiences (Clandinin and Connelly, 2000), and these remain with us as we "move from field to field text to research text" (Clandinin and Connelly, 2000, p.177). By understanding my autobiographical relationship to the research topic and methodology adopted, and recognising my assumptions and bias, I was able to monitor my own subjectivity and the effect of my 'self' in this research (Glesne, 2011). Etherington (2004, p.32) sums this up as follows:

> *"If we can be aware of how our own thoughts, feelings, culture, environment and social and personal history inform us as we dialogue with participants, transcribe their conversations with us and write our representation of the work, then perhaps we can come close to the rigour that is required of good qualitative research."*

And this challenge was my intention, to recount the experiences and perceptions of my participants that was transparent, rigorous and authentic.

3.6 Data collection

Participants	Number	Process	Data
Phase 2 Science participants	Total = 18 6 x Year 12 6 x Undergraduate 6 x Postgraduate *Table 3.2 shows science disciplines studied*	1 x semi-structured interview, part narrative-style. Completed: 2015	Audio files and transcriptions. Transcribed by researcher. Respondent validation.
Phase 3 Celebrity scientist participants	Total = 5 Sir David Attenborough; Professor Steve Jones; Baroness Susan Greenfield; Professor Mark Miodownik MBE; Roma Agrawal MBE.	1 x semi-structured interview. Completed: 2016	Audio files and transcriptions. Transcribed by researcher. Respondent validation.

Table 3.1: Data collection overview

Phase 2: Science student participants (Overview: Table 3.1)

Sample selection: Initial sampling for participation in these narratives was specifically purposive, wanting to "illuminate the research question at hand" (Denscombe, 2003, p.16). Purposive sampling requires the researcher to "think critically about the parameters of the population we are studying" and to choose participants accordingly (Silverman, 2013, p.148). With this in mind, there were eighteen participants in total, all engaged in post-compulsory science education, and comprised six students from each of the following education stages: year 12 ('A' Level), university undergraduate, and university postgraduate. Although gender was not a focus of this research, and therefore data was not collected, it may be helpful to the reader to know that the student sample was heterogeneous, that is, it was mixed gender. In addition, they were studying a range of disciplines, and these can be seen in Table 3.2.

Criteria for purposive sampling was based on the expectation that they believed they had a story to tell, and they were willing to meet for up to 45 minutes. 'A' level science student participants were drawn from the pool of students taking two or more science subjects at a large comprehensive school, facilitated by the Head of Sixth Form; undergraduate and postgraduate students were all drawn from the same university, science programme leaders contacted their cohorts inviting any interested students to contact me directly. These strategies ensured that all student participants self-referred.

Participant cohort	Science discipline(s) studied
Y12	Biology, Chemistry, Physics; aspires to be a dentist Biology, Chemistry; aspires to be a Sports Scientist Physics, Chemistry; aspires to be a physicist Biology, Chemistry, Mathematics, Business studies; aspires to study Biology or Chemistry at University Chemistry, Biology; aspires to study Chemistry at University or an apprenticeship in Chemical Engineering Chemistry, Biology, Physics; aspires to study Chemistry at University
UG	Human Biology Forensic Science Nursing Nursing Physics Human Biology
PG	Biological Sciences Biological Sciences Biological Sciences Sport & Exercise Forensic Science Sport & Exercise

Table 3.2: Science disciplines studied by student participants

Data collection was initially a narrative biographical interview, eliciting personal science stories and influences, from earliest memories, through the different stages of their education to date. This gave participants time and space to share memories and influences that they felt were important; essentially they were re-membering relevant critical incidents, rather than a whole life chronology. Participants were encouraged to direct their own responses, with prompting and paraphrasing, as appropriate. This was supported by written guidance (see Appendix 4: Student interview schedule, Part A, p.-42-), which the participants received prior to the interview (minimum of 24 hours). To conclude, participants were asked to articulate who or what were the key influences on their decision-making. The intention of using this approach was to elicit both the implicit and explicit key influences on their decision to continue with science, including any reference to celebrity scientists or the media.

This narrative approach was followed by an in-depth, semi-structured interview, considering the notions of scientific literacy, celebrity and celebrity scientists, and the perceived influence of the 'Brian Cox effect' (see Appendix 4: Student interview schedule, Part B, p.-42-). The interviews were designed to be broadly consistent for each participant, in terms of question order and focus, but with flexibility to explore any tangents that might arise.

The interviews were intended to last no longer than 45 minutes. Each was recorded, transcripts prepared and returned to the participants for respondent validation; permission to use anonymised data was gained.

The two-fold interview approach allowed both explicit and implicit influences and perceptions to be elicited, organised around the phenomena of uptake of science and the role of celebrity scientists.

Phase 3: Celebrity scientist participants (Overview: Table 3.1)
In terms of sample selection, the first question here was, "Who is a celebrity scientist?" In order to decide who to contact, a definition was required, and this was established as follows. My definition of a scientist is someone with an advanced knowledge of an area within the natural sciences, is involved in scientific research and/or dissemination, and may or may not be an academic. A celebrity is defined as someone who is famous, and received public attention in the media. My definition of a celebrity scientist, then, is a scientist who is actively involved in public engagement and communication, who has become well known within their field of expertise, with a presence in the media.

Using the above definition, celebrity scientists named by the student participants, and others drawn from my knowledge of scientists with a current, or historical presence in the media were contacted. This was done directly, via work place email, personal website, their media agency, or personal letter. Five celebrity scientists were interviewed: Sir David Attenborough; Professor Steve Jones; Baroness Susan Greenfield; Professor Mark Miodownik MBE; and Roma Agrawal MBE.

Semi-structured interviews were supported by written guidance (see Appendix 5: Interview schedule, p.-50-), and an overview of these questions was included on initial contact, through the 'Participant Information' letter. This was to enable the celebrity scientists to make an informed judgement regarding their response, that is, if they were willing to be involved, they would be able to offer their thoughts immediately via email, or contact me to arrange an interview. The length of interview was intended to be approximately 30 minutes, but was to be guided by participants themselves. Each interview was recorded, transcripts prepared and returned to the participants for respondent validation. Permission to use their non-anonymised data was gained.

3.7 Conclusion

In this chapter I elucidated the philosophical, paradigmatic and the practicalities of data collection. Essentially, this research is qualitative, with overarching interpretivist and constructionist paradigms. The emphasis is on meaning-meaning, wanting to illuminate participants' science stories and influences. Much emphasis is placed on reflexivity, and this continues in Chapter 4: Data analysis, interpretation and presentation, focussing on the notions of trustworthiness, authenticity and plausibility.

Chapter 4: Data analysis, interpretation and presentation of findings

Exemplification of this process can be seen in Appendix 3.

4.1 Introduction

The purpose of this research was to explore the unique experiences and perceptions of the student and celebrity participants as they pertained to celebrity scientist influence, and the general influences enhancing the science capital of young people. On completion, as part of the theoretical framework development (Aim 4), it is intended that the findings will be shared with stakeholders, including young people, to inform policy and practice, with a view to raising science aspirations and promoting future engagement with science careers. With this in mind, a method of data analysis and presentation of findings that would be engaging and thought-provoking, and yet, in terms of validity, remain trustworthy, authentic and plausible was required. I believed that my participants had important stories to tell, and therefore I needed a means by which these stories could be “validly, vividly, and persuasively told” (Saldaña, 1999, p.61), and that young people would find enjoyable to read and might spark their imagination (Watson, 2015). In this chapter, I explain the practicalities of this process, embedding them in academic principles and practices of narrative data analysis, interpretation, and presentation.

Saldaña (2012) and Leavy (2009) were the key researchers underpinning the data analysis and presentation decision-making process. Saldaña provided comprehensive insight into the range and rationale of approaches to data analysis, whilst Leavy provided insight into arts-based presentations of data; both are involved in narrative research.

Miles *et al*. (2014) view data analysis as three concurrent flows of activity: data condensation, data display, and conclusion drawing/verification; these underpin the structure of this section; ‘data display’ is referred to as ‘data presentation’ in this thesis.

4.2 Data condensation (Miles *et al.*, 2014)

Data organisation was structured by participant. Each had a file that included mp3 audio, transcript of interview, transcript annotated using coding from conceptual framework, individual conceptual framework highlighted with data, copy of consent form, and returned respondent validation letter or email.

Interviews were transcribed verbatim, that is, the pauses, laughter, false starts, and utterances that are common in everyday speech were included. This decision was based on their intended use “for reporting the subjects’ accounts in a readable public story” (Kvale, 2007, p.95); the focus was not only on what participants said, but also how it was said (Elliott, 2005; Kvale, 2007).

Thematic analysis was the approach taken to data condensation (Saldaña, 2012; Miles *et al*., 2014). The conceptual framework, derived in part from thematic analysis of the scoping study, provided the themes, that is, the categories and sub-categories that underpinned analysis of both science student and celebrity scientist interview data. This was a two-fold process, exemplified in Appendix 3, whereby each participant's transcript was coded using themes from the conceptual framework (Figure 2.1, p.69), followed by further first-cycle coding, to elicit any new, outlying themes using *in vivo* coding, where participants own words were used as the codes themselves, as recommended by Saldaña (2012); this was important so that any new data could be integrated directly into the scripts. Data condensation leads to data presentation, and this is where there is divergence from the more conventional approach: thematic analysis was not used to present the data, although it was used to draw the themes together in preparation for constructing the monologues and constructed dialogue scripts.

Reduced data can be displayed in diagram or visual form, through frameworks, matrices and charts, enabling the researcher to see more readily what the data is showing (Bryman, 2012; Miles *et al*., 2014). Data are generally organised into cells consisting of core themes and subthemes, and include brief quotations, with a note of where it can be found in the transcript. Although the words of the participants are kept, abbreviations can also be used to avoid cells becoming too full.

To bridge data reduction and data presentation, a means of collating the quotations from the transcripts into the categories and sub-categories of the conceptual framework, so that they could be re-formatted into the scripts, was required. It was not practical to have a paper-based matrix as it was important to keep the quotations intact. To this end, a more physical, interactive approach was taken. Transcripts were highlighted, using colour-coding, according to the categories of the conceptual framework, and these were physically cut up using scissors and placed together in groups on my living room floor. They were then re-sorted according to the sub-categories, physically spreading the data out further; in essence, my living room floor became the matrix. In this way all of the language of the participants was kept, and colours ascribed to identify participants guaranteed that the source of each quotation was also preserved. Furthermore, it ensured that outlying data and new insights were not lost, thereby retaining "the holistic nature of the data" (Simons, 2009, p.117). I was literally fully immersed in the data, akin to the notion of 'dancing with the data' described by Simons (2009, p.140). This process is fully exemplified in Appendix 3, taking the reader from the transcript to the finished monologue and constructed dialogue.

Whilst it was essential that the data collected was reduced, Simons (2009), referring to Wolcott's (1994) notion of transforming qualitative data, suggests that this is more "open and expansive" and "evokes a sense of movement" (p.121), and certainly my physical, hands-on approach allowed the data not only to be reduced, but also left it ready to be transformed into interpretative stories, that is, monologues and constructed dialogue, in order to illuminate the phenomenon of celebrity science culture. The process led to the generation of interpretative stories that documented my analysis and findings. Essentially, then, in order to create/construct these scripts/narratives, data sets for each of the five categories of the conceptual framework were analysed both structurally and hermeneutically. The more conventional approach with limited quoted and abbreviated material in the cells would have been restrictive; I wanted to present as much of the participant data that I could, seeking to create a rich and detailed account of their experiences and perceptions, in order that the reader might "vicariously experience" (Simons, 2009, p.23) and identify with the content of the scripts.

This process is exemplified in Appendix 3.

4.3 Data presentation (Miles *et al.*, 2014) (see Appendix 3 for exemplification of the process)
This section includes a description of how the data was presented, the rationale for these approaches, and a consideration of issues raised. Monologues and a constructed dialogue were the presentation methods employed. Bold (2011, p.26) describes these as "meta-narratives", or a story about a story. Although this was not collaborative, respondent validation of both the original transcripts and examples of both genres took place to ensure that the scripts represented the experiences and perceptions of the participants.

Choice of presentation format:
Having collected data and had made sense of what I had heard through the analytical process, I had "a story to tell, insights to communicate, and wisdom to impart" (Simons, 2009, p.147), in the most persuasive way that I could, whilst retaining the authenticity of the data (Simons, 2009, p.147). Data can be presented in a variety of ways (see Simons, 2009, pp.148-152), and they are not necessarily approached as discrete forms; there may well be combinations and variations. The form chosen is influenced by the purpose for which data was collected, and how

this might be best communicated (Simons, 2009). Two forms are particularly relevant to this research: portrayal and story-telling.

The purpose of portrayal reporting is to engage the reader with the veracity and experience of the case through the organisation or juxtaposition of data; data is displayed rather than interpreted and discussed, it is data-led, direct quotations are frequent, with comparison and contrasting of perspectives (Simons, 2009). Portrayals can be collages of different voices, recognising that the "inclusion of different voices may at times appear fragmentary" (Simons, 2009, p.149). The intention, however, is that the underlying coherence is maintained so that the essential elements of the story will be told. The aim of story-telling is to engage the reader's intellect, feelings and emotions, enabling them to readily "connect with the story being told" (Simons, 2009, p.150). The reader/listener is active in the process, identifying with what is being told, such that the "creative imagination" is stimulated (Simons, 2009, p.150). Although this is not story-telling in the fictional sense, there is "much to learn from the skills and intent of story-telling to communicate insights and observations in a readable, accessible form" (Simons, 2009, p.150). These two forms of reporting led to the choice of monologue and constructed dialogue to present the student and celebrity scientist data, respectively; the rationale is as follows.

The purpose of the monologue is to enable the reader to "vicariously experience" (Simons, 2009, p.23) the experiences, influences and perceptions of student participants in as succinct a format as possible, where key data is essentially exemplified. The rhetorical nature of monologues as a literary genre adds dimensionality, showing complexity through the weaving together of different voices, as such they are intended to be unique, engaging and insightful texts, constructed in order to bring the student data to life. In terms of future impact, and being forward-facing, the monologues are intended to be performed, rather than presented as a text to read, primarily to young people, with the intention that they might identify with the experiences, influences and perceptions portrayed, recognise aspects of their own science journey, and build or sustain their science aspirations. The alternative of constructing a dialogue with multiple characters has the potential to move the focus from the content of the monologue to the characteristics of the different actors; as they stand, the monologues can be performed by young people of different genders, ethnicities, socio-economic backgrounds, and so on. On balance, the choice of monologue was the most appropriate format for presenting student data.

The purpose of the constructed dialogue, again looking ahead, is to creatively engage stakeholders (especially teachers, scientists, the media, and policy makers), to appreciate the commonalities and juxtapositions of the celebrity scientists, in order to inform policy and practice. The monologues played a crucial role in its construction, in that by drawing student participant data together, in as succinct a format as possible, without losing the richness of the data, key experiences, influences and perceptions made could be readily used as key foci on which the constructed dialogue was built. Both formats, the monologues and constructed dialogue are strongly linked, focussing, reflecting and making meaning and sense of the complex picture of celebrity science culture, within the limitations of this research.

The monologues and constructed dialogue must not be seen, therefore, as separate entities. Whilst they have separate roles, they also work together as a means of interpreting the data, illuminating the phenomenon of celebrity science culture, and thereby making meaning out of the combined participant experiences, influences and perceptions of celebrity science culture. Therefore, I believe that presenting student data in the form of monologues, as collages of participant data, and celebrity scientist data as a constructed dialogue, were the most appropriate formats to serve the intended outcomes, and illuminate the research question.

4.3.1 Monologues (Student participants) (see Appendix 3 for exemplification of this process)
Monologues are one actor deliveries of a narrative, which can be a direct address to an audience, as in this research, or as a 'soliloquy' (Saldaña, 2010, p.62). They are recognised as media for exploring subjectivity, providing insight into how young people view their social world (Welsh, 2017), that is they "capture and express" a participant's identity (Saldaña, 2010, p.64); in this research, their identity as scientists. Furthermore, monologues can be used to "help the reader develop a stronger understanding of the particular circumstances and life choices" of participants (Bold, 2011, p.24).

Monologues, then, were constructed as a form of representation to provide insight into the lived experiences of the science students interviewed; they were chosen as a method that would capture the complexity and multivoicedness of their journey, and their perceptions of the role of celebrity scientists.

There are generally two approaches to constructing monologues: directly from the data, in this case the interview transcripts, or by the researcher during the interpretation phase (Saldaña, 1998; Leavy, 2009; Saldaña, 2010). In this research the conceptual framework itself scaffolded both the structure and content of the monologues, so that both approaches were utilised. The quotations thus collated, according to the sub-headings of the conceptual framework, were re-ordered to produce dramatic representations of the data (see Appendix 3 for exemplification of the process).

Initially, the data of two student participants from each educational phase cohort were reordered as individual monologues. However, this raised issues in terms of which participants to choose: whose voice was most valid? They all had important insights that needed to be heard. Leavy (2009, p.147) suggests that characters in scripts can be "constructed as composites", so that a character type is created; here the character type was the education phase of the students. According to Saldaña (1999, p.64), "collective story creation" is advantageous in that they "offer triangulation through their supporting statements [and] highlight disconfirming evidence from their contrast and juxtaposition [through their] multiplicity of perspectives"; this is important in that validity is recognised as a potential issue when fictional devices are employed (Rhodes and Brown, 2005; Barone, 2007). With this understanding in mind, data from the six participants within each cohort was combined to produce a single monologue: one 'A' Level, one undergraduate and one postgraduate; in order to be non-gender specific they were named according to their education stage: Y12, Undergraduate and Postgraduate. The rationale for maintaining these three discrete groups relates directly to their choice as participants; each had the potential to offer differing insights regarding the influence of celebrity science culture. The Y12 cohort were choosing which curriculum subjects to continue with, within the same time frame that the media was referring to the 'Brian Cox effect' and the increase in the uptake of science post-compulsory age. The Undergraduate and Postgraduate cohorts had already invested themselves in science at this stage, by already having chosen to continue with science. Whilst one might expect to find similar insights for these two cohorts, it was considered important to interview those who had chosen to move formally into a science career by embarking on postgraduate research.

There are several considerations and potential disadvantages when creating monologues and dialogues. Transparency is a key word running through this thesis, and as such it is important to be open about who/what has been included and excluded, and indeed whose voices may not be clear, and these are addressed as follows.

i) How did I choose the quotations from within each theme, that is, the categories and sub-categories of the conceptual framework, to illustrate these collective voices? (Appendix 3 guides the reader through this process). Of course, all research involves a data reduction process, however, in performance studies Saldaña raises a potential issue whereby data is condensed by the researcher to "the juicy stuff" in order to achieve dramatic impact (Saldaña, 1998, p.181). Here again, my personal predilections, interests and science background had the potential to influence the script writing process (Wellington *et al*., 2012). Therefore, as Saldaña (1998) suggests, whilst creating the scripts, in order to avoid only including the "juicy stuff" (p.181), and having sorted the quotations into the different categories, I asked myself the question: "Who gets to speak and who doesn't?**"**, and indeed "Who gets the best lines?" and "Who gets the final word?" Clearly, there would be some subjectivity here, but inclusion of Appendix 3 allows the reader to see that whilst they were "creatively edited", they were also "strategically edited" (Saldaña, 1999, p.63), thus avoiding only selecting Saldaña's "juicy stuff" (1998, p.181).

ii) How did I configure these direct quotations to make a coherent, authentic monologue or dialogue? Recognising that the voice of one participant may be "privileged over another" (Goldstein, 2008, p.15), a high level of reflexivity was required, as discussed in the paragraph above. With this in mind, the following decisions were made: where participants were essentially saying the same thing, only one was chosen to exemplify the experience, perception or insight made, and lengthy sentences or extraneous passages whose absence would not alter the integrity of the voice or quality of the data being shared were omitted or edited. The categories of the conceptual framework, as part of its pluralistic function, were used to structure the scripts, offering coherence and clear links back to the literature review and forward to the discussion.

iii) How did I ensure that areas of divergence or new examples and insights were not lost? When creating the monologues, the issue arose of how to include and integrate the contrary views and perceptions and the different experiences of participants in the monologues. This was important in ensuring that the perceptions and experiences of all participants were treated equitably, as valid, valuable and authentic voices, plus it was important that sufficient evidence of the range of responses from participants was included to enable readers to have confidence in the data presented. A decision was made to incorporate these under the dramatic device of referring to the experiences or perceptions of a 'friend', by including literary devices such as: "I asked my friends about this…" Although this is explained further in the introduction to 'Section 4.5 Student participant monologues' (p.113), it seems apposite to exemplify this here with two examples from the Y12 monologue, in order that the reader will recognise this literary device when reading the monologues and appreciate the rationale for their inclusion.

Example 1. Y12 monologue (p.116):

> "My friend talks about Brian Cox working at CERN, at the Hadron Collider. All the time we get: '*it's like my dream job to work there, it would be amazing, wouldn't it? Learning about new particles and accelerating them to dead high electron volts to make new particles, yeah, that would be amazing*.'"

The general consensus from all participants in the paragraph leading up to the section above was that it was about the science and wanting to do what the scientists or television presenters were doing. Only one participant explicitly referred to the work of Brian Cox, and that they wanted to do the same as him. At this stage this participant did not know that the focus of this research was celebrity science culture or the 'Brian Cox effect'.

Example 2. Y12 monologue (p121):

> *"I asked my friends about this and most are like me, but one has a cousin who studies a veterinary course, and she influenced to at least carry on with sciences. Another's dad did physics when he was at college and he was always talking about it and explaining things, and that kind of sparked my friend to do science as well, and another's dad was a chemistry teacher, and that also helped."*

In this example, the general consensus was that family played more of a supportive role, however, three family members were referred to as having some influence over their choice.

In practice, then, I used direct and para-phrased quotations to construct the monologues, linked by narrative devices to enhance the flow. This process, I believe, is one of 'inclusion' rather than 'exclusion', in that whole quotations were maintained where possible, rather than the typically reduced and abbreviated quotations found in more traditional thematic analysis frameworks or matrices (Bryman, 2012; Miles *et al.,* 2014). The themes, experiences and perceptions within the monologues belong to the participants; my words are only included as a means of joining the data together into an eloquent, coherent script. At this stage they are, in a sense, collages of verbatim interview transcript excerpts, but for dissemination to stakeholders, as scripts as well as performance pieces, the intention is to have them professionally edited. The monologues, therefore, are essentially my edited versions of the students' words, however, as other researchers have done (Cooke, 2014; Welsh, 2017), I did not incorporate my analysis of the raw data within the monologues; this can be seen in the Discussion chapter (Chapter 5).

4.3.2 Constructed dialogue (Celebrity scientist participants) (Miles *et al.*, 2014) (see Appendix 3 for exemplification of this process)

A means of conjoining celebrity scientist data with that of the science students was required in order to explore commonalities and differences of opinion between the celebrity scientists and science students, and indeed to allow the perceptions and experiences of the celebrity scientists to be compared and contrasted. I was looking to "compose character-participant talk through action, reaction and interaction" (Saldaña, 2010, p.65), a function of writing dialogue. Most dialogic exchanges in ethnodramas are "creative non-fiction" or "plausibly truthful constructions" (Saldaña, 2010, p.65); the 'factional stories' of Kallio (2015) where the boundary between fact and fiction may be blurred. The text is, more often than not, reconstructed from self-contained stories found within interviews (Saldaña, 2010), hence the term 'constructed dialogue' for my form of presentation here. The constructed dialogue was created by imagining that the following fictional scenario had taken place:

> *The five celebrity scientists were in a meeting room together, and each had read the three student monologues. During this meeting they discussed the perceptions and issues raised by the students regarding the influences on the uptake of science, and the role of celebrity scientists within that. Sir David Attenborough chaired the meeting.*

The monologues, then, were used as a dramatic device to analyse and present the voices of the celebrity scientists. Wellington *et al.* (2012) assert that 'fictionality' should be made explicit, and indeed my method of presenting this data was an "imaginative yet reality based reconstruction[s] of participants' concerns" (Saldaña, 2010, p.65). The dialogue was constructed in line with the categories of the conceptual framework, in order to maintain the systematic and rigorous approach required of qualitative research (Bryman, 2012). Although the scenario was fictional, the data used to create the dialogue was not, it comprised direct quotations from the celebrity scientists, collated by coding elicited from the conceptual framework, as previously described. As with the monologues, quotations included in the constructed dialogue were linked by narrative devices to give a sense of conversation.

4.3.3 Creative analytic practices: Rationale, validity and reflexivity

'Creative analytic practices' is the phrase used by Wellington *et al.* (2012) to describe more creative approaches to data analysis, noting that they are produced as academic scholarship, which privilege subjectivities and the place of the affect and emotion in all aspects of social life; they describe them as "highly appropriate in social research when human experience is the focus" (p.157). They suggest that they should come with an analytic commentary, and that is my intention below.

To ensure a rigorous, transparent approach to this dramatic presentation of data, Leavy (2009, p.157) offers a checklist of considerations:

1. What is the goal of the study, and how does performance serve the goal?
2. Will the entire structure of the research design be dramatic, or will drama serve as a data collection or representational form only?
3. How will the data be obtained (ethnography, interview, public documents, etc.)? What performance-based method will be employed? Is this method collaborative?
4. During script construction how will plot, narrative, and overall structure be conceived? How will characters be created? What validity checks am I using to ensure three-dimensional portrayals? How will dialogue and monologue be generated? What ethical issues might emerge?
5. How do I deal with disconfirming data? What procedures for yielding authenticity and validity will be employed? What procedures for post-show dialogue will be used?

Considerations 2 and 3 have been addressed previously. What follows below is the use of considerations 1, 4 and 5 to explore the practicalities of creating the monologues and constructed dialogue. As at this stage they are not being performed, the list has been adapted to 'dramatic presentation' rather than performance. The scripts are therefore "closet dramas" (Saldaña, 2010, p.68), in that they were created without a performance happening; the script format was used solely as a "writing vehicle" (Leavy 2009, p.143). The first two are considered within this data presentation section, and the third within the 'Conclusion drawing/verification' sections below.

How does dramatic presentation serve the aims of this research?

The monologues and constructed dialogue can be understood as dramatised representations of the research data, that is, they are data-informed scripts (Saldaña, 2005; Leavy, 2009). According to Saldaña (2010, p.68) "Humans are theatre," in that we continually tell 'monologues' and exchange 'dialogue' with others; they are "fundamental parts of our social lives and our study of it" (Leavy, 2009, p.25).

Interestingly, Saldaña (1999, p.60) draws a similarity between the aims of qualitative researchers and scriptwriters, in that both try “to create a unique, engaging, and insightful text about the human condition”; they can “bring research findings to life, adding dimensionality” (Leavy, 2009, p.135). However, in this research, I not only wanted to tell participant stories, I also wanted to make meaning through the process (Wellington *et al*., 2012, p.117).

Denzin believes that dramatic texts are a powerful way of “interrogate[ing] the meanings of lived experience” (Denzin, 1997, pp.94-95). This was my intention: to turn my data into play scripts to enable the reader to “get inside the skin” of others (Turner, 1982, p.90); to “vicariously experience” them, as Simons (2009, p.23) would say. Saldaña (2010, p.61), again, suggests that they should be chosen when they will “most credibly, vividly and persuasively exhibit for readers and audiences the investigated social world”; in this case, the social world of celebrity science. This approach, then, had the ability to “get at and present rich, textured, descriptive, situated, contextual experiences and multiple meanings from the perspectives of those studied in the field” (Leavy, 2009, p.145).

As well as engaging audiences, drama has the power to educate and empower, with the potential of promoting social change, including educational policy-making (Boal, 2008; Leavy, 2009; Saldaña, 2010; Cannon, 2012). Indeed, as a teacher and teacher educator, I have used theatre groups as a pedagogical tool to raise awareness of, for example, bullying and climate change. One aim of this research, post-study, is to disseminate the findings to stakeholders including young people, the media and policy makers, in order to promote the uptake of science. The monologues will be used directly with these stakeholders. The dramatic format will allow this to be done in an engaging and accessible way.

Overall, then, the intention was to access participants’ science stories, experiences and perceptions, and to engage in a process of storying in order to explore and subsequently present the complexity of science journeys, and the perceptions of celebrity science culture; as Leavy (2009, p.27) suggests, to “present an authentic and compelling rendering of the data.”

Script production

This understanding underpins why and how the data collected was analysed, interpreted and presented. Combining qualitative research, narrative and the empathetic potential of theatre, I set out to find a method to analyse my data and create the scripts. Table 4.1 summarises this process.

During script construction:	
How was plot, narrative, and overall structure conceived?	Practical aspects and rationale explored below
How were characters created?	Monologues: student voices from each cohort combined; Constructed dialogue: individual celebrity scientist voices maintained
What validity checks did I use to ensure three-dimensional portrayals?	Respondent validation Range of audiences and readers: e.g. conferences, Director of Study, Second Supervisor, colleagues.
How were monologues and dialogue generated?	Previously described (see sections 4.3.1 and 4.3.2)
What ethical issues emerged?	Constructed dialogue – respondent validation, permission given to name individual scientists; Monologues – respondent validation, anonymity protected through the process of conflation and combining of data.

Table 4.1: Practicalities of script production

As researcher, my role was essentially that of a 'ghostwriter', in that I wrote the stories attributed to my participants (Rhodes, 2000). In a sense, this was akin to Kim's "narrative configuration" (2006, p.4), in that using the conceptual framework to extract emerging themes, I configured the data, that is, the direct quotations, to make "disconnected research elements coherent, so that the story can appeal to the reader's understanding and imagination" (Kim, 2006, p5). This configuration needed to be planned in order for the data to be authentic and trustworthy.

Fiction writing techniques were explored to generate the narratives, for example, plot, storyline and emplotment, where plot is the overall play structure, storyline is the progression or sequence of events within the plot (Saldaña, 2003), and emplotment is the assembly of a sequence of historical events into a narrative. Czarniawaska (2004) highlights emplotment as an important feature in a story, and in the monologues this was used to recount student participant science stories chronologically; it was a useful device to draw together data regarding their science memories from both the narrative phase and the semi-structured phase.

Dramaturgical coding (Saldaña, 2012) was initially explored to structure the scripts. Whilst dramaturgical coding is appropriate for exploring intra- and inter-personal experience, it is essentially a means of exploring people's motives. To motivate is the act of giving somebody a reason to do something, whereas this research was looking at influences, a higher order level skill which makes the desired action feel like the other person's ideas, rather than the other way round. To this end, the dramaturgical notions of participant objectives, conflicts and tactics as codes were not relevant in the context of this research (Miles *et al.,* 2014).

Language choice and rhetorical devices are recognised as important narrative features (Riessman, 2001). In terms of language choice, the scripts were written without reference to gender, and when the data was combined, I removed vernacular forms of language, choosing to use Standard English, without regional accents or colloquialisms. My intention was to avoid any potential sidetracks or stereotyping, or links to identity that might occur as the reader engaged with the scripts, so that the focus was maintained on what was being said. One rhetorical device can be observed, that is, alongside the headers, each monologue included the same phrase or question in the script to highlight for the reader where the different foci of the interview schedule are explored.

By offering prompts to the students on which to scaffold their science stories, transcribing the interviews verbatim, and using the conceptual framework to both analyse and structure data presentation, I believe I created a consistent, coherent and transparent approach to structuring the scripts, one that allowed similarities and differences across the cohorts to be explored. Individual voices are not lost, disconfirming data is included as 'friend' as discussed previously (section 4.3.1, p.106).

4.4 Conclusion drawing/verification (Miles *et al.*, 2014)

Standards of validity for dramatic presentations centre on issues of authenticity, trustworthiness and plausibility, rather than generalisation (Leavy, 2009), underpinned by the notions of "juicy stuff" (Saldaña, 1998, p.181), 'Narrative truth' (Spence 1984), and "virtual reality" (Kim, 2006, p.5).

Juicy stuff: The task of configuring the direct quotations to make a coherent, authentic monologue or dialogue required a high level of reflexivity, recognising that the voice of one participant may be "privileged over another" (Goldstein, 2008, p.15). Of course, all research involves a data reduction process, however, in performance studies Saldaña raises a potential whereby the data is condensed to "the juicy stuff" in order to achieve dramatic impact (Saldaña, 1998, p.181). The practical outworkings of this were explored above (section 4.3.1, pp105-106).

Narrative truth: What I was looking for when writing the monologues and constructed dialogue, was to achieve scripts that were trustworthy, that is, was there a sense of ''narrative truth''

(Spence, 1984), where the reader could say that that "such and such is a good story, that a given explanation carries conviction" (Kaasila, 2007, p.212).

Virtual reality: Essentially, I was creating a "virtual reality" (Kim, 2006, p.5), one which would promote empathic understanding of the science stories and influences of the student participants. The construction of "virtual reality" refers to the reader's ability to "believe in the possibility or the credibility of the virtual world as an analogue to the 'real' one" (p.5). Here the audience has a role to play in terms of validity: is the script plausible? That is, does it promote "empathic understanding of the lives of the protagonists" (Kim, 2006, p.5). To ensure trustworthiness and plausibility, as well as respondent validation, the scripts have been presented to my Director of Study, Second Supervisor, and to peers and colleagues at meetings and conferences. Feedback has been that the scripts do indeed sound plausible, and could be trusted; there was a sense of "narrative truth."

In conclusion, by writing monologues and the constructed dialogue, I have been exploring research as a creative act. The scripts are in essence a combination of the raw data drawn together using narrative devices. By experimenting with the relationship between fact and fiction (Rhodes and Browne, 2005), I have been working at the more playful end of narrative inquiry (Smith, 2007). This required that strategies be put in place to enable the creation of storylines that were "impactful, emotion-evoking monologue[s] and dialogue" (Saldaña 2010, p.62), whilst remaining authentic, trustworthy, and plausible (Leavy, 2009), and, importantly, were enjoyable to read (Watson, 2015). This is where the conceptual framework played an essential role, and exemplification of this process can be seen in Appendix 3.

4.5 Student participant monologues

The following literary devices have been used to ensure that the monologues are accessible and coherent:

1. Each monologue starts with the same phrase:

> "I've just read 'The Brian Cox effect is a star turn' in The Telegraph! They're calling him a celebrity! Have you seen it?

This is a literary device to set the research question into context, that is, the causal relationship asserted by the media regarding the influence of Brian Cox on the uptake of science by young people.

2. The categories of the conceptual framework are used as headers to offer structure and clarity by guiding the reader through the script. For the ‘Celebrity Science and Scientists’ section I have further separated the sections of the script with the interview questions.

3. The literary device of referring to a ‘friend’ has been used in order to integrate contrasting experiences, influences and perceptions; this has been previously discussed (Section 4.3.1, p.106).

4.5.1 Y12: Combined data from Year 12, the 'A' level cohort

Celebrity Science and Scientists:

- *What is a celebrity?*

I've just read 'The Brian Cox effect is a star turn' in The Telegraph! They're calling him a celebrity! Have you seen it? A celebrity? I'm not sure because a celebrity is someone who, I don't know, someone who's like famous, or infamous, they're certainly well known for some reason, like singing or acting. You know some people become celebrities for the randomest reasons, probably not deserved sometimes … in fact some may have just got it through looks! A celebrity in my eyes is someone doing good, so I suppose it depends on the context you put them in. Someone could be a celebrity just to you, someone who's famous to you - they might not be in the media, but they could be a celebrity to you because you have a connection with them, you're interested in them.

- *Can scientists be celebrities?*

Perhaps there are two different kinds of celebrity, like there's someone who's actually made a life for themselves and actually deserves the fame, like scientists, and those who don't. You know, Isaac Newton and Einstein, they're well known and played a big part, they gained fame for certain theories, and Charles Darwin because everyone knows his theory of evolution. Who else? Carl Linnaeus, Alexander Fleming, Ohm for his law. There's Thomas Edison, he created the lightbulb, but I wouldn't call him a celebrity. There's Hippocrates, he did the model of the atom. What about modern scientists? Brian Cox of course. Those are obviously the more famous ones if you think of any. There are a lot of scientists I suppose that fly under the radar because they're not well known. I mean, everyone knows who Einstein is but not many people would know who Tesla is. There are some women of course, although that's harder. There's Marie Curie, everyone knows her, and Florence Nightingale if she is a scientist, I don't know. I can't remember that person who created the DNA model, I'm trying to picture her, oh yes, Rosalind Franklin.

But I do think I'd go more on the basis of calling them scientists and famous, rather than a celebrity really. But, it's like they are because they've done something, and they're sort of well-known, and quite big and famous, but, you never really hear of them as celebrities do you? It's tricky, but I suppose they are in a way, it depends who the audience is I think, yes, and, as I've said, if they have celebrity status to you. Actually, I think the media has a big part in deciding who gets celebrity status. There are fantastic scientists that don't get coverage which rightly they might…probably don't want paparazzi!

So … back to Brian Cox, I think he would be a celebrity scientist, because he does a lot in the community now and he's quite well known by many people with a lot of BBC shows - he's even on reality television shows!

- *Do you think they influence people?*

But does he, and do other celebrity scientists too, influence people like the newspapers have been saying? I'd like to think that they do because they help the world out by developing new theories and new models, you know, they shape what we learn about today, like Charles Darwin's evolutionary theory. But, I'm in two minds really! I suppose Brian Cox might because he's on television and people have access to be inspired by him easily … but I can't think of many others that can reach out to people to inspire them. But if someone doesn't have an interest in science and they see Brian Cox, I don't think they would see him as much of a role model as someone else would if they actually liked science, because they can relate to it, can't they? I suppose they could inspire you to work harder at school, if you have a drive to do well in science! But then I suppose people could still watch his programmes, and maybe learn to like science, yes? I guess then, that the people who are more interested in science, they have a big influence on, but the people that are sort of not too bothered, it goes over their head.

- *Have they influenced you?*

It made me question though whether they had influenced me? I suppose in a way they have, the curiosity side of it. But it wasn't any particular person, or not necessarily a person, more the content of what's there. Do you know the doctor on 'Embarrassing Bodies'? I'd quite like to do that! I don't think I would call it 'influence' though, it's more of an interest. But you know, if it wasn't for television programmes, maybe I wouldn't have got interested in it quite so much … I find it interesting anyway, so it wasn't really difficult for celebrity scientists, I suppose, to get me interested in it. I suppose they could be like a role model, you know, if you see them make discoveries. That's kind of what made me do science, I want to make new discoveries, like Einstein did, like Brian Cox did, yes. I know it might not happen but it fuels me! My friend talks about Brian Cox working at CERN, at the Hadron Collider. All the time, we get: "It's like my dream job to work there, it would be amazing, wouldn't it? Learning about new particles and accelerating them to dead high electron volts to make new particles, yeah, that would be amazing."

- *Who might they influence?*

If people think celebrity scientists influence, do you know what they should really do? Target GCSE students…because at that point they're not making many massive life decisions, but are quite malleable! They could really capture children's imagination! And maybe they'd take science at 'A' level, and then you'd have more chance of people taking it at University. They might even, you know, influence adults! Just a general interest wanting to learn more, or they might think of a career change. I still think you've got to have an interest, and if people aren't interested in it at the age where they have the chance to choose, then you're not going to have many people taking it further. People idolise celebrities don't they? They could want to follow them, and so I suppose it might spark an interest somewhere. You never know! If people are motivated for science, I guess, and they have an idol, they might want to work in that area.

- *Do they inspire or entertain?*

I think a celebrity scientist's main aim though is to try and develop whatever it is they're trying to do, and then it's quite a bonus if people are influenced by them. Even if they're not influenced, they could still find their work entertaining, especially if they like science … because science is a kind of entertainment in itself, isn't it? And actually, I think if you're entertained, then it will probably inspire you! You know, if you're captured and you want to re-watch it, there must be something! But, if you're just watching it and you don't have an interest to pursue science, or take on what they say, then it's just entertainment. So it's only influencing when you like it and you can relate to it, if you know what I mean. I do think, though, that scientists should strive to do both: entertain and inspire. Because you've got to entertain and get the viewership, but you've also got to hope that a percentage of them take it on board and want to go further. You can't really go one way or the other without risking jeopardising it, because if you're not entertaining, you're not going to get people watching, but if you're not going to inspire anyone, then there's no point doing it in the first place. So I think you've got to get that sort of balance, hmm, definitely.

- *Do you think the 'Brian Cox effect' is true?*

As I've said, the media is saying that there's been a massive increase in people taking physics now because of Brian Cox, and because of Stephen Hawking before him. It wasn't overly subscribed, but now there are a lot more people taking physics courses. I suppose it is possible, individual people can bring about change in society, you know, civil rights and social change have come about through other figures. This is obviously on a more serious level within society, as opposed to someone just wanting to take physics. But the 'Brian Cox effect' as a thing?

Hmm, I wouldn't know whether to say it exists or not. The media thinks it's true, but I don't know if that was their aim. I think that's just come with it to be honest with you. I could think it's true, because we've not had someone like him on a programme before, have we? Someone that's kind of new and relevant towards science, and I suppose a younger generation could look at him and think "Oh, look at all these new discoveries they've made, and the advances in science they've made." So I suppose it could help to get them on the same road towards success, and learn more about science. Even films like "Interstellar" are probably sparking people's interest in physics as well.

Thinking about it, though, I know people who went into physics since Brian Cox. They say they were unaware of how far you can go, and how broad it is, but he put it in their mind that you can study the stars, you can be an astroscientist! I suppose he's put physics on the map as well as "What else can I do within science?" He is a really good scientist, and, yes, I think he is very much the social face of science at the minute, because he's so prominent in the media, and in television, that when you think about physics, most people would probably think about him. He's been doing Stargazing, Natural Universe, Human Universe, and all sorts of things. He asks quite important questions, but he does simplify it so that most people can understand; which some people see as a bad thing, but I'm not quite sure why. He's on programmes other than physics as well, which is OK as long as he knows what he is talking about, but I think though that maybe chemistry and biology need their own celebrity scientists as well, because I think Brian Cox is definitely the face of physics! So if he is inspiring a lot of people to take it further into their lives, it can only be good for the field … when you've got so many more people wanting to do it, you're going to make headway quicker. And if it is true, I think it proves that if you do put science in the media, in the reach of normal people, it can inspire them to do more than they probably would have if they didn't have access to it. So, yes, I think even if you were just doing programmes like nutrition, for example, its biology, and it's getting people interested. But I suppose at the end of the day it's just not for some people. You've got to have some sort of interest to enjoy it, and some people don't, and that's up to them. It's just how you are as a person, I suppose.

Nature of Science and Scientists:

- What is science?

As for me, science is definitely for me, I really enjoy it! And I do think it's a big part of everyone's lives, even if they don't notice it. Like this table not moving, it's in equilibrium isn't it? The CO_2 we breathe out – plants take in and give out oxygen. And I love that we're always making new breakthroughs in science, aren't we? We're developing new products and advanced equipment, and better medicines. You can never say "I know everything", so the more people there are studying science, the more chance there is of finding solutions to problems. Like we might get malaria sorted out quicker, and typhoid and TB. The environment as well. Pollution, extinction, greenhouse gases … you know I don't think people realise how much damage they're actually doing to the world.

- *What does it mean to be a scientist?*

You've probably realised that I'm passionate about science, and I call myself a scientist! I like to think that I have moral standards, able to see the bigger picture! I'm certainly willing to put the work in, and read up on it, to make myself understand it, and even watch programmes about it – David Attenborough and that sort of thing. In effect, to be a scientist, you've got to learn your trade! You need an open mind to take on new theories, if you haven't it's a barrier and you can't make new discoveries! What I've noticed as well is that every scientist has got a strong curiosity for everything, just wanting to know more. So yes, you've got to have a love for it! You've got to enjoy it and be passionate about it. And that's me! Like … just imagine discovering the Higgs boson and things like that. Just the thought of like, just finding something new and, and, making a breakthrough….that just makes me want to keep going.

Science narrative:

- *What are your memories of science?*

But how did I get to where I am today? Science has always been around for me, and my interest probably goes way back to infant school when we went on a kind of expedition, collecting different samples of leaves, and we took them back and did tests on how soft they felt, and now I know that it's the waxy cuticle, isn't it? I remember as well going to a convention called "Making it", and built some sort of toy rocket, and in the juniors we went to a museum that showed the different stages of the solar system. I always liked science because of the simple experiments, like we thought it was magic when water evaporated, and we discovered salt! We even looked at a mouldy pumpkin! I liked seeing how things reacted … have you ever done the Mentos in coke? I used to look forward to science and got excited when they told us that we were doing it that day.

At secondary school, we started doing more of the theory sort of stuff, like biodiversity, dissections, even the limestone cycle! There were more developed experiments, and we started using new equipment. I mean in chemistry we'd do things like Bunsen burners and experiment with different chemicals – we made methane bubbles! Thinking of chemistry, I remember we had a visitor in year 7 who came to talk to us, and that got me interested in it as well. It became more and more my favourite subject, so that I wanted to learn more and carry on at ‘A’ level. What I really liked was how you’d learn bits of a concept, and then a whole concept would come together.

Another thing that I really liked was one of our teachers used to have microscopes out to look at plates of different bacteria and things. You could just to go in and have a look, and we used to make drawings and try and figure out bits on our own from homework. Me and my friends would always just go in and do extra work in there, bar from doing stuff like football outside. That really sparked my love of science. At ‘A’ level it was completely different … the gap between the start and where I am now is magnificent! There’s like titrations now! You wouldn’t even know what they were when you were younger!

Who or what influenced you? Internal and external voices:

- *Personal Interest:*

So although it’s always been around me, and I enjoy it, it’s still difficult to say what actually influenced me to carry on with science. Certainly the science itself did. I started reading up on things that were going on in science, what was actually happening. I started to appreciate what actually research is, and how important some of it is. I wanted to get more of an insight and learn, I suppose, about ourselves, and the world, really. Again I just like the thought of finding something new, or making a breakthrough … that’s a major influence, that just makes me want to keep going. And, you know, I’ve always tried to make sure that whatever I do I’m doing for my own enjoyment, or for my own progression. I suppose then that I kind of motivated myself to carry on with it because I enjoyed it that much, and I also enjoyed it because I was successful, and I was successful because I enjoyed it! I got an ‘A Star’ at GCSE! So as you can see, I’ve always enjoyed science and I’ve always had an interest in it.

- *Family and Friends:*

My family has been important. Mum and dad always got me interested in different things and allowed me to explore. They took me to the science museum, and places like that. They support me in anything I’m doing, they just don’t mind what I do as long as I’m happy. Actually not many of my family have gone to university, not studying science at least, so I’ve not really got my interest to carry on with science specifically from them, they’re not “sciency” really, although my dad has a real big interest, but, you know, he’s not done a degree or anything. “I asked my friends about this and most are like me, but one has a cousin who studies a veterinary course, and she was influenced to at least carry on with sciences. Another’s dad did physics when he was at college and he was always talking about it and explaining things, and that kind of sparked my friend to do science as well, and another’s dad was a chemistry teacher, and that also helped.”

Friends? No they haven’t really influenced me to carry on with science, but it helps that my chemistry and biology buddies are into science as well. Actually, one person, a year older than me who’s having to retake it, told me how chemistry was his favourite and he said “really you should take it” - I was going to anyway but he gave me a bit more comfort about it. So really, I’ve chosen my options to benefit me the most, I mean I do enjoy being with my friends but I think it’s more important that I get the qualifications I need.

- *Science Education:*

Teachers, thinking about it, my teachers mostly influenced me, you know, the way their knowledge is like amazing – I’d love to know that much about a section of science! I want to be like that one day. They got me on the path towards actually, really, technically doing science, like actually appreciating the theory behind it. They’ve been really encouraging, talking to us about where science is going, and the sort of things that people are looking into. They know what you enjoy and try to make boring stuff more enjoyable. You know, it wasn’t just learning the facts, it was how they relate to the world around us. Like when we looked at controlling air pollution, they’d say “have you seen the latest figures in the news?”, and we’d learn about how we as a country could reduce them, and things like that. I also remember at our sixth form open evening, they were quite motivational and quite ambitious, because they wanted us to be interested in it, and they wanted the best for us. They’d find out how well we were doing at GCSE, and encourage us to carry on with those subjects. They made me want to continue, they definitely sparked a proper interest in the sciences, yes, definitely.

- *Nature of Science and scientists:*

Scientists themselves are also inspiring because I think they’re finally making headway towards something. They’ve made a lot of big dents in some of the bigger questions in recent years, with the likes of Hawking about, and with the Hadron Collider.

Conclusion:

So although it is possible that scientists like Hawking and Cox might be big inspirations, for me personally, if I was in the position of wanting to take science, I don’t think someone like Brian Cox could influence me to do it, it would just be myself, what I enjoy personally.

5.5.2 Undergraduate: combined data from undergraduate cohort

Celebrity Science and Scientists:

- *What is a celebrity?*

I've just read 'The Brian Cox effect is a star turn' in The Telegraph! They're calling him a celebrity! Have you seen it? A celebrity? Really…aren't they on "Big Brother" or you know "I'm a Celebrity", that kind of show, you know glamorous, popular, that kind of thing. Like pop stars and movie stars, and footballers and singers…they've got the talent and they work hard. I suppose for me celebrity means just people in people's eyes, they're role models, people that you look up to. They're certainly noticeable, and well known for something that people consider important in some way…sport or music or…scientific achievement? Maybe.

- *Can scientists be celebrities?*

They're not particularly scientists! In which case Stephen Hawking would very much be a celebrity, I mean, everybody's heard of Einstein and Newton…people have heard of the big ones. I don't know if Attenborough would count as a scientist, but there's him as well, and I guess Brian Cox, he's become a celebrity through TV. And I remember there was somebody who got a Nobel Prize recently for, I think it was something to do with quantum physics, I think it was Higgs. I can't think of any women, though, other than…what's her name? I can picture her, she's really quite pretty, Professor Alice Roberts, yes. Scientists should be celebrities though, especially in certain aspects, like finding cures for different diseases. Usually you hear about what's happening in science but you don't hear about the scientists themselves, so it would be nice for them to be acknowledged for what they're doing. And like your professors, they probably don't get noticed, whereas they should. You know some see scientists as people who have crazy hair and very geeky and sort of keep themselves to themselves, people who find out things for the greater good but don't necessarily take the limelight.

- *Do you think they influence people?*

But do they influence people like the newspapers are saying? I honestly don't believe that they had an effect on me, but on others, I think so, yes. Like people in school, by just hearing about what they've done and reading about them. But I think it depends on the individual, and I think you've got to have an interest before being inspired to do something, not the other way round. You'd have to have an interest in what they're doing, to be able to follow the same sort of pathway. So they probably have a small role to play because obviously people are going to be watching what they're doing, and if they're interested in it they'll realise "Oh, yeah", and they'll probably be more likely to take on that role as well. I think they might also have an influence on other scientists, and possibly the general public as well.

- *Have they influenced you?*

But as for influencing me, not necessarily, which might sound odd. I think they're doing what they do, and they're wonderful people but they've never really affected me as such. I just have great respect for them. For me it's always been a personal interest, and I think it's more that if you're interested initially in science maybe those types of people might reinforce that science is quite cool, and that it doesn't have to always be really boring and "oh, let's read a text book", it could be something as simple as going on TV and seeing that they present some very interesting television programmes. And I think that's great, yes. So maybe they've had a bit of an effect on me, through reading about what they do and what they say and seeing them on TV. Actually, although it's not quite the same as celebrity scientists, watching TV programmes about nursing made me want to be a nurse, things like 'Midwives' and 'Twenty four hours in A&E'. I used to watch them and I just went on and thought "Oh, I want to do that." They opened my options because by watching I could see what I wanted to do…like be a psychologist and do mental health nursing. So, yes, I think there's a place for those types of programme, and I think quite a lot of young people do watch them as well, but you never would think to relate them to science…would you?

- *Who might they influence?*

I can see the potential, then, for people to be influenced. I mean, let me put it this way, I recognise Wayne Rooney as a superstar footballer, even though I don't play football. And so younger people who are perhaps fresh from college or indeed still at school, might think: "I could play football and become a superstar or I could become a professor of physics and become a superstar." So there is a possibility, there is that potential path, maybe, but I think it would help if there were more in the media because you know younger people are interested in facts, and interested in celebrities in magazines and stuff. But even at GCSE you're not really taught about scientists today...you learn about the older ones, but not the one's today.

- *Do they inspire or entertain?*

The TV programmes I've mentioned can really be classed as entertainment, but I think in terms of inspiring people to do a science I think you need less entertainment and more content that influences. Celebrity scientists should actually inspire people to do something as opposed to just reading about them. But I know that people do science because they enjoy it, and because they enjoy it they're more likely to do something! So their influence is the science itself! It's not just documentaries either, there are some non-factual programmes about science like 'Big Bang Theory'. I think that one is mostly entertainment really, maybe a bit of inspiration because they give different views on science and scientists. It's the same with an interesting programme on nuclear power, I think it was called Pandora's Promise, and that showed a lot of what went on behind the scenes. So I suppose people could get interested depending on what the programme is about, and if they're interested it might inspire them to push a bit more for that sort of position. So these programmes both influence and entertain.

- *Do you think the 'Brian Cox effect' is true?*

Perhaps the 'Brian Cox Effect' is real then? I don't know whether it's because I'm getting more involved, but it seems to have shifted that way, it's there for people to see and come across every day in the news. Science is in the public eye more and people hear about these kinds of documentaries. So I do think that what they're doing and the way they're putting themselves out there is helping. So yes, I think there's possibly some truth in it…possibly just the people who follow what he does, as obviously anybody would have to be interested in science at least to some extent just to watch it and listen to what he's done, but yes. I watched a few of his programmes but they didn't really affect me. He did something like "Dr Who" where he sort of explained things…I watched that with my parents. There's been a film out about Stephen Hawking as well, which I definitely want to go and watch but, yes, I think if it…if it's helping people want to carry on with science I think it's a brilliant thing. I think people can relate to them and so we could use them to show something to look up to, I guess.

Nature of science and scientists:

- *What is science?*

That's really how it was for me…I could relate to the programmes because I love science! We use science every day, you know, without even realising it. The drugs that saved my life, and my telephone is based upon really complex knowledge of physics and chemistry. Even though I like my science to make sense, I also like the 'mystery' of it, and how you use scientific method to observe the world and create theory rather than going on what you believe. For me it's a way of understanding the things that we don't see on a regular basis. We go through our lives, we're busy, but sometimes it's just nice to stop and appreciate the things that you're not necessarily seeing all the time. I was reading the other day about the double helix of DNA. It was Rosalind Franklin, she found out something amazing that we just take as common knowledge now, and I think that's something that should be celebrated. There are always new things to find out about life, the universe, how everything works!

- *What does it mean to be a scientist?*

I'm a scientist, and this means that I am methodical, logical, and curious, wanting to know more, wanting to improve the world! I have learned the basics of all the different aspects of biology, chemistry and physics, and this is important, I am always keen to find out more! I'm not afraid of getting things wrong either, because through history people have had theories and they don't always turn out right! On my course, I always feel like I'll be helping someone and it's a big responsibility. We're always talking about finding cures for diseases, and preventing issues in the future, like with the environment. And medical appliances - we've just excelled so far and imagine what we can do later, it's brilliant. Even new materials like Kevlar to use in everyday life. Science has definitely helped people and will continue to help people. But here, communication is really important, because you have to share what you have discovered. It's a shame really, but I don't think there is much in education today about what's current in the news. I mean, you can research it yourself, you can go online and on Twitter, but I think in school you're just taught the main things that are relevant for science, but there's nothing that's really sort of current. If I was in secondary school now and somebody was saying "Oh, here's about three-parent babies" or something, I would be really interested, you know. We've got a debate at the moment on my course about "23 me", the genetics testing thing, and it's very intriguing but at the same time I feel like it could be a great help if we just all band together and communicate.

Science narrative:

- *What are your memories of science?*

But how did I get to where I am today? Who influenced me? I've always been interested in science from a very young age, in the way things work in the world. At primary school, I just remember it being a lot of fun like practicals, things like magnets and invisible forces; I just wondered where they came from! We did a space project, and another about volcanoes, it was just so interesting, and it was so rewarding and it made you want to do more. In fact I remember showing something to the class that I'd researched, I think it was a glass and you put salt and water in it and it evaporated and made a crystal! I remember in year six there was a question: "What happens when you put too much water in a plant pot?" It was something really silly like that, and I remember being like, "Oh, I don't know", and it really affected me! It was so strange that I actually went away afterwards and found out. Even outside of school I'd do a lot of things, like with electricity, experimenting making circuits…that was always fun. And I remember for birthdays my parents would always buy me science experiments, and I subscribed to ‘Horrible Sciences’? I used to collect all the magazines, and the freebies, and I got some microscopes as well. Another thing I used to do was play doctors with my family. I would see if they were alright, pretending to listen to their heartbeat. So there were a lot of little things, I suppose, that influenced me. Science was just a really massive thing in my childhood, and to this day, it’s still got me!

At secondary school, science was one of my favourite lessons, we did a lot on the body and we dissected a heart. There was progression from primary, with a lot more background, like the science behind radiation and things…that was interesting to me. I’ve always enjoyed the experimental side of it. I can remember the test where you put Mentos into lemonade…I thought it was amusing at the time, I was really young! We did some practical activities, but, because at that age puberty hits and people are quite boisterous and rebellious. I don’t think we had a lot of experiments in chemistry, because I don’t think a lot of people took it seriously. But I was always interested in it…it didn’t stop me from wanting to pursue it! We went on a few school trips, like an astronomy trip, which I thought was really cool, and in the last year we went to the zoo…that was fun and it motivated me because it was about animals and conserving them. That influenced me to carry on biology. There was also a very eccentric man who came into school when I was in year nine. He poured hydrogen peroxide into this big funnel, but as he poured, it all came out and blew all the tiles off the roof. That was a good moment…and he threw frozen bananas across the hall. He just went for it, and it was fun; you never got business speakers being all eccentric and exciting!

At ‘A’ Level, I really enjoyed all of my science subjects, they were great. My friend struggled with physics…it was the maths apparently. One of the other things I remember was a time when we had to talk about who was your role model, and there were a lot of people saying “Oh, my mum is” or this pop star and mine was Antoine Lavoisier, the scientist with the periodic table, I put him down! Everybody was like “who’s that?”

Who or what influenced you? Internal and external voices:

- *Personal interest*

So even though science has always been around me, and I enjoy it, it’s difficult to say what actually influenced me to carry on with it. I liked the challenge of it, and there were always new things to find out. I really like quantum stuff, it’s almost like another language…some people just don't get it, but I just love that you meet so many people who do, and you can almost talk on a different level with them. I just love it, it's a nice sort of escape from reality.

One of my friends had a gap between A' Levels and starting this course. Although he originally wanted to be a science teacher, he ended up working in the recruitment industry, describing it as 'lucrative' but a nasty environment to work in. Then he had a nasty accident and ended up in intensive care! At that point, he thought "if things had gone badly could I say I've lived my life to the full?" The answer was no, and he is now on my course. It was absolutely life changing - one of those moments that puts life into perspective. The science had always been there, and he went back to it…his own influence, if you like.

- *Family and Friends*

My parents were a massive influence. They encouraged me to go into what I was enjoying and they knew I really liked science. And they always thought "Wow, OK!" I remember them taking me to lots of museums, like Isaac Newton's house and the Science Museum. They didn't really have much of a science education at school…but they were so supportive and pushed me to explore it further. I asked my friends about who influenced them. A few said they have family who work in science, and that it helped to spark their interest. One was from a very sciency family with mum a nurse and dad a pharmacist, and said "science in a way runs in our family, so I got quite a lot of help and support." Another grumbled though remembering how his dad, who had a PhD in physics, talked him into doing 'A' Level physics and said "it wasn't really my thing!"

Another friend said their actual interest in forensics came from mum and family. Apparently it was always a kind of weird fascination and they would watch not television shows like all your 'CSI', they didn't like any of that... it was always like your real life documentaries, and reading, and wondering why a person did it! Others also talked about TV programmes as well, and how they interested them, like "24 hours in A&E", "Holby City", and "Casualty," they said they're not real life but there are aspects in them.

Friends? No, they didn't influence me. None of them went on to do science, and actually they thought I was really weird for being so interested, and I could never explain it to them.

- *Science Education*

Teachers were also a really big influence. I had a few good science teachers through secondary school, pushing our grades, and giving us a different way to learn. My first chemistry teacher at 'A' Level wasn't really interested which upset me a little bit, but my second teacher in the second year was a doctor of chemistry and physics, so she was just on the ball. And it was, I think it was the first time I was properly like, “Oh! This is wonderful, I really understand it.” And I started to read up afterwards. That was the final rung where everything kind of clicked, and I thought right, something along the chemistry line is where I want to go. I took physics at ‘A’ Level as well despite always having quite negative experiences with teachers, but I just think it made me in a way want to prove them wrong, that I could do well.

Actually, one of my science teachers was absolutely obsessed with Brian Cox, she thought he was wonderful. She ended up arranging for the year below us to go and meet him…for them of course, not for her! It was just some sort of personal excitement and to say that she had! I believe she looked up to him and thought he was a wonderful person, and she wanted the students to think the same. I suppose it was nice to know that someone in the science field could be that important just to a complete stranger like the way actresses are to other people.

Conclusion

Anyway, celebrity scientists? I think, although I have great respect for them, and they present some really interesting television programmes that could influence people to carry on with science, but I think someone would have to be interested in science at least to some extent to watch them. And this is how it was for me. In fact anyone I’ve really known, whose known me well, has always said that science is the right place for me to be. There’s never really been a question.

4.5.3 Postgraduate: combined data from postgraduate cohort

Celebrity Science and Scientists:

- *What is a celebrity?*

I’ve just read ‘The Brian Cox effect is a star turn’ in The Telegraph! They’re calling him a celebrity! Have you seen it? A celebrity? Isn’t a celebrity someone who, I don’t know, someone famous, like a household name…you see their picture, or hear their name, and you know who they are, and possibly what their opinions are! Sometimes though they’re famous for nothing, or just being related to somebody…they’ve probably done nothing to make the world better.

- *Can scientists be celebrities?*

There are lots of people though that are incredibly well known but not thought of as celebrities…just because you don’t see them on television, you know, like those scientists that have Nobel prizes! It makes me a bit frustrated that Nobel prizes aren’t televised but the Academy Awards are…that my field isn't as greatly acknowledged as others. Perhaps these scientists should be known as celebrity scientists! Probably not, because celebrity is based on gossip and personal life, and if you're a scientist…I know I wouldn't want people to go into my personal life. I wouldn't even say that Einstein and Newton were celebrities, not even Einstein with his name and quotes on t-shirts, you know, and even if nobody knows what his science means, they know who he was. I'd just say they were important figures in the past, or high profile scientists, like Rosalind Franklin, she would be one, Marie Curie, Fleming…you just don't realise that they've had such an influence on society. There’s Brian Cox, he’s done a lot for astronomy, and there are also BBC programmes like "Bang Goes the Theory", and who's that guy that does "The Men Who Made Us Fat" and "Embarrassing Bodies?” I can't think of his name…is it Dr Christian? Who else is there? Richard Dawkins, Neil deGrasse Tyson, Stephen Hawking, David Attenborough, Bill Nye: they're definitely ‘celebrities’…they're known the world over by scientists and non-scientists alike. I’m struggling to think of any women today that are involved in science. I know a couple, they're on TV shows, but the male is the host, with the female in the background. You know, I wonder if there are different degrees of celebrity! There are global celebrities the same as Brad Pitt! But there could also be more area specific celebrities, like key scientists who aren’t world renowned, but among scientific groups they are celebrities.

So OK then, scientists can be celebrities, but I suppose it's the power of the media that really creates a well-known celebrity. Actually, I think it’s a hard world to get into. If you do go down that route, though, I don't think you can be both. I think Brian Cox has got a bit too much face value now. He's lost his way, he's doing all these extra things. I'm like, if you just go back to the basics and start doing what you started doing, you'd get better.

- *Do you think they influence people?*

But does Brian Cox, and do the other celebrity scientists, influence people like the newspapers have been saying? Science itself is certainly influential, even if it only spreads to one other person and it helps them improve their life. And that's part of the beauty of it, science can be influential to anyone of any age, from anywhere, it's literally a universal thing, scientific principles apply all over the planet! But celebrity scientists? I think they do you know, look at David Attenborough! They're the sort of people you'd be more willing to agree with. If they were explaining their opinion on television or radio, or you were reading an article they'd written, I think you would definitely be more inclined to trust what they're saying and learn from them. You know, because scientists are generally deemed to be intelligent, so I think people would perhaps look up to them and definitely take their advice. But you know sometimes it can be negative, look at Dr Wakefield. He wrote that paper about autism and vaccines. And even though his paper was retracted, he's still getting people quoting him. He's still going on talk shows telling people not to vaccinate children, and he's still influencing the opinions of other celebrities. So yes they can have a massive impact.

- *Have they influenced you?*

It's made me question whether they influenced me… but, no, I mean they wouldn't have been my influence. I always found shows like that interesting, but … actually perhaps *they are* part of what got me into science in the first place, people showing that science wasn't boring, it wasn't irrelevant. Like even today, if I hear scientists talking on TV about a subject it encourages me to find their papers, like Dr Ben Goldacre, I've been on the websites that he's suggested. But having said that, I do think that the people immediately around you are the ones that influence you, like my teachers because I could actually physically have a conversation with them. So I think maybe celebrity scientists are influencing us without us realising it, but I definitely think it's those 'immediate' people. Like I was at a CPD event with a sports scientist, and although he's not a celebrity scientist, I listened to him and I certainly felt influenced by what he said. I suppose within the industry he'd be a celebrity. I think he would have influenced a lot of people on that day because of his knowledge and experience, and his reputation. There's also a couple of scientists at university that I aspire to, but basically I want to come into my own, I don’t want to be someone else. There's definitely an element of wanting to be where they are, not because they're on TV, but because they're successful academically and professionally and get to be involved with all sorts of things that anyone'd dream of being involved in. So they do matter to me personally because science is part of who I am…I'm interested and passionate about these things. But I understand that everyone's going to go a different way with their life, they’ll take an interest in other things, but you know, I do think that celebrity science is going to have a much bigger influence in preparing the next generation of scientists than a lot of pop culture is.

- *Who might they influence?*

So if people do think celebrity scientists influence, do you know what they should do? Target year nines and year tens - they're making their choices at that time. Target them, get them interested in science and they should continue with it. If you target year elevens, or year sevens, they're not going to really care because they've already made their choices, or they're just too young and don't really want to think about it. So year nines and tens, and maybe younger as well, like primary school? Maybe to get the interest there, in the back of their minds ticking over, and then if you hit them at year nine, they'll be like "Yeah!" And if we could start televising Nobel prize-givings and award shows for science that would put science in such a better light for children as well. They'd be like "Oh! I wanna' be like Brian Cox", instead of Kim Kardashian or whatever. That would advance science so much as well by getting ‘new brain’ in, because, you know, the newer ones are the ones with the ideas sometimes. There are some science programmes as well like "Brainiac" and "MythBusters", where they try to put the scientific method sort of-ish, as long as there are explosions! They try to influence young people, and, I may not like it because it's not real science, but it does attract people. My teachers used to use TV clips if they couldn’t demonstrate things in the lab, but actually genuinely believing that someone's going to make a life changing seven/eight year commitment on the back of a TV programme is just ludicrous, it's … it's foolish.

It’s not just about school students, though, the older generation might be influenced as well, because I know a lot of people have become interested in science just from listening to podcasts. They might feel that it's too late to get into that career path so they just keep listening or buying a telescope. Other professionals in their field as well might be influenced, you know, people would listen to them and come for advice…they would lead other people. And, thinking about people in the media, because sometimes they parrot what's said, you know, they hear a clip from a seminar and make an entire column out of it, even if it's out of context. Like Katie Hopkins, who religiously follows Dr Wakefield! So, yes they do affect people, they do have an influence, but I think people have to first learn about them and see why their work's so remarkable, and you'd have to target certain audiences, but it depends on the person to be honest. You know, its baby steps to get people into science, but once there it's got you gripped, because as soon as I was interested that was it, I knew I was doing it.

- *Do they inspire or entertain?*

Their programmes are definitely entertaining. I mean all the nature shows that David Attenborough has presented, but it's like teaching as well, because you're learning about different animals…he can both entertain and inform! But, I think they probably influence more than entertain. In fact, some programmes can be hugely influential but not terribly entertaining, like environmentalism, which can be very boring but extremely informative. On the other hand you can also get "scientists" who are hugely entertaining but not terribly educational…no matter how many explosions you put in your programme, if it's not scientific method, it’s not terribly useful. So, it depends on the celebrity, and it depends on what they're talking about. Because, you know, there are things within science that just don't get seen, and they are what really needs to be shown by these people, and made available to younger age groups so that they can actually fully understand where they can go within science. So I really think it's a bit of both, they influence and entertain, and I don't think it should be limited to either especially with celebrity scientists. They're a form of entertainment in themselves, I mean there's no question on that one, but it's that subject specific entertainment that could leave people asking "Why does that happen?" I think the interest helps and the entertainment helps, and between the two they could be enough to spark a passion.

- *Do you think the ‘Brian Cox effect’ is real?*

But the ‘Brian Cox effect’ as a thing? I’m not sure really. He's not one that I particularly follow because obviously he's very physics based isn't he? But I do know of him, him and the comedian Dara Ó Briain … he’s actually got a PhD in astrophysics! But I'm not aware of all of his work to be honest. On the show about the solar eclipse, they had all the children around them and were showing them how they could see it using different techniques. So I do think they have an influence, but maybe on a certain field of science. Obviously not on biology or chemistry, although I think he did do a biology programme, which was good in terms of getting science across to society, although within the scientific community it might have been frowned upon, because it's not his field of work. They probably should've got someone that was biology-based, but then as people already know of Brian Cox, and they don't know of anybody that does biology, unless it's David Attenborough, no-one would watch it would they? They wouldn't be interested if they didn't know who the person was I suppose.

It does make sense because it fits in with the celebrity effect, where if a celebrity does it there's suddenly a surge, like the "CSI Effect" where people watch "CSI" and decide they're going to be a "CSI". And then three years later they're like, “Oh! This is not as amazing as I thought it was going to be.” For some friends of mine, the main reason they joined a forensic science undergrad over anything else was because of TV shows, things like NCIS. They watched it and thought "Oh that's interesting, I'd like to know more". I know it’s fiction, but I think it's still applying the same principles, and it's still making people ask the same questions, isn’t it, even if it is purely intended as entertainment. And if it gets people asking questions then I would say it's done the right job. Personally though I'd expect that people would have an interest in science first. If someone hasn’t got an interest in forensics then they're probably not going to find something like CSI very entertaining, and if it hasn’t got the entertainment factor, then they're going to lose interest.

But, specifically the ‘Brian Cox effect’? Actually, if you think about it, science had already started increasing in popularity before Brian Cox happened, people had already made their decision to study science further. So it's like, it's not Brian Cox causing it, its people getting an interest in science early on and loving it, because that's what you have to do: love it! So I don't think he’s been inspirational in my lifetime. I think I just got lucky with good teachers and parents who were pushing me the right amount to, well not even to get into science, to just do what I loved. But I do think that he will influence young people in the future, and I do think they should try and find a few different people, because some of the programmes he's on, they also have really weird people as well, and they're probably having the opposite effect! Because he does it and he's cool about it, whereas I think it's quite easy to come across "not cool"! Anyway, I think that the media got lucky, and Brian Cox also got lucky by making such a transformation from what he was studying, to his lifestyle now, but I don't know if that could be replicated very well through anyone else. I guess its personal preference, I think he's funny, my other half can't stand him!

I suppose what I’m saying is that if people want to do science they will. They can have role models, they can have idols, whatever, but fundamentally when it comes down to it, if someone doesn’t want to do science, they won’t do science. I do think celebrity scientists draw people to try it, which is a positive I suppose, but I don't think it actually pushes people further into science as much as they think. Having said that, very often I find that the media can be quite belittling and negative about science, and it's very rare that you get many positive stories, so I'm quite happy to get behind what they're calling the 'Brian Cox effect'. I've got no problem with that at all. And I do honestly think that science programmes are really good for getting people involved with science, showing them how amazing science can be, giving a 'wow' factor! That's what's really important for younger people to see, you know, just how incredible something can be through science.

Nature of science and scientists:

- *What is science?*

And that's how it is for me…I love science! It's 'The future'! It's everyday life…it's all science: you move, it's physics, you make a drink, its chemistry, you drink it, it's biology. And everything links together. You discover new things, and you're never bored! There's always that next thing to interest you…like my current research, I've had to backtrack, because every big question I ask, I have a hundred little questions to answer before I get there. It can be frustrating, but it's also one of the best things to happen, because it's always going to be, "Ok I've answered this, now what?" It's certainly not stagnant!

- *What does it mean to be a scientist?*

Some people might not even realise they're scientists, depending on what industry you work in, or what your job is. Because, obviously when I get a job the title might be 'scientist', but…like my parents are farmers, and there are quite a lot of 'sciency' things that they have to do, like soil analysis. So they might not know it, but they are engaging in science. It comes down to scientific literacy, you know, and I think it would be beneficial if people were more scientifically literate than they are at the minute. I'm a major advocate of this because I know a number of people who aren't scientifically literate at all, and sometimes I feel like it holds them back from understanding things, and seeing things the same way that someone like myself would. I think a lot of scientists, although are scientifically literate, probably don't know how to get their published work out there into society, you know, how to communicate it, and actually being able to teach someone else is almost a test of how well you know something yourself. And I think that's one of the major problems – science just needs to be communicated. Especially as right now there seems to be an anti-intellectualism! As I've already said, society tends to put scientists in a bad light a lot of the time…it gets a lot of bad press, with the media diluting the importance of science by grabbing a headline. Like there's one newspaper that drives me crazy…every substance known to man either causes or cures cancer! You can't even look to see if it was a true article! I think the media has a responsibility here, if they are going to publish peoples' results, they need to collaborate with the scientists and actually write down what is true! I know it’s difficult, we are modifying things we shouldn't do, we're playing God, but at the same time science has basically created our society as it is, and we wouldn't have technology or clean water, so I do wish the public would get a bit closer and actually realise that scientists aren't all bad, we're actually trying to help. But I do know that public trust needs to be earned, because if people aren't behind it then they're not going to understand why we're doing it…there has to be a balance between peoples’ perceptions of science itself because it's not supposed to be an enemy situation! It's extremely important to have quality information, and educated people making decisions…if you don't then you get situations where people are told that, I don’t know, vaccines cause autism! Then everyone’s scared, and it destroys peoples' lives. It might sound a bit overblown, but that's what happens if there is a breakdown in communication.

Science narrative:

- *What are your memories of science?*

Anyway, I’ll get off my soapbox! You’ve probably realised that I’m passionate about science! And actually quite persistent, and dedicated with a real thirst for knowledge. I always try to think outside the box but still in the ‘realms of reality’! Actually science blows your mind! It can be frustrating, especially as a researcher, but definitely (mimes fireworks). So let me tell you about my science journey, how I got where I am today.

I remember that I just loved science at primary school, I got bored in every other lesson although I don't really remember much detail. I can remember things like looking at plants and sex education, but that was about it…but I still loved it. It was at secondary school when I became more interested. I didn't like physics that much because of all the formulas and maths, but I liked chemistry and biology. I remember being in a biology lesson in GCSE, and we were sat there dissecting a pig's eye, everyone else fainted on the floor…but not me? I just liked cutting it up, lenses everywhere! It was brilliant. When I was fourteen I remember going to a seminar where there was a lady from a university…she was the first prominent female scientist I'd seen. She talked about what was possible, and how dynamic science is. It wasn't just…you go into an office, spend eight hours pushing paper and then go home. She said that her team had made inroads on finding new medications, and cures for diseases. And that really interested me and that's when I starting focussing more on science.

At 'A' Level it was brilliant! I remember in the sixth form going to a university, where we learned about the main physiological tests and the equipment that they used with sports teams, like how you'd calculate power or somebody's VO_2. It really gave me an insight into how it's applied in an elite setting, and that influenced me to continue with science. We also went to museums, and other places where you can see science in action, like national parks with fossilised leaves and shells. It was better than just sitting in a classroom having information taught to you.

After my 'A' levels I went to university to do a degree. I remember going to the zoo…it was nice to see that animals were being saved from being endangered. And in the third year we had seminars with guest lecturers from all aspects of science. I remember there was one guy that was particularly interesting, he was looking at fingerprints on notes and being able to track drugs because of metabolites that come out through sweat! My science was important but I didn't really know what I wanted to do until my second year really. I knew I wanted to go on to do research because I just found it so interesting, especially molecular biology and microbiology. These are things so small that you can't even see them, and yet they have such a large effect on our lives, and, so as soon as I started microbiology it was like "this is for me." I did some research on different Oncoviruses, and Merkel Cell was very new at that point so I got a little bit of a taster into it and I thought "that's what I want to study", and I am. My friends are doing interesting things as well. One is hoping to patent a new antimicrobial that we haven't seen before for acne treatment … one that's not steroidal and is not going to harm you. Another's work is forensic based, developing a technique to be adopted by a police force that will give closure to victims of crime, as well as helping to catch the criminals. And another is working on knocking milliseconds off someone running a race!

Who or what influenced you? Internal and external voices:

- *Personal interest*

So there you are! Three years down the line and still loving it. I've always said that science is who you are not what you do, and that's become quite clear for me. I was always a curious child! I just wanted to know the reason behind everything…my constant question was "why?" And I think that's kind of what drew me to science in the first place. So it's like you can't take the science out of the person, it's your mind set, it's who you are. And with microbiology, it just clicked even more firmly in my head that this was my next step. I just couldn't see myself not doing it. And I am quite ambitious, I want a PhD before I'm thirty, and to get into lecturing…so I'm both subject driven and academically driven! So I suppose if I had to pin it down, I was my own influence, I just always knew that science was for me!

- *Family and Friends*

My parents, though, have always been a big encouragement, always helping me to learn and figure things out. Even when I was playing in the garden it would be "look at this, see if you can figure out what this is." And we went on trips too! I remember going to a silk mill and they bought me a dried silk worm. I was also bought science books, and I remember getting a science kit where I ended up in a lot of trouble doing experiments in my bedroom and making a mess! But even though they knew that I was like a different child in my science lessons, they didn't really push me, but they did aim me in that direction. Some of my family are scientists, and that influenced me. My brother's a microbiologist and I've got a cousin in technology. Mum's a big science buff, she did a geology degree, and subscribed to "New Scientist". I was lucky really, because most of my friend's parents weren't actually into science at all. So my parents have been brilliant…supportive one hundred *per cent*, whatever I wanted to do, pushing me to be academically strong. They're less of an influence now, of course, because I'm not living at home, but especially in the pre-school years, they really made a massive effort to spark a passion, so that when I went to school I would seek out knowledge for myself.

- *Science Education*

My teachers were important too: they were enthusiastic, dedicated, and absolutely brilliant, just really passionate about what they did. I had one fantastic science teacher who would do the science lesson, with lots of hands-on experiments, and she'd go off on tangents with side stories of her own…she always kept things interesting. My teachers made sure that I got my answers correct preparing for exams, and I asked their advice about the best university to go to. I remember my primary school teacher writing a note on one of my reports that said "she can do whatever she wants to do," isn't that amazing? At secondary school, even those that weren't the best teachers in the world, they always pushed me, but they never told me I had to do biology, or that I needed to do 'whatever', it was always my decision. It wasn't just the science teachers either, it was the technicians too, they were always really nice people. At my friend's school, they went through quite a few science teachers, they never seemed to hang around, which I don't think helped, but it was a school in quite a deprived area, and I think if you weren't teaching top set it probably wasn't such an enjoyable experience! Another friend was educated abroad as a teenager, and says that a lot of the teachers there were quite poorly educated when it came to science, and how frustrating it was when a student went into a class knowing more than their teachers…especially when one was an evolution denialist…that was extremely frustrating! But these friends still went on to be scientists. Throughout my undergrad, all of the lecturers were influential and motivating, very good at giving directions of where you might want to go, they asked the right questions for us to find the right answers, and they channelled us towards what to do next, and how to best prepare us for the careers we wanted. One of my lecturers, though, was *the* major influence. She knew everything about every virus that you could ever think of, so yes, she's been very, very supportive. In fact, it was through her that I started my Merkel Cell Polyomavirus research. And they were all so enthusiastic and I think that's what kind of kept me in science, you know, how happy people are to stay in science once they get there! And you know, I've met scientists who've been frustrated, or who have been angry, but I've never met a scientist who's been bored! They may be bored with their current project, they may be bored with routine lab work, that's temporary, but they're never bored with the science.

Conclusion

Anyway, celebrity scientists? To be honest with you my opinion is 'yes', science on TV can influence people. Like David Attenborough, I think he is one of the best introductions to science. My son is only eleven months old and he'll sit and watch his documentaries because his voice is so commanding, and the colours, and the way that it's presented. He'll just sit there and watch the birds, I think last week it was penguins. But quite honestly anyone bright enough to get through a degree is not going to make a huge life changing decision only based on a TV programme. It may have some effect, but for smart, intelligent people it's not going to be the same as Kim Kardashian telling someone to get Botox! It's not going to be a snap decision. We're talking five or six years out of someone's life. I don't, I genuinely don't believe it's going to be made on the back of some celebrity going, "Ah! It's shiny science." So again, alongside my personal experience, the enthusiasm of my teachers has made more of a difference than any TV programme. Because there's a difference between watching someone who you know could be faking it, to having someone in front of you with a chunk of sodium going "Stand back!"

4.6 Celebrity scientist constructed dialogue

Includes data from all five celebrity scientists:

- Sir David Attenborough
- Baroness Susan Greenfield
- Professor Steve Jones
- Professor Mark Miodownik MBE
- Roma Agrawal MBE

Please note that rather than having a name attached to the monologues, which could allude to a specific gender, they have been simply named: Y12, Undergraduate and Postgraduate, and the celebrity scientists in the dialogue below refer to them in this way. In an earlier draft, they were named Alpha, Beta and Gamma respectively, but this caused confusion with my readers in terms of remembering which cohort was being referred to.

Roma: The students were really quite negative about celebrities, especially Undergraduate associating them with 'Big Brother' and 'I'm a Celebrity'. And actually I find it embarrassing to think that people might call me a celebrity.

David: Yes, I despise the word…I bristle at it really.

Susan: It has so much baggage attached to it, doesn't it? Although Y12 did suggest that they are people who are 'doing good'.

Mark: I call myself a TV scientist, because people don't know who I am, I'm not a 'household name' as Postgraduate described. I think as well that when you're a celebrity there's a currency about any aspect of your life. Y12 mentioned the 'paparazzi' as a reason why scientists might not want to be celebrities, and Postgraduate doesn't like the idea of the media looking into their personal lives. And they're right because your face can be in the media outside of what you actually do! Like Brian Cox, he would definitely fit there.

Roma: Yes, he's the obvious one.

Mark: And he's probably the only one in science that is a true celebrity according to that definition. In fact, as Y12 said, he does do a lot in the community and is even on reality television!

Roma: I think you, David, are the major one, though.

Steve: I agree, you are the king of them all! Interestingly, Undergraduate alluded to the possibility of scientific achievement leading to celebrity status, as they deserve the fame. And Y12 went as far as suggesting that there are two different kinds of celebrity, those who deserve the fame, like scientists, and those that don't. And I agree with this, there are two kinds, that is, two sides of the celebrity scientist coin: professional scientists, like Brian Cox, and non-scientists, like Dara Ó Briain. I think they both play a part, although I think the professional scientists probably play a slightly larger part with the more serious part of the audience, perhaps because they have more credibility. But I think both are valuable, and possibly equally valuable.

Mark: I think Dara Ó Briain is a proper celebrity, a scientist by training, and he's got a science brain. There are some science programmes where you can see the presenter is presenting the science and they don't understand it, I think that's a real problem but he's not one of those. I think he's just wholeheartedly brilliant for the subject, and he's also bringing humour into it, and a humanity to it. Hmm, so is there something here about who the audience is, as both Y12 and Postgraduate suggest? And that as well as global celebrities someone can be a celebrity to your specific scientific group. And they're right, this whole paradigm of celebrity does already exist in science, it just exists in a friendly form, you can only have a voice when you've got a certain seniority in terms of your science and engineering, and then you're allowed to be some sort of celebrity.

David: I was interested in Postgraduate's understanding that it's the power of the media that creates a celebrity. I mean Brian Cox's fame, if it wasn't for television it would be only a handful of people at his university who knew him. He's a brilliant communicator, and the BBCs responsibility, when I was running things, was to find those people. Who is it that has this talent to come through the screen, and grab people by the throat? We found them and then gave them the opportunity to do these things.

Susan: I agree, without the print or broadcast media, especially the broadcast media, then no-one would know of you, how would they know of you, otherwise?

Mark: They created my role, but really it was a collaboration. However, it's also true that once you say 'yes' to a programme you are less of an architect and an author than the editors and the producers. You're more of a puppet, it doesn't sound like a very attractive thing to say, but it's true. But, on the other hand, they do pick presenters for certain things they want to project about science, so there has been collaboration with the BBC over the last ten years, as they have wanted to project science and engineering as human, and with people more contemporary, and they want diversity. They've brought out loads of women, and that's brilliant.

Roma: And I'm an example of that. I think what you need is to have some kind of story or brand that catches their attention, and I think with me, it was fairly obvious it was the Shard. So there was this hook that they had that, "Oh here's a young woman that's worked on the Shard, it's a really iconic building, everyone knows what it is, let's talk to her."

Susan: Actually, one of the things that concerned me about these young people was that they struggled to name women scientists, especially contemporary ones, other than Alice Roberts.

Roma: It's a shame because there are a lot of quite young, vibrant voices as well, and that's good, because people need to be able to relate to them.

Mark: Yes, but I think most women would say 'no' because there aren't enough people supporting them. Postgraduate makes an interesting point about the lack of high profile female scientists, and that perhaps it is still seen as a male-dominated field, and wondering if this is because they like to stay out of the limelight, and just keep on track with their research, whereas men like to show off!

Roma: I think women need to be proactive, and tap into the power that the media has. The thing to do is to try and get on an exciting, interesting project that you are passionate about, it's about trying to find that hook, or story, and selling that to the media. I don't mean this in a rude way, but they want a simple idea that they can pick up on and build around. For us, it's probably a combination of learning what the media is looking for, and giving that to the media, and then once we are in there, we can play on our other messages to our hearts content.

Mark: As a warning though, you don't get that much choice on TV. Like you get to say 'yes' or 'no' to an offer. But if you say 'yes' to something which is not exactly what you want to do, it may get you your next opportunity. For instance 'The Christmas Lectures', I didn't have total authorship, but I had a lot over the content.

David: What do you think about Postgraduate's comments regarding Brian Cox? That he's lost his way because you can't be both scientist and celebrity? In the past there was a belief that if a person became popular, he was automatically debasing the currency. And a lot of people criticised Brian Cox for this, but they did find out that he did indeed have an integrated and carefully ordered educational brief.

Mark: I have to disagree with Postgraduate here. I’ve seen a massive change. I’ve been doing this for 15 years, and I went from the point where everyone thought it was (a) a waste of time, to (b) it made me intellectually worse in their eyes. I even had heads of department who wouldn’t sign grant applications. But now, although not everyone is on board with it, the community is much more accepting of it. I suspect it’s because there’s so many of us doing it, if it was just Brian Cox it would still be this weird, special thing. So our role, and the perceptions of the science community, have changed over time.

Roma: Yes, people like me have been able to create a name for myself, whereas I might not have been able to do that fifteen years ago.

Mark: I think the one thing I’m most proud of is that we’ve bust the door open a bit, you can do this, you're allowed to do this now and still be considered within the academy as someone who’s not an outsider. We’ve really changed that paradigm, and I think that’s been great because the next generation who come along, and I already see it with our PhD students and postgrads, is that it's just totally normal for them to want to write a newspaper article, or do a YouTube video, it's fine, it's totally fine.

Susan: Indeed, things have changed. If you think of someone like you David, or Patrick Moore, in a sense they were very benign, very much loved cultural figures, but now celebrity scientists to my mind fall into two different types. On the one hand, there are people that carry on in that tradition, and just explain things very simply, so let’s take Brian Cox as a very obvious example of that, you know, someone who doesn’t say anything highly novel or original, but plays a very valuable role in interpreting difficult concepts for the general person; another person would be Robert Winston. On the other hand, there are scientists like Richard Dawkins say, or myself, who actually happen to be scientists, but are putting forward controversial ideas. And these ideas are wanted by students, Undergraduate wanted to discuss 3-parent families and ’23-me’.

Steve: If we start thinking about influence, although you’ve called them ‘benign’, Brian Cox, and you David, as professional scientists they play a slightly larger part with the more serious audience, because they perhaps have more credibility. As Postgraduate said, you are inclined to trust them and learn from them, because they’re deemed to be intelligent.

David: Yes, and both Y12 and Undergraduate discussed the need to relate to scientists. And in fact my job as a television producer was to find that someone who would make an impression on the audience in order to convey a specific message. He certainly lives up to Postgraduate’s expectations of showing that science isn’t boring or irrelevant.

Roma: Yes, people do need to be able to relate to them, and Y12 also talked about Brian Cox influencing people because they have access to him.

Steve: I can appreciate this but I'm not sure the BBC sees itself in the job of influencing people, it can inform them and I think it does. I mean Maggie Aderin-Pocock does a very good job of informing them, and she's a good role model of course, but I don't think she overtly influences them. I mean she doesn't say, now come and do astronomy. And indeed personally, I would never explicitly, as far as I know, say, 'come and do biology'. I'd say biology is interesting and fun to do, which it is. I think the pantheon of science populisers all the way from the big beasts down to the small fry, generally do a very good job. It's on air, it's interesting, it's in a ghetto to an extent, there's no science on ITV as far as I can see.

David: You're right, it's not the responsibility of the BBC. And I don't think there's that sort of obligation for the scientists themselves. That's for the person themselves to decide what sort of career they want. I mean Brian takes it very seriously, and goes out of his way to proselytize; he is very active in that, and very commendably so.

Susan: One of things that we and the media could do more of is give more of the personal side. I mean when I was at school no-one told me you could be a research scientist, I had no idea at all. And also of the different options if you do science. You know you can go into patent law, you can go into the media, you can even go into politics, you know, and areas actually where scientists are very rare and much needed. I think this is especially important with girls and women, because there's very few, and as we know the take up for women and girls is less, although it's getting better, and I think that's because they mainly see white men as scientists, and this was one of Steve's criticisms of the BBC, I would extend that for people of other ethnicities as well. I agree about someone like Maggie Aderin-Pocock, she's an astronomer, she's wonderful, but she's so unusual. I mean, she's an Afro-Caribbean woman, and just wheeling her out in front of school girls must do wonders for them. Postgraduate's experience with the prominent female scientist is testament to this.

Roma: For me, that's what it is all about actually, and that's why I do it, and that's how I came into this whole kind of strange world. I believe that we have a responsibility and a duty to portray what we do in a way that's inspiring and interesting. Y12 is clear that the science content is important, but that scientists could be role models if they see us make discoveries. I would hope that most other people would feel the same, because they're so passionate about what they do anyway so it's kind of portraying that passion. Undergraduate wants us to make science ‘cool’. And different organisations like StairSteady, and the Institute of Engineering and Technology are trying to create a set of ambassadors who are celebrities, and use us with the press to raise the profile of their campaigns and to raise the profile of maths and physics, especially as they don’t ‘look’ like ‘physics’, I think they’re breaking that stereotype as well.

Mark: And that’s definitely what I’m trying to do too. I realised that very few British students were actually choosing engineering, and for those that were, it wasn’t a very positive choice for a lot of them, it was kind of, “Oh, you’ll get a good job!” And I didn’t want the job under those circumstances. I wanted to change the people coming in and so I spent a lot of time going to schools and giving talks. And I came to the conclusion that the existential problem was that there were no role models outside the classroom. If you had a good science teacher then great, that’s the best person you can have, but if you didn’t then your role models were nothing. And if I compare that to medicine, there is a diet of high quality, highly respected and entertaining medical dramas; medicine is represented in the media, it’s part of culture, and as we’ve seen, these programmes were important to Undergraduate, showing the different opportunities in nursing. Engineering was not part of culture, and this was a big problem. So the very idea of finding different ways of thinking about my subject, and talking about my subject, was attractive to me…you’ve got to be really up for it, and I was! And again, Undergraduate thinks it would help if there were more scientists in the media, and that they should actually be taught about scientists today. And that’s good but you don’t realise that media outlets need a constant amount of content, and if they don't get it from us, they will get it from other people, or be replaced by people talking about tattoos! And they don’t realise just how exhausting it is, to be constantly coming up with programme ideas, and doing the programmes, and having, you know, life! So if we’re going to achieve this we need more and more people to do it, not less and less. And as Postgraduate said, you might get people saying they want to be like Brian Cox rather than Kim Kardashian!

Susan: What is important though, is that the science we deliver is ‘real’. As Postgraduate said, some programmes are more about the explosions! And although I can see the value of these programmes up to a point, I also would hate it to become full of sensationalism and ‘wow!’ and, you know, sort of spectacular. I think that one has to engage young people in a deeper way in terms of showing them the relevance of what science is to their lives. And that’s what young people are asking for, Postgraduate even wants the Nobel prize-givings to be televised, like the Academy Awards are.

David: Indeed, our primary job is creating something which will engage people’s interest, and hold that interest, coupled with the fact of being accurate, you know. And at the BBC we were very clear about what our function was, it was to cover the widest spectrum of human interest we could, and to deal with it responsibly in the eyes of those people who were specialists in those particular fields. And the BBC, from their point of view, would be anxious to make the programmes in a way that attracted both people who are expert in those subjects, and people who knew nothing about them, and we know about that, and they know about their bit, and the two of us can get together, but in the end it’s the BBC that’s responsible for these things and the content.

Roma: I think ‘Stargazing’ probably fits this bill. As well as experts and adults, it also had a younger audience. And because they are directly involving children maybe some more kids would watch that. Undergraduate was aware of the presence of children in the studio with Brian Cox on what they called the ‘eclipse’ show, and that this might be influential. Things like ‘Food Doctors’ and ‘Science Club’…I’m not sure if young kids are watching them or not, unless their parents say, “Oh, watch this.”

Mark: Actually BBC ‘Science Club’ was watched by kids, and it did portray science accurately as David hopes. And its impact filtered all the way down. I had loads of emails and loads of calls from people who were using it in lots of different ways. Teachers and kids, and people at home self-educating their kids, and loads of people who just enjoyed it because they thought it was very good fun. I mean it was just aimed at anyone who was curious about the world. None of the bits were assuming you had a science education, but at the same time we taught and we gave people entertainment, a lot of entertainment, we gave people things to think about. It's quite hard to get that right, to basically appeal to both the kids and the adults but I think we were doing that. And there was the mix of experts and non-experts that David was describing, I felt it had this nice level of in depth conversation, but it wasn't taking itself too seriously; it was taking the subject seriously, but it wasn't self-important. It was a shame that it didn’t continue, if you asked me the kind of programmes I would have wanted to watch as a kid, that’s it! Anyway the nice thing about that programme was that it had both policy makers on the programme, politicians, it really was trying to say, ‘look science is such a vital part of culture, it involves everyone and therefore the show should involve everyone’, and I think that's the key, it's really the key.

Steve: It is, because we need to remember that we're not doing it to get people into science particularly, we're doing it as a profession for some of them, but also as part of culture. And the students recognised this and believed that our influence extends to older audiences, and to the science community itself. I think science is more embedded into British culture than it is in American culture, and quite a lot of that comes from this so-called celebrity science theme. I think that's an important point because an awful lot of people who do history or PPE and so on watch these programmes. I mean Brian Cox gets huge audiences, you David get huge audiences. So these people are watching them to be educated, entertained and informed. This is what we should be doing.

David: The students were all very clear about this as well, that our programmes should both inspire and entertain, because if you're not entertaining, you're not going to get people watching them to be inspired! Y12 though prioritised the science itself, in that a celebrity's main aim should be to develop what they are trying to do, and if people are influenced, it's a bonus. And I can give an example, some people think you shouldn't be talking about the biology of elephants, when elephants are on the verge of extinction. I think that's misguided. I don't think anybody will care about the survival of the elephant, if they don't know something about what it was, and what it did. So the two things in my mind are inextricably linked. My view is that you don't get people caring about things, unless they know about things. I would think you spend more time saying how wonderful they are, and at the end you've only got to say 'but it's in danger and that it's being poached', that's all you need to do. You needn't show them rotting corpses. So as Undergraduate said, the "influence is the science itself." Postgraduate actually puts it very eloquently talking about our science programmes as 'subject-specific entertainment' that leaves people asking "Why does that happen?" What we need to remember though is that you can give the messages, but the question is how they're received. And they're received in proportion to how much people think that the person concerned is worth listening to and telling the truth. We are back to credibility here.

Mark: Yes, but we mustn't forget that for most of science programming, the first thing on their menu is the entertainment. When I first started doing it I got loads of emails from colleagues who were like, "Oh, you didn't explain that properly, that's not always true." And I would have to sort of construct these emails like, people are not getting facts, this is not education. This isn't replacing a lesson. In my view, all I want people to say is "when I remember the programme, I feel good about science and engineering, I feel positive." So that the next time they meet something that's related, they just feel, "Oh, this might also be entertaining, interesting, I'm curious."

David: Yes, you hope to interest people into the subjects that you're dealing with. Be aware though that what television doesn't do is communicate complex information very well. But, what television does do, is light the flame of enthusiasm, which if it it's properly tended will then send people to the library shelves, and the number of loans from these subjects should shoot up enormously. If they don't then the people concerned in television, who put on the programme should be shot! Or at least fired because they're failing! The object of the programmes is to spark people's enthusiasm and curiosity.

Mark: Absolutely, and as well I think the thing is, it doesn't put you off, and the fact that you could go to school the next day, and go to your mates and to the science teacher, and talk about it, and no one would go, "that's a bit square" because it wasn't square. And that's where Dara Ó Briain really helped, because he was well known, and because he's a great comedian, suddenly you can talk about the stuff he did in the 'Science Club', and you're not being square!

David: I think an important message for us comes from Postgraduate, and it is worth me reading this out for us: "Do you know, there are things within science that just don't get seen, and they are what really needs to be shown by these people, and made available to younger age groups so that they can actually fully understand where they can go, and what they can learn about within science."

Steve: I absolutely agree, yes, but I think a certain honesty by the science communicating community is called for, or at least a certain honesty by the current world radio, television and newspapers is called for. You know, biology is actually now becoming a hard science, but it is still sold as a soft science. So that when students get into the second and third year, they get a nasty shock, because it's hard. It's not really something that most science popularisers point out, partly because we're not given the opportunity to point it out, and that might be a useful thing to do. Brian Cox has said to me several times that he is shocked by the kids he gets into his science degree in Manchester with no mathematical background and you can't do physics without maths. And another problem is being realistic about prospects for jobs in science, which are not good, and it depresses me to know that every year more kids graduate with a degree in forensic science, than there are forensic scientists in Britain. But of course there are many, many people with a degree in history than there are historians in Britain, so that one could say, in some senses, people should do what they want to do, without necessarily the implication of getting a job. And I think in terms of getting a job, a non-appropriate job, you're probably better off with a science degree. I mean given that everybody's getting degrees, I would certainly encourage them to do a science degree.

Mark: That's interesting, because I'm aware that I'm not projecting all the downsides. You know, celebrity, it's just the hook, we're bringing a lot more people in, which is great, but we mustn't disappoint them when they get here. The profession has changed, there's a lot of women now which is brilliant, but the women and men attracted to the professions, think it's going to be full of those type of people, but it's not, and that bothers me. We've kind of projected the side of engineering that I'd like to be a 100% of the time, and it's really like that 5% of the time. Is it a deception? That bothers me.

Steve: So what do we think about the 'Brian Cox effect'? Y12 could see the potential, individual people can bring about change, and it's certainly my perception that, you know, the 'superstars' and so on, like you David, have been very, very important in attracting people towards science, so this is probably true for people like Brian Cox.

David: Yes, it's true that my name has become embedded in some people's minds, even though in my mind, it's the natural history that's the important thing. But inevitably the way that communications go, it's easier to put a label on a face, than an idea, and this is why Y12 describes Brian Cox as the "social face of science, a face of physics." Brian Cox has become associated with astronomy, and that's a very good example, because astronomy is a very vague kind of thing, people don't know what it is, but they know what Brian Cox looks like. But Brian Cox would not have become interesting unless it was for astronomy. So the two things are intermingled, difficult to separate. If a subject is popular, a name will nearly always become associated with it. But do people look at Brian Cox's programmes because they're interested in astronomy, or because they're interested in Brian Cox? I would have thought that the answer is both.

Steve: Postgraduate compared the 'Brian Cox effect' to the 'CSI effect', and how, although it was fiction, it was still applying the same principles, and was still making people ask the same questions, even if it was purely intended as entertainment. And of course this is right, following CSI there was a plague of forensic scientists.

David: Yes, you would expect it of documentaries, for example, as a producer I used to work on a programme called 'Animal, Vegetable, Mineral?' which was an archaeological series and the people who became interested in archaeology, young people who wanted to take it up as a career shot up astonishingly. When you put on such a series, if it didn't, as I've said, you as a broadcaster are wasting your time. And the students all talked about fictional television programmes as influential, in that they have the potential to open options about careers and give different views on science and scientists, and that someone might be inspired to push a bit more for that sort of position. So, yes, they're bound to, I mean it's all of a piece as far as the audience is concerned.

Mark: The other thing of course is that Postgraduate was aware that the uptake of science had already started increasing, so the 'Brian Cox effect' couldn't be true. But potential was seen for the future, and that more should be found. Unfortunately, some people on television with Brian Cox were described as weird and that they may have the opposite effect. And this is important in terms of not reinforcing stereotypes. You know you don't have to be 'brain box', you don't have to be this amazingly nerdy person, but that is the perception. Brian Cox was described as cool about it, but it was seen as quite easy to come across 'not cool'. I think most people are intelligent enough to do very well in science, and I think we just need to try and get people to think "That's a person I could go to the pub with, or a café with, and that I could have a normal conversation with, and they're an engineer!" That's my ambition, to promote the image of scientists and engineers.

David: Brian Cox of course works outside his field of physics. Postgraduate was insightful here in that the perception was that the producers should have got someone that was biology-based for the biology programmes, but it was recognised that as people already knew of Brian Cox, and they probably didn't know anybody that does biology, other than me, as Postgraduate suggests, no-one would watch it. And as I've said before the medium and the message and the messenger are all intermingled and it's very difficult to disentangle them. The producers wanted their programme to be successful and so chose an established 'celebrity scientist' to present it.

Mark: I agree, this notion of message, medium and messenger is an issue with the engineers in my field. A lot of them think that the technology will speak for itself, a bridge will speak for itself but it doesn't. Unless the engineers who make that bridge make a big fuss and song and dance about it, and have emotional content around it then people would find it very convenient going over the bridge, and they might even say that they love that bridge, but they wouldn't want to be a bridge engineer, and that's the 'message'! And I think that without the emotional content then they think maybe the people who make those bridges have to wear fluorescent outfits and a hard hat and live a very boring life, and they don't want to do that. But actually that isn't the reality of my life, so you should project the reality of it. The 'messengers', that is the engineers, need to use the media in whatever form to promote the 'message'.

Susan: Doesn't this take us back to the student's assertion that personal interest is key? You know Y12 and Undergraduate both believe that there is possibly some truth in the 'Brian Cox effect', even though it probably wasn't the aim of the media, but possibly just with the people who follow what he does anyway, so you would need to be interested in his science to start with. The message may be lost if it is intermingled, as David suggests, with an unknown messenger.

David: Well, Postgraduate thinks that the media got lucky, and that Brian Cox got lucky making such a transformation, and also doubted that it could it be replicated through anyone else. And actually I do believe that the media just got hung up on the 'Brian Cox effect', and as Y12 said, although the media thinks it's true, it probably wasn't their aim.

Steve: Student perceptions of the 'Brian Cox effect' are not all positive though, they raised several issues. I am in agreement with some of these. News sections do sometimes include complete crap about ghosts and 'dates cure cancer'. I can think of one newspaper where there is some very good science coverage, but in some cases science is reported in a very peculiar way, it reports it on the basis of press releases and quirky stories, which is a false balance. And indeed this was one of the main criticisms I raised in the BBC Trust report. I think the media fails because they fail to use celebrity scientists to front science stories, the up-to-date stories. You know, I think there's a bit of a hole here, celebrity scientists are describing almost exclusively past science, Susan referred to this earlier as 'benign', science is seen through a mid-range lens, they don't have opportunity to present today's science. The other thing is that although I don't believe we have much anti-science in Britain, you know, some, but almost nothing compared to the States, Postgraduate is aware that the media can be belittling and negative towards science, and so is quite happy to get behind the 'Brian Cox effect'. And in its broadest sense, this is what we do to a degree. I mean I go to an awful lot of schools and I do a lot of paid and unpaid stuff. Which I do because I think that scientifically grounded societies are a useful thing to have.

Mark: They are absolutely, and the students discussed the importance of this scientific literacy in society. They are aware, as we are, that it's important in order to be able to talk in the school playground with someone who says they're not going to have their kid vaccinated, and say "do you realise that you're putting us all in danger if you do that?...it’s not just your choice, it's all of us or it's not gonna' work.” It’s better to say “do you realise that?” than saying "you're wrong." In fact this specific issue of vaccination and the risk of autism was another negative issue raised by Postgraduate. Although Andrew Wakefield’s research was retracted, Postgraduate was still conscious that people still quote him, and that media people follow him, like Katie Hopkins.

Steve: Hmm, it has to be said that the issues surrounding MMR vaccination were extraordinarily badly handled.

Mark: I think there is a bigger political and cultural agenda here. I think that science is the establishment, but that it’s somehow chained in a way. I mean, you see this with the drugs policy and energy policy, it really frustrates me, you’ve got all these people saying the same thing and they just ignore it. As scientists we have some power, but not the power we would like to have. And this is where the media could play a role, to shift the balance of power, in that the more power science and engineering have in the media, the greater politics I think will take note of it. Because the media is an outside voice, and a voice that is perceived to come from people, even though it doesn’t really, but, it sort of echoes public concerns. And I think there is something here that the celebrity scientist would say is an important thing: the media is a vehicle, back to David’s ‘medium’ here, which you can use, or we could use more of, in the same way that Jamie Oliver has. Like why has he had more impact than a whole load of nutritionists? Because he’s got people power. So if science wants to have the power that celebrity has, it needs to have some celebrity scientists, to me that logic is inescapable.

David: I understand what you are saying but I think that the BBC would be very incautious to take upon itself such detailed ambitions. The BBC is not there to manipulate society, and it would be getting too big for its boots if it thought it was, and who is it to determine how society should be manipulated?...That’s not the responsibility of the BBC.

Steve: No it isn’t but scientifically grounded societies are a useful thing to have. The main thing is to saturate society with science as much as there is with sport. In surveys science does come quite high, but that’s of course because people don’t like to admit that they spend time watching football. People like to say that they like something intellectual!

Roma: And even if it isn't the responsibility of the BBC, or the media in general, I think it is part of our role. We need to influence not just the people that study the subject, those already interested, but actually the people that don't as well. I think this will have a direct influence down the line. And as Postgraduate said, there's a sense of people being held back in some way without scientific literacy.

Mark: It isn't just our role though, other people have an influence. The students were clear that parents and teachers were significant influences. And I agree, so perhaps our role should be to influence and support them. Like as a parent, if your kid comes home and says "I'm interested in science," instead of saying "Oh my God! What's that about?" they'll be like "Oh yeah! I know Dara Ó Briain and Brian Cox, I like their programmes, that's cool." So that the immediate reaction is not, "Oh, that's not for you and not for us," it's like "Yes it is."

Roma: That's true, so when I do something like 'The One Show' the people that are texting me saying, 'Oh I saw you on the tele', are parents. And I think, well, if I can break a little stereotyping in the parents minds about what an engineer looks like or does, then that's a win for me as well. Interestingly with physics, it's the mothers telling daughters not to do it apparently, so the IET ran a campaign for mums and they did live Twitter chats on 'Mumsnet' about physics.

Mark: My father was a scientist, and actually that was helpful to me, especially as I didn't have a very good education, but like Undergraduate, it didn't stop me either.

Steve: My school inspiration was also very weak, and although my father was a chemist, if anything, it had the opposite effect.

Susan: I have to say that I hoped that there was still a place for the teacher who believed in their pupils more than they believed in themselves, who got them excited in the way an iPad never could. And that's what I have seen in school. But their influence was more than the 'science', and 'sparking' an interest, their teachers wanted the best for them, regardless of whether they chose science.

Steve: I'm confident that we do have a big impact on teachers…and probably on some of their better students, but I hope it goes deeper than that.

Mark: Yes but I think teachers need our help too, we could constantly feed interesting things into their classrooms, things that are not just about passing an exam. I loved Postgraduate's comment about teachers, that “there’s a difference between watching someone who could be faking it, to having someone in front of you with a chunk of sodium going ‘stand back!”

Susan: Yes, I think that would be a good thing for the media to take on, because on the whole the teacher is overworked, underpaid, stressed out, so asking them to take on promoting celebrities as well? That’s not the right channel I don’t think. We should support them.

Roma: That’s what I’m saying about being on the television, I hope that teachers would also watch that kind of thing and think “That’s really interesting, maybe I should tell my kids about it.” But of course there will be a small number of kids that despite what their parents and teachers tell them, will still want to do what they want to do. So does interest come first? And what if that isn’t science?

David: That takes us back to the students and what influenced them. The thing that struck me when reading their monologues was their passion for science, their natural curiosity…their motives came across as altruistic, clearly wanting to be helpful to their fellow human beings.

Steve: Yes, a lot of people are drawn into biology by the hope that they can help with practical problems. It was clear that science was something they had always wanted to do, and I think that what unites most serious professional scientists, is a feeling they’ve had since they were children. This was true for me, my desire to become a scientist was because of the Arthur Ransome books, but I can’t read them now without my flesh creeping.

Roma: It’s interesting that Postgraduate believes that, regardless of role models and idols, if someone doesn’t want to do science, they won’t. And even though it does draw people to try it, Postgraduate doesn’t think it actually pushes people further into science as much as they think. And this was true for me. I knew that I was going to do something in science or maths anyway but I think the scientists I saw brought the subject to life for me. It was the content, but it was also who they were and the way they communicated what they were doing. They were very passionate, I remember the passion I might not remember the subject but I remember them loving what they did. So for me they were the catalyst, the inspiration for what I was already thinking.

David: For me it was simply the way in which boys are interested in natural history – the way any child is interested in natural history.”

Roma: We keep returning to the sense that we and the students were already interested in science and that’s why we are now scientists. But we need to be aware of a danger here, because a lot of parents might say, “My kid doesn’t have that interest, therefore they can’t possibly do science.” But we know that science is something that can be nurtured and taught, and this is our role.

Mark: It is, but actually what I would say to them is “Do what you love.” That's the privilege of living in this age, isn't it? Even in higher education, what I say to PhD students and undergrads is that academia is only one very small part of being a scientist or engineer, there’s lots of other ways of being one that they should think about. It doesn't really matter what job they get, but they should go, you know, and change the world, because they can with education, and that's important.

Roma: I always tell young people not to listen to any stereotypes, do your own research, figure it out for yourself, and basically don't listen to what people think they know about science. I gave a talk once about engineering and this little girl of six or seven asked me if I ever hurt myself carrying stuff. She’d obviously got this idea in her head that I carry stuff around on the construction site and that’s what an engineer does. I have no idea where the girl got that from, so we’re basically fighting against the stereotypes.

Steve: I’d say “Do I know the maths?” because science is getting more and more mathematical. My less precise advice would be to do what you want to do.

David: And I would ask them: “Do you want to make sense of the world around you?” It’s certainly why I’m interested in natural history, but there are many other reasons because it’s outdoors, it’s about beautiful things, but it’s not about wealth. So do what gives you pleasure. Yes, the idealism of youth is a perpetual source of comfort really.

4.7 Conclusion

The intention of presenting the findings as monologues and a constructed dialogue was to enable the reader to experience them vicariously (Simons, 2009). Trustworthiness, authenticity and plausibility were ensured by using the conceptual framework to both analyse the data collected and to structure the scripts. These findings are now discussed in Chapter 5.

Chapter 5. Discussion

5.1 Introduction

Narrative inquiry was used in this research to elicit and tell participant stories, in order to illuminate the complex phenomenon of who or what influences young people to continue with science, and the role of celebrity science culture in that process (Shulman, 1986; Clandinin and Connelly, 2000; Sikes and Gale, 2006). The narratives created, the monologues and constructed dialogue, are the focus of this exploration (Riessman, 2003). I was not looking to test a hypothesis, or to build an argument, rather the emphasis was on meaning-making and sense-making (Hinchman and Hinchman, 1997; Elliot, 2005; Sikes and Gale, 2006; De Fina and Georgakopoulo, 2012).

This chapter, then, builds a picture: in essence, a diptych, that is, a piece of 'art' created in two parts that can be used to show different perspectives of the same subject. The first part illuminates what influenced the student participants in this research to continue with science, including the influence of celebrity science culture; whilst the second part explores participant perceptions of the potential role of celebrity scientists to inspire young people.

The conceptual framework is used to structure the discussion. Through the methodology, I made a claim regarding its validity, and therefore a further role of this chapter is to reflect on whether or not it is still a useful model, or if it needs re-constructing or re-orienting. This is integral to Aim 4: to develop a theoretical framework that will inform future academic research, and with the potential to inform the development of science education policy and the involvement of the media (including celebrity scientists); an original contribution of this research.

Findings from young people and celebrity scientists are conjoined, where appropriate, to discuss the synergies and consistent messages elicited, however, in order to acknowledge differing perspectives and experiences, the data from specific cohorts, and indeed, from individual participants, are also referred to explicitly. Whilst the monologues and constructed dialogue speak for themselves, specific quotations are drawn from them to exemplify the experiences and perceptions discussed.

The chapter begins by considering the limitations of this research. I have used the data collected to produce narratives, and these narratives underpin the discussion. Through the analytical stages, I made decisions about which data to use and which not. The question is, how sure am I that the process allowed trustworthy, authentic and plausible insights to emerge?

5.2 Limitations

Trustworthiness

A criticism of narrative inquiry is that it lacks rigour and is unsystematic (Chase, 2011; Edwards and Holland, 2013); this is due in part to the recognition that there is no fixed practice (Sikes and Gale, 2006; Squire, 2008), and, especially as in this case, working at the more playful end of creative analytic practices (Smith, 2007; Wellington *et al*., 2012). In order to mitigate this, the research was conducted strategically and systematically by using the conceptual framework to underpin all aspects of the research: the literature review, methodology, data analysis and presentation of findings.

A further limitation is that it is not possible to replicate (Edwards and Holland, 2013). Each participant was a single case, a focus of interest in their own right. They were selected according to identified criteria such as their phase of education, or celebrity status, but as they self-identified as scientists, from a range of science disciplines, they were also unique. The conceptual framework was used to draw their experiences and perceptions together, within the different categories, without losing any contrary or outlying data. Findings were also compared with, and critiqued against, research outlined in the literature review, as such this offered a degree of triangulation for those areas that have been extensively researched, such as the influence of teachers and family; as others had also used narrative approaches in this area of research, this gave confidence that the methodology was appropriate for exploring the role of celebrity science culture.

The narrative biographies collected were not expected to be “objective renditions of life” (Webster and Mertova, 2007, p.3). If the participants were asked to recount their stories again, it is possible that different memories may be included, with different emphases placed on different events (Denzin, 1989; Hinchman and Hinchman, 1997; Elliott, 2005). Their narratives, then, were one version of their truth, within the social, cultural and temporal context of their specific interview. In order to moderate the effect of memory (Bold, 2011), the narrative inquiry interview prompts were given in advance (Part 1 of the interview schedule, Appendix 4, p.-22-) so that participants had time to reflect. In terms of the influence of celebrity scientists, it is possible that some of the participants may have been influenced to continue with science, but it did not occur to them to tell me, not seen as relevant, or even that they had not thought about it before. This was addressed by asking them explicitly if they had been influenced by celebrity scientists, during the semi-structured interview phase. Participants were also asked if they had anything else to add at the end of the interview. Furthermore, through respondent validation, if a memory of a celebrity scientist or specific television programme had been remembered during the time between interview and receiving the transcript, there was opportunity to say.

Findings were also shaped by my interpretation (Mishler, 1991; Squire, 2008), and how I chose to present their stories and perceptions. I minimised my influence during data collection by not interrupting, waiting for a gap in the story, conscious of whether they needed a prompt to continue. Furthermore, the student participants did not know that the main focus of the research was celebrity science culture, until their stories had been collected.

The final potential limitations here are researcher positionality and power dynamics (Gillham, 2005; Yow, 2006; Kvale, 2007; Cousin, 2010; Edwards and Holland, 2013). Data collected was also influenced by my interview process and my presence as researcher (Riessman, 1993). My position was made explicit, they knew that I was a science teacher, therefore it was possible that participant stories were biased towards what they perceived I wanted to hear. Power dynamics also have the potential to influence data collected (Bold, 2011; Etherington, 2013), and whilst I was not the participant's teacher or lecturer, they were aware of my role within the university. In order to mitigate this, it was important that the students offered themselves as participants, and that interviews were conducted in safe places; undergraduate and postgraduate interviews took place in a neutral space in the university, rather than in my office, and those of the school students were conducted within their own 'sixth form' area. Participants were in control of what they shared during the narrative biographical phase, thus limiting researcher reactivity, and they were able to withdraw any data prior to integration. None of the participants withdrew their data, recordings show that the atmosphere was relaxed, and that participants were treated with respect. An interesting power dynamic was actually from my perspective, and this was when I interviewed the celebrity scientists. Roma Agrawal and Mark Miodownik were very easy to talk to, and the interview became more like a professional dialogue between peers; the interview schedule became a vehicle to collect their perceptions rather than a script. This was also true of Steve Jones, but as an internationally renowned scientist, Fellow of the Royal Society, and the scientist invited to conduct the BBCs science review (Jones, 2011; Jones, 2012), I was nervous about meeting him, and remained close to the interview schedule script. The interview with Susan Greenfield was conducted over the telephone. I had been kindly given fifteen minutes, and I was conscious of keeping below that. This affected which questions I asked, and which ones I followed up with subsidiary questions. As a result, the data collected was not as detailed, but nevertheless, very important. The power dynamic most evident, however, was that with David Attenborough: I was star-struck. Although he went out of his way to make me welcome and comfortable, and whilst I remained professional and kept to my interview schedule and within the boundaries of my ethical approval documentation, there were so many other things unrelated to the research that I wanted to talk about. The main outcome of this was my lack of confidence to pursue a line of questioning or to challenge the responses given. Having a well-structured interview schedule was key to managing my emotions when preparing to interview the celebrity scientists; the recordings evidence the professional and respectful way that the interviews were conducted. Again, respondent validation was offered as a means of ensuring the accuracy of the insights and perceptions shared, giving confidence in the trustworthiness of the data collected.

Authenticity

Whilst the functionality of the monologues and constructed dialogue has been made explicit, acknowledging that they are “imaginative yet reality-based reconstructions” (Saldaña, 2010, p.65), Kallio’s (2015)’factional stories’, the issue of authenticity remains. There was a high degree of synergy between the experiences and perceptions of the participants in each cohort, resulting in a number of quotations that could have been included to exemplify a point made. Decisions, therefore, needed to be made about whose words were chosen, and even who had the final word; clearly, one voice was going to be privileged over another. This required a high degree of reflexivity, alongside a systematic approach to script construction underpinned by the conceptual framework, to ensure that I did not just choose the “juicy stuff” (Saldaña, 1998, p.181). In order for this process to be transparent, each quotation included can be tracked back to the individual participant, and as such gives confidence in their authenticity. Whilst respondent validation was a key aspect of ensuring that quotations used could be ascribed to individual participants, because of informed consent regarding confidentiality, respondent validation of the monologues did not take place.

Plausibility

A potential limitation of this research was the low numbers of participants. The reader needs to believe in the plausibility of the “virtual reality” (Kim, 2006, p.5) created, but was this possible with the small sample size? Studying eighteen science students and five celebrity scientists narrowed the research’s focus to the experiences and perceptions of only those people. Furthermore, they were not necessarily representative of all science students or celebrity scientists; indeed this was not the intention. All participants had volunteered to take part, but whereas large cohorts of students received the invitation, the celebrity scientists had been invited personally. I did not include non-scientists, I was looking explicitly at who/what influenced participants to continue with science, not the contrary. Clearly, the findings cannot be generalised to all science students or celebrity scientists. Recognising this, scripts were presented to different audiences, and feedback acknowledged their plausibility in that they did promote emphatic understanding of participant science stories and influence; they were able to "vicariously experience" (Simons, 2009, p.23) what the participants were saying. The data-informed scripts were considered to be "authentic and compelling rendering of the data" (Leavy, 2009, p.27); and indeed enjoyable to read (Watson, 2015).

5.3 Part 1. Significant influences on participants' decisions to continue with science

"*Science is who you are, not what you do … you can't take the science out of the person, it's your mindset, it's who you are … I was my own influence*" (PG)

This was the overriding key message from all participants in this research, and appears to be the polar opposite of the assertion made by the media regarding the 'Brian Cox effect'. In this chapter I discuss both of these extremes, 'Personal interest' and 'Celebrity science culture', but also integrate the other significant voices within the conceptual framework: 'Nature of science and scientists'; 'Science education', and 'Family and Friends'.

5.3.1 Personal Interest

The 'Personal interest' section of the conceptual framework comprises the following subcategories:

- Interest in science *per se*
- Transformational: Wanting to make a difference
- Transformational: Wanting a career in science
- Utilitarian
- Success academically

Student participants in this study had all self-identified as scientists. Having chosen to continue with science post-compulsory age, their self-efficacy as a scientist was high (Bandura, 1982; Zeldin and Perjures, 2008; Archer *et al.*, 2014a); science was clearly "for them" (Jenkins and Nelson, 2005; DeWitt *et al.*, 2013a). Through the narrative biographical stage of data collection, they expressed high levels of engagement with their specific science choices, and a strong long-term personal interest in science *per se:* "*I have always been interested in the way* *things work in science*" wanting to "… *get more of an insight and learn about ourselves and the world*" (Y12). Anecdotes were shared, such as the explosion of 'Mentos in coke'. They laughed about their experiences, their love of science, and the importance of enjoyment, becoming quite animated as they said, for example, "*there are always new things to find out*" (UG) and "*I've tried to make sure that whatever I do, I'm doing it for my own enjoyment, or for my own progression*" (Y12). This resonated with the celebrity scientists, in that science was something they had also always wanted to do. Steve Jones went as far as suggesting that "*what unites most serious professional scientists, is a feeling they've had since they were children*"; as with student participants, personal interest was key. Participants, then, did not appear to have been passive receivers of their science education (Laugksch, 2000), they were proactive, with high levels of intrinsic motivation (Schiefele, 1996; Schraw, Flowerday and Lehman, 2001; Schraw and Lehman, 2001; Maltese and Tai, 2010; Renninger and Hidi, 2011; European Commission, 2012; Maltese *et al.,* 2014), building their own science capital (Archer *et al*., 2013a,), and in some cases, their family habitus (Archer *et al.*, 2012; DeWitt *et al*., 2013a; Archer *et al*., 2014a). Findings, therefore, evidenced latent interest (Schiefele, 1996), a stable, long-term orientation towards science which had developed over time (Krapp, 2005; Ainley and Ainley, 2011; Krapp and Prenzel, 2011), through "constant and consistent interaction" with science (Chen *et al*., 2001, p.384); these "interactions", or as referred to in this research the other significant voices, are discussed within subsequent sections of this chapter. An example of the stability of this long-term orientation was shared by one the undergraduate participants, who, having rejected science post-'A' level, for a more "*lucrative career in recruitment"* (UG), returned to science following a significant, life-threatening accident and an awareness that there was more to life than money. For this participant, it appears that science capital and habitus were sufficiently developed to enable this change of career.

The purpose of their personal interest in science was transformative, they wanted to make a difference, and chose science career pathways to facilitate this, such as nursing, forensic science, and molecular biology: "*I just like the thought of finding something new, or making a breakthrough – that's a major influence*" (Y12). Undergraduate and postgraduate participants were beginning to see the difference they were making through their increasingly specific foci. This was reflected in the responses of the celebrity scientist participants, for example, David Attenborough believed that young people are motivated by "*altruistic and very high motives*." These personal aspirations appeared to reinforce their self-identification as scientists (Zeldin and Pajares, 2008; Archer *et al*., 2014a), and they embodied what it means to be a scientist, with scientific skills, in that by "*reading up and teaching myself, I appreciate the importance of research*" (Y12). Indeed, one participant talked about ambition from an academic perspective, as well as at subject level, "*wanting a PhD before I'm thirty*" (PG).

The increasing intellectual challenge of science the further they progressed was referred to by participants, and indeed, science is acknowledged as a hard subject by the research community (Wong, 2012; Archer *et al.*, 2013; Rodd *et al.*, 2014), especially physics with its high status and mathematical components (Francis, 2000; Bourdieu, 2004; Bleazby, 2015). Nevertheless, this was not perceived as a personal barrier; one Y12 participant recognised the positive nature of the challenge: the "*gap between the start and where I am now is magnificent!"* (Y12). Furthermore, their academic success in science impacted positively on motivation, again potentially enhancing their self-efficacy and identity as scientists (Bandura, 1982; Zeldin and Pajares, 2008; Archer *et al*., 2014a): "*I enjoyed it because I was successful, and I was successful because I enjoyed it*" (Y12). This is important, in that seeing oneself as 'good at science' enhances the likelihood that interest and aspirations will be maintained, potentially influencing the continued uptake of science career pathways (Ipsos MORI, 2013). Here, both source (science *per se*) and reward (academic success) were part of participant's intrinsic motivation to learn (Bruner, 1963; Schiefele, 1996; Schraw, Flowerday and Lehman, 2001; Schraw and Lehman, 2001), reflecting Krapp's (2005) assertion that interest is a precondition of learning. It is not surprising, then, that none of the participants were using science from a utilitarian perspective, Wong's (2016) extrinsic motivation, in that it was not simply seen as one of a number of higher grade GCSEs required to gain access to higher education; there was a real purpose for their choice of science.

To summarise, both 'value-related' and 'feeling-related' components of latent interest were evident (Schiefele, 1991; 1999), with participants referring to intrinsic motivation, personal aspirations, and studying science for transformative purposes as principal influences. They were studying science because they enjoyed it, and could identify themselves as scientists: "*I just love science*" (UG) and "*I just knew straight away that it was for me*" (PG). All participants wanted to make a difference, and acknowledged the need to work hard to overcome challenges, and to gain access to their chosen field. Together, these aspects underpinned their sense of self as scientists, with participants appearing to have personally enhanced and embedded their own science capital and habitus (Maltese and Tai, 2010; Archer *et al*., 2013a; Archer *et al*., 2014b; Maltese *et al.*, 2014). In essence, a long-term personal interest in science dictated their future subject and career pathways (Krapp, 2005; Ainley and Ainley, 2011; Krapp and Prenzel, 2011); it did not rely on other people. These findings confirm the appropriateness of the subcategories of the conceptual framework.

Participants appeared to be ascribing ‘power’ to science, in that they all asserted that an interest in it had actively directed their career pathways, whether it was studying hard at ‘A’ level to being able to follow their subject interests into higher education, to undertake original research, and, for the celebrity scientists, to promote science in schools and with the general public. So what is it about science that is so influential for these participants? This is the focus of the next section: the ‘Nature of science and scientists’.

5.3.2 Nature of Science and Scientists

The ‘Nature of science and scientists’ section of the conceptual framework comprises the following subcategories; they are linked to Brake’s (2010) classification of the nature of science:

- Scientific literacy: knowledge, understanding and scientific processes
- Scientific literacy: willingness to engage in science
- Scientific literacy: real contexts
- Science communication and engagement

Brake’s (2010) classification of the nature of science is used to structure this discussion. It links with the strands of scientific literacy (OECD, 2006) as shown in Table 5.1.

Science as:	**Scientific literacy strand:**
Body of knowledge	Knowledge, understanding and scientific processes; Real contexts.
Method	Knowledge, understanding and scientific processes; Real contexts; Science communication and engagement.
Key driver of the economy	Willingness to engage in science.
Institution	Willingness to engage in science; Science communication and engagement.
Worldview	Science communication and engagement.

Table 5.1: Links between strands of scientific literacy (OECD, 2006) and Brake’s (2010) classification

Science as a body of knowledge: For all participants, knowledge and understanding was important. They wanted to know and understand the natural world, and apply it to solving real problems or to develop new technologies or better medicines. They saw science as creative, intellectually exciting, and beautiful (Silverman, 2015); an undergraduate talked about the 'mystery' of science. They appreciated the sense of science evolving (Brake, 2010), acknowledging that "*You can never say you know everything*" (Y12).

Science as a method: Science was seen as most influential when the focus was on real and relevant contexts. This was especially evidenced by the postgraduate cohort, very much wanting clarity of purpose for their work (Butt *et al*., 2010; Ipsos MORI, 2013). Examples were a sports scientist reducing the time to run a race, taking "*milliseconds out of someone running a race*" (PG), as well as addressing the obesity crisis by informing recreational settings; a microbiologist patenting a new antimicrobial cream for acne treatment "*that's not steroidal and [not] gonna harm you*" (PG); and a forensic scientist developing a technique to be adopted by the police, so that they can give "*closure to victims of crime as well as help[ed] catch the criminals*" (PG). Although there was no explicit reference to scientists working collaboratively, science communication and engagement were paramount for all participants, thereby evidencing awareness of the social nature of science to some extent, asserting *"you have to share what you have discovered to help progress" (PG),* echoing the sentiment of Marcus du Sautoy (2009). In line with other research (Millar, 2006; Russell, 2010; Bucchi, 2011; Dillon, 2011; Millar, 2012), participants saw science and scientific literacy as "*extremely important" (PG)* to society, aware that public trust needs to be earned. This was extended to the school curriculum and the importance of "*current scientific matters*" being included in the syllabus: "*If I was in a secondary school now and someone was saying 'Oh, here's about 'three-parent families' or something, I would be really interested*" (UG). Celebrity scientist participants were all engaged in this work and strongly advocated a contemporary focus in school. Indeed, the impact of this was evidenced in this research by those participants who named Brian Cox, Stephen Hawking and David Attenborough, as well as fictional television programmes, as influencing their specific career choices.

Science as a key driver of the economy: This can be summarised as "the creation of wealth, goods, food and comfort" (Brake, 2010, p.20). The intention of all participants was to use science to make a difference to the world, evidencing both feeling-related and value-related aspects of latent interest (Schiefele, 1991; 1999); they were willing to be engaged in science. Whilst their aspirations were indeed transformational, there was no sense of student participants relating this explicitly to science as a 'key driver of the economy'. Having said that, there was some appreciation that progress in science is not accidental, participants recognised that science is deliberately planned in response to a specific need, citing, for example, specific diseases and environmental issues as important areas of study. However, celebrity participants could relate to this notion of science being a key driver of the economy directly, aware of the current STEM-skills gap and its implications.

Science as an institution: The scientific community is recognised as being influential (Butt *et al*., 2010; Russell, 2010; Ipsos MORI, 2013; Kantar Public, 2017), and works deliberately to engage young people in science. Participants could all recall specific scientists who had made a difference to the world, either historical or contemporary, in person or via the media, real or fictional; this is akin to the notion of significant persons, modelling and defining science (Sjaastad, 2012). Even the celebrity scientist participants, who are actively engaged in this work, could recall the current influence of STEM scientists. Credibility and trustworthiness were considered crucial, both of the scientists themselves and the science they present, if participants were to be able to identify with them (Springate *et al*., 2008; DeWitt *et al*., 2013a; Archer *et al.*, 2014b), aware that negative stereotypes can be limiting factors (Archer *et al.*, 2010; DeWitt *et al*., 2013a; Archer *et al*., 2014b). Participants' understanding of the role of scientists was in line with previous research (Archer et al., 2013a; DeWitt *et al*., 2013a; Ipsos MORI, 2013). They had self-identified as scientists (Zeldin and Pajares, 2008; Archer *et al*., 2014a), and could, therefore, imagine themselves within this institution, in a particular science occupation. There was no sense of negativity, or that they were more 'clever' than their peers (Archer *et al.*, 2014a), they did not see themselves as 'geeks', nor as part of an elite group (Brake, 2010; DeWitt *et al.*, 2013a; Wong, 2016). They saw science as very much "for them", as opposed to "not for me" (Jenkins and Nelson, 2005; DeWitt *et al*., 2013a).

Science as a worldview: According to Brake (2010), the "sole purpose of communicating science is so that the public appreciate the status of science and scientists" (p.26), thus building on the notion of science as an institution. For the postgraduate and celebrity scientist cohorts this was a high priority. They believed the impetus for this should come from the scientists themselves, reflecting the current position within the science community (Russell, 2010; Bowater and Yeoman, 2013). They were aware of the importance of having a positive relationship between the public and scientists, and the damage that can ensue if this breaks down (Whitmarsh *et al*., 2005; Dillon, 2011). Examples were given of the impact of the MMR vaccination controversy, on the morbidity and mortality of children. This is discussed further in section 5.3.6 (p.176), Celebrity science and scientist influence.

In summary, the anecdotes and illustrations shared, confirm that the nature of science itself was indeed influential to student participants: the more they knew and understood, the more they were inspired to know and understand. The ‘Nature of science and scientists’, then, can be seen to have been an influential voice for all participants. It was both the foundation and vision of their personal interest and intrinsic motivation: they enjoyed building science knowledge for its own sake; they enjoyed working scientifically and solving problems; they wanted to make a difference to the world; and they wanted others to share their passion for science. Being aware of the negative impact of poor communication, the postgraduate and celebrity scientist participants saw science communication and engagement as an important aspect of their role. Whilst the intention of this research is to synthesise participant voices, it is important here to acknowledge a major difference between the cohorts. Although the nature of science and scientists was influential for all participants, for the Y12 cohort, emphasis was essentially on knowledge and understanding, whereas for the undergraduate and postgraduate cohorts there was a shift towards the importance of their own work, and their personal responsibility to communicate and engage with the science community and the general public; they were maturing as scientists. There are potential implications here for future engagement with children and young people in school, developing their awareness of the importance of communicating their work and developing the skills to do so at an early age. Bringing scientists into school to listen to the research that children and young people themselves have undertaken has the potential to be empowering.

Including the nature of science and scientists into the research through specific interview questions, was also intended to validate the students as participants. All were recognised as being scientifically literate, and as such their voices are relevant as sources of insights into celebrity science culture.

The ‘Nature of science and scientists’, then, can be seen to have been an influential factor. Participants demonstrated a clear understanding of what science is and what scientists do, but where did this understanding come from? Returning to the quotation at the start of this chapter: “*science is who you are not what you do … you can't take the science out of the person, it's your mind set, it's who you are … I was my own influence*”, possibly implies that interest in science is innate and develops in isolation. The next three sections continue to illuminate this phenomenon from the perspective of ‘significant voices’ (Sjaastad, 2012); that is their science education (teachers and lecturers, and the situational interest they provided), their family and friends, and their experience and perceptions of celebrity scientists.

5.3.3 Science Education

The ‘Science education’ section of the conceptual framework comprises the following subcategories:

- Teacher/lecturer interests, passion for science
- Teacher/lecturer awareness of student’s potential, ability and interests
- Teacher/lecturer knowledge of science careers
- School/university science curriculum
- School/university links with external science community

Teachers and lecturers

In line with other research, participants recognised their teachers and lecturers as influential (Maltese and Tai, 2010; European Commission, 2012; Logan and Skamp, 2013; Ipsos MORI, 2013; Rodd *et al*., 2013; Archer *et al*., 2014b; DeWitt *et al*., 2014; Maltese *et al.,* 2014). They displayed science in general, defining and modelling science, scientists and science careers (Sjaastad, 2012); this was generic at school, whilst becoming more specific at university, as they developed their own research interests and career pathways.

Participants were aware of the multifaceted nature of this relationship with their teachers and lecturers, and their influence on their engagement with science (Butt *et al.,* 2010; Maltese and Tai, 2010; BIS, 2011; European Commission, 2012; Ipsos MORI, 2013; Archer *et al.,* 2013a; Rodd *et al*., 2013; Maltese *et al.*, 2014; Silverman, 2015). Advanced subject knowledge led to a sense of awe, “*I’d love to know that much about a section of science*” (Y12) and “*She knows everything about every virus that you could think of*” (PG). Their enthusiasm was seen as contagious: *“being genuinely interested in your subject kind of gets everyone else’s enthusiasm going*” (PG). Science technicians were also included as a source of influence, describing them as “*knowledgeable and enthusiastic*” (PG).

The situational interest provided through the choice of pedagogical approaches and real and relevant contexts also raised their interest in science (Hidi, 1990; Schraw and Lehman, 2001; Wade, 2001; Krapp, 2002; Dierks *et al*., 2014), and were considered important by participants in this research, for example, “*one teacher talked to us about where science is going*” (Y12), and "*she'd go off on tangents with sort of side stories of her own and it always kept things interesting*" (PG); this is explored in the 'Science Curriculum' section below.

Whilst the role of teachers and lecturers, as significant voices, is generally understood as defining and modelling a sense of 'self' from the perspective of being a scientist (Sjaastad, 2012), Rodd *et al*. (2013) referring to the work of Britzman (2011), argue that they can also be seen as 'emotional figures', displaying a similar role to family, defining and modelling a more global sense of 'self' (Sjaastad, 2012). In addition, Maltese and Tai (2010) suggest that as students progress through school, a teacher's personality comes into play. Student participants did indeed acknowledge this, considering teachers and lecturers to be encouraging, and "*quite motivational and quite ambitious [for you] … [wanting] the best for you*" (Y12), supporting individual choices, pushing grades, and supporting examination preparation. Indeed, Susan Greenfield, from her experience of working in schools, recognised that teacher influence was more than the 'science', and 'sparking' an interest, they wanted the best for them, regardless of whether science was chosen.

In terms of specific career guidance, participants believed that teachers were well equipped to support and prepare pupils for their future, considering them an important source of knowledge about science careers and university courses; they were "*very good at giving direction, and asking the right questions for you to find the answer, to sort of channel you … sort of prepare you for the career you want*" (PG). This was contrary to Wellcome Trust Monitor (Ipsos MORI, 2013), where although 47% of 14-18 year olds perceived teachers as a source of career advice, only 18 % found it useful; perhaps this was because participants in this research already had an interest in science, and were actively focussing on finding a career in science.

Whilst the positive school science experiences described are in line with the recognition that they play a major role in whether pupils see science as for them, and for sustaining interest (Maltese and Tai, 2010; European Commission, 2012; Ipsos MORI, 2013; Archer *et al*., 2013a; DeWitt *et al.,* 2014; Maltese *et al.,* 2014), the picture is not this simple. Positive experiences for some may not lead to continued uptake of science (Cleaves, 2005; Vidal Rodeiro, 2007; Bennett and Hogarth, 2009), whereas someone who had a negative experiences may (Cleaves, 2005). This was exemplified in this research: participants raised personal issues of science teacher retention; limited subject knowledge; and the poor behaviour of peers resulting in teachers limiting the opportunities for practical work. Despite the issues raised, the participants' strong personal interest, already discussed, allowed their aspirations to be sustained. This illustrates the complexity of the relationship (Sjaastad, 2012; DeWitt *et al.*, 2014), and the perceived stability and resistance to change of science aspirations (Krapp, 2005; Ainley and Ainley, 2011; Krapp and Prenzel, 2011; Archer *et al*., 2014b). The negative anecdotes recounted were not the full picture of their engagement with science, the nature of science itself has already been shown to be important in sustaining their interest and aspirations, therefore statements like the following were not unexpected: " *... but I was always interested in it, you know, it didn't stop me from wanting to pursue it*" (UG), and "*it made me want to prove them wrong*" (UG). This participant's self-belief as a scientist sustained the negativity experienced.

Susan Greenfield hoped that there was still a place for the teacher who "*believes in them more than they believe in themselves ... who gets you excited in the way an iPad never can*"; and as such believed that supporting teachers was part of their role as celebrity scientists. Mark Miodownik also advocated "*constantly feed[ing] interesting things into their classrooms, things that are not just about passing an exam*", whilst Roma Agrawal hoped that teachers would watch their programmes and then tell their pupils about it.

In summary, then, teachers and lecturers were considered by all participants as trustworthy and credible voices, people they could relate to and identify with. This is summarised by one postgraduate participant: "*there's a difference between watching someone who could be faking it, to having someone in front of you with a chunk of sodium going 'stand back!"* (PG).

Science Curriculum

During the narrative biographical phase, student participants recounted their earliest memories of science at home and through their school years. Memories of Primary school science (Key stages 1 and 2, age four to eleven years) were very limited, with recollection of simple experiments. The explosive 'Mentos in coke' experiment was referred to, and exploring magnetism was described, with laughter, as 'magic'. There was much resonance here with the findings of Maltese *et al.* (2014) and interest in science being initiated early in life.

During Key Stages 3 and 4 at Secondary school (age eleven to sixteen years), science was recognised as becoming more theoretical, focussing on specific curriculum areas, such as radiation, the limestone cycle, and biodiversity. Experiments were becoming more developed, with complex science equipment and procedures to explore, such as the "*brilliant*" (PG) experience of dissecting a pig's eye. An example of situational interest provided outside of direct classroom teaching was that of a teacher having "*microscopes*" (Y12) out in the laboratory for students to engage with outside of lessons; this teacher was defining and modelling what scientists do (Sjaastad, 2012), recognising the importance of building real-life situations into the curriculum (Robert, 2007). Here authentic science activities were provided (Butt *et al*., 2010; European Commission, 2012; Archer *et al*., 2013a; Ipsos MORI, 2013; Logan and Skamp, 2013; Mujtaba and Reiss, 2013; DeWitt *et al*., 2014; Maltese et al., 2014; Silverman, 2015; Kantar Public, 2017). There was reference to ‘wow’ science, such as making “*methane bubbles*” (Y12), and the ‘Mentos in coke’ explosion again, describing it as “*amusing at the time*” (UG). These practical, hands-on opportunities were valued, as long as the science was scientifically explicit and accurate, key aspects of scientific literacy (OECD, 2006; Holbrook and Rannikmae, 2007; Bybee and McCrae, 2011), they wanted science to be taken seriously, reflecting the findings of the Wellcome Trust (Butt *et al*., 2010; Ipsos MORI, 2013; Kantar Public, 2017).

Memories of science, post-GCSE, were related to specific courses or vocations; there was limited detail of what they actually did. A notable difference here was how subjects were defined. Whereas the Y12 cohort still referred to the separate subjects of biology, chemistry and physics, by postgraduate level, participants were describing specific areas such as zoology, molecular biology, microbiology, and biomechanics. For undergraduate and postgraduate participants, their field of study had narrowed, they were talking about science in context, and its relationship to the world. Here, participants were recognised as active and discerning consumers of information, not passive recipients (Laugksch, 2000); their curriculum experiences had appeared to influence their decision-making (Roberts, 2007).

Links with science organisations

Informal learning opportunities, such as science visits and visitors, are recognised as having the potential to raise interest in science (Ipsos MORI, 2013; Kantar Public, 2017). Memories of science visits were limited, and generally recounted following prompting. Nevertheless, where they occurred they were considered to be interesting and motivational. This included those of Roma Agrawal as she remembered the passion, and how one experience had been a *“catalyst, the inspiration for what I was already thinking*.” This reflects the findings of SET (Kantar Public, 2017) where 40% of 14-18 year olds who had visited a science attraction felt inspired to study science further. Science was seen as real, relevant and credible, participants were able to identify with it and see themselves within it (Jenkins and Nelson, 2005; DeWitt *et al.,* 2013a). The scientists they engaged with raised awareness of what a career in science could look like; that is, they were significant voices in modelling and defining what it meant to be a scientist (Sjaastad, 2012). Their schools and universities, then, had provided opportunities of situational interest, which enhanced individual interest (Hidi, 1990; Krapp, 2002; Dierks *et al*., 2014), thereby raising their science aspirations.

Whilst not a personal experience, an example linked to celebrity scientist influence was given by one of the undergraduates of a teacher in their school who was "*absolutely obsessed with Brian Cox*." She arranged for her students to go and meet him for, according to the participant, "*personal excitement ... She looked up to him and she wanted the students to think the same*" (UG). This teacher was already a scientist, and therefore had not been influenced by Brian Cox to have a career in science. As a result of her intrinsic interest, and an ability to relate to his work, this teacher had developed an emotional bond with him (Pfau and Parrott, 1993; Rojek, 2001; Ferris, 2010; Marshall, 2014), wanting her students to be influenced by him in the same way that she was; this is an example of "imitative consumption" (Rojek, 2001, p.34), and an awareness of the potential "transformational power" that Brian Cox and potentially other celebrity scientists hold (Rojek, 2001, p.38). The participant concluded: "*It was nice to know that someone in the science field could be that important just to a complete stranger, like the way actresses are to other people*" (UG).

Memories of science visitors were also limited. One Y12 participant noted that science became "*more and more my favourite subject*" (Y12) following input from a visiting chemist; whilst a postgraduate participant described the impact of hearing how the real research of guest lecturers was benefitting society. These examples reflect the assertion by Archer *et al*. (2014b) that contact with scientists may support the pre-existing aspirations of young people. However, in contrast, a visitor described by an undergraduate participant as an "*eccentric man*", and "*fun*", as he damaged the school hall ceiling with a reaction of H_2O_2, and threw frozen bananas across the room, did not inspire a further interest in science, but was certainly memorable.

Whilst these examples were engaging and entertaining, and all participants experienced positive specific momentary psychological states (Schraw and Lehman, 2001; Schraw, Flowerday and Lehman, 2001; Dierks *et al*., 2014), only the former experiences were influential in terms of continuing uptake of science. Again, participants were aware that in order to raise science aspirations the situational interest provided must be credible, with real and relevant applications (Butt *et al.,* 2010; European Commission, 2012; Archer *et al*., 2013a; Ipsos MORI, 2013; Mujtaba and Reiss, 2013; DeWitt *et al*., 2014; Maltese *et al.,* 2014; Silverman, 2015).

In summary, all participants had adopted a science identity, able to see science as ‘for them’ (Jenkins and Nelson, 2005; DeWitt *et al*., 2013a). The important role that teachers play in encouraging science and STEM careers is well established (Maltese and Tai, 2010; European Commission, 2012; Ipsos, MORI, 2013; Logan and Skamp, 2013; Maltese *et al.,* 2014), and participants described how their relationships with teachers and lecturers were indeed major influences in their decisions to continue with science, despite the anecdotes of poor teaching. Although pedagogical approaches were important in terms of sustaining interest and engagement (Logan and Skamp, 2013), the science culture and environment that teachers and lecturers created were considered more critical (Maltese and Tai, 2010; DeWitt *et al*., 2013a; Archer *et al*., 2014a; Maltese *et al.*, 2014). At best, teachers defined and modelled science and science careers, providing hands-on experience and real-world applications (Sjaastad, 2012). It could be argued that Roberts (2007) ‘Vision 2’ is extended to include relationship with the teacher, as it is their passion that has been described as adding relevance and the sense of value, or ’realness’, to subject knowledge (Vision 1). Participants gave examples of when their self-efficacy and self-confidence had been bolstered by teachers (Bandura *et al*., 2001; Zeldin and Pajares, 2008; Maltese and Tai, 2010; Archer *et al*., 2014a; DeWitt *et al.*, 2014), and research shows that these attributes are important in maintaining and motivating young people’s science aspirations, and subsequent career choices (Cleaves, 2005; Archer *et al*., 2014b). Good relationships with their teachers, observing them and following their chosen pathways and interests, also resulted in their sense of ‘self’ being defined and modelled (Sjaastad, 2012), akin to the influence of parents. The influence of family and friends is considered next.

5.3.4 Family and Friends

The ‘Family and Friends’ section of the conceptual framework comprises the following subcategories:

- Family or friend’s personal interest
- Family or friend’s experiences of science
- Cultural influences and expectations
- Best interest of young person at heart
- Awareness of their potential, ability and interests

Family

Data collected found that, on the whole, the influence of 'family' on participants was more 'global', more holistic, when defining and modelling 'self', and more 'specific', when defining and modelling career aspirations (Sjaastad, 2012). These are recognised as being informed by the family's economic, social and cultural capital and habitus (Bourdieu, 1986; Archer *et al.*, 2012; Archer *et al.*, 2013a), or as Aschbacher *et al.* (2010) call it, the family 'microclimate'. The overriding role and influence of family for all participants was one of encouragement, of having their children's best interest at heart, aware of their potential, ability, and interests. Furthermore, the underpinning family capital and habitus provided seemed to encourage their children to achieve academic potential in a field of their choice: *"… to go into what I was enjoying*" (UG) rather than steering them in a particular direction (Sjaastad, 2012); as such they expanded their field of view in terms of career choices (DeWitt *et al.*, 2013a; Ipsos MORI, 2013; Archer *et al.*, 2014b). In essence, then, their families primarily defined and modelled general work-related skills, attitudes and attributes (Sjaastad, 2012). Postgraduate participants summarised it as follows: they "*made a massive effort to spark a passion, so that when I went to school I would then seek knowledge myself*" (PG), thus facilitating a love of learning as they were "*pushed to be academically strong*" (PG).

Participants in this study talked about science at home, and how as children they were encouraged to make things; with parents described as: "*quite big into teaching us, helping us to learn and figure things out*" (PG). References were made to: a museum visit resulting in the purchase of a silk worm (PG); subscription to the 'Horrible Sciences' magazine; and science experiments and microscopes (UG) bought for birthdays. The memories of a home-schooled participant, with a 'very sciencey' mother, included science kits for birthdays that "*caused mess in the bedroom!*" (PG). The celebrity scientist participants remembered similar influences, for example, Steve Jones referred to the Arthur Ransome books as influential, noting, however, that he "*can't read [them] now without my flesh creeping*." Whilst David Attenborough described how he became interested in natural history "*simply in the way in which boys are interested in natural history – any child is interested in natural history*." Here, situational interest was provided to support individual interest (Hidi, 1990; Schraw and Lehman, 2001; Wade, 2001; Krapp, 2002; Dierks *et al.*, 2014), thus building science capital (Archer *et al.*, 2013a).

With respect to explicitly raising science aspirations, research suggests that family is highly influential, both positively and negatively (Butt *et al.*, 2010; Maltese and Tai, 2010; Archer *et* *al.*, 2012; DeWitt *et al*., 2013a; Ipsos MORI, 2013; Archer *et al*., 2014a; Maltese *et al.*, 2014; Archer and DeWitt, 2017). For those participants belonging to 'science families' (Morrow 1999; Archer *et al*., 2012; Archer *et al*., 2014a), where science is part of family identity, the interaction of family capital and habitus results in science being highly visible and desirable. Such that, for one participant science was seen as "*run[ning] in our family … so I got a lot of help and support with them*" (UG). This was also true for Mark Miodownik, whose father was a scientist, considering this to be "*helpful*." Family science careers and experiences were explicitly referred to, for example, nursing, pharmacology, microbiology, and veterinary medicine. For participants in these families, science careers were explicitly defined and modelled (Sjaastad, 2012), potentially embedding and enhancing science capital and habitus further (Archer *et al.*, 2013a; Wong, 2012). For one undergraduate student, however, the influence of family science capital and habitus was not seen as a positive experience, feeling pushed into physics, and becoming more confused; this participant is now a biologist, an example of the inherent stability of latent interest (Krapp, 2005; Ainley and Ainley, 2011; Krapp and Prenzel, 2011).

Celebrity scientist participants also referred to the important role that parents play, believing that they are a group with whom they themselves should engage with, not only to raise the profile of science by providing engaging and entertaining television programmes, but also by breaking the stereotypical view of what a scientist or engineer looks like.

Friends

When asked to reflect upon the influence of friends, *as per* the research of DeWitt *et al*. (2013b), responses suggested that they were less critical: it was important "*that I got the qualifications I need*" (Y12). Examples of older peers confirming decisions to continue with science were given, but here participants had already embarked on a science pathway: "*he told me that it was his most favourite … and he just said really, you should take it', and I was going to anyway, but [he] gave me more comfort to know that I'd like it*" (Y12). Nevertheless, they were pleased when their friends took science as well, in that they could generally support and encourage each other to continue "*even if you're struggling*" (UG). Furthermore, research suggests that science and cleverness are closely aligned (DeWitt *et al.*, 2013a; Archer *et al.*, 2014b; Wong, 2016), and that young people may be subject to teasing and bullying (Mendick and Francis, 2012), a potential barrier to continuing with science. Participants in this research had all chosen science pathways, there was no reference to negative peer-pressure (Francis, 2000), or even the more positive increase in kudos of 'geek-chic' (Mendick and Francis, 2012, p.70). However, one undergraduate participant recalled being called "weird" for continuing with science post-GCSE, but like 'Samantha' in Wong (2012) this participant "*laugh[ed] it off as a compliment*", a strategy recognised by Nayak and Kehily (2006).

In summary, participant families were considered to be influential, primarily from the perspective of supporting their chosen subject and career pathways, rather than specifically into science; they appeared to be defining and modelling their child's sense of self (Sjaastad, 2012). From a Bourdieusian perspective (1986), families of these participants, through the opportunities and situational interest provided (Hidi, 1990; Schraw and Lehman, 2001; Wade, 2001; Krapp, 2002; Krapp, 2005), had enhanced the social, cultural and, for some, the science capital and habitus that their child possessed, alongside developing a general 'love of learning'. On the whole, participants trusted their family's opinions, valuing their support and commitment. Friends were considered less influential, although older peers studying science were seen as credible voices, giving them confidence in the decisions already made; negative peer pressure was not an issue (Francis, 2000; Nayak and Kehily, 2006; Mendick and Francis, 2012; Wong, 2012; DeWitt *et al.*, 2013b; Wong, 2016).

5.3.5 Interim review: summary prior to discussion of celebrity science culture

The intention of this discussion is to illuminate the phenomenon of what influences young people to continue with science. Data collected was analysed according to the categories of the conceptual framework and used to build a picture of these influences. As a review so far, 'Personal interest' in science was the key influence for all participants, and the 'Nature of science and scientists' category provided insights into what this interest and motivation looked like; this appeared to be self-sustaining. Recognising that the depth and intensity of this interest was unlikely to have been sustained without direct engagement with science, the 'Science education' category was used to explore which aspects of their engagement were particularly important in embedding and enhancing their science capital. Teachers and lecturers themselves were key to this, providing situational interest which defined and modelled both a sense of 'self' and of 'science'. Whilst there was no surprise that teachers would define and model science and science careers, the depth of influence on participants sense of 'self' was not anticipated; this role is generally recognised to belong to parents and carers. Whilst it is recognised that the potential to raise science aspirations is enhanced when teachers and parents communicate about the pupil (Munro and Elsom, 2000), this relationship was not referred to by participants in this research.

By coining the phrase, the ‘Brian Cox effect’, the media have suggested implicitly that celebrity scientists can be this significant person, and indeed, Rodd *et al.* (2013), question this potential. This is discussed in the next section: Celebrity science and scientists.

5.3.6 Celebrity science and scientists

The ‘Celebrity science and scientists’ section of the conceptual framework comprises the following subcategories:

- Inspire to continue with science
- Raise awareness of opportunities within science
- Raise general interest in science
- Entertain

Firstly, the influence of celebrity science and scientists on the science student participants of this research are explored, and secondly, the perceptions of the celebrity scientist participants regarding their role in influencing young people are considered. The intention is to ascertain whether there is resonance between the influence described by the student participants, and what the celebrity scientist participants perceived their role to be.

Science student participants

Part 1 of the main data collection process for the science student participants included an initial narrative biographical approach, inviting them to share their memories of science, and who or what had influenced them to continue with science, post-compulsory age. Part of the rationale here was to discern any implicit references to celebrity scientist influence, prior to participants knowing that this was the main focus of the research.

Reference was made to specific television programmes, and to David Attenborough, Stephen Hawking, Brian Cox and the historical scientist, Antoine Lavoisier, during this part of the interview, by five of the student participants. However, there was no sense that these programmes and celebrity scientists influenced their decision to continue with science; they were not the initial impetus, interest in science came first. For example, an interest in the Large Hadron Collider led to an interest in the work of Brian Cox and Stephen Hawking: “*since the Hadron Collider, I’ve had a real interest in all that sort of thing*” (Y12); their role appeared to be one of sustaining and building personal ambition and interest; their science capital was further enhanced and embedded (Archer *et al.*, 2013a). A postgraduate participant gave an example of how David Attenborough’s programmes were shown to an eleven month old son, hoping he might develop an interest in science, the programmes were described as "*one of the best introductions … [because] the voice is so commanding and the colours, and the way that it's presented. He'll just sit there and watch the birds*" (PG). As a parent, and therefore a significant voice as discussed previously, this participant was providing situational interest in order to define and model science (Sjaastad, 2012), an example of Entertainment-Education (Weinmann *et al.,* 2013) and the enjoyment realised by engaging with a media product (Wirth *et al.,* 2012), with the potential of building the child's science capital (Archer *et al*., 2013a). Whilst not personally influenced, this parent recognised the potential of celebrity science and scientists.

Celebrity science and scientists did, however, appear to play a role in participant's decisions to follow specific career pathways within their already chosen field. Forensic and medical documentaries and dramas were named by two undergraduate participants, one enrolled on a forensic science degree, and the other nursing; this resonates with the 'CSI effect' (Kim *et al.*, 2009; Hook and Brake, 2010), and enrolment on midwifery programmes (Cullen, 2016). Again, personal and family interest in these fields were already in place, and although they did not influence them to continue with science, they did inform a specific career pathway within these fields, recognising that "*they're not real life*", there were "*aspects around it*" (UG). For participants, through "long-term, repeated exposure to the different aspects of the same theme" (Lacayo and Singhal, 2008, p.9), these programmes had raised awareness of the opportunities in science. These examples of informal science education (Miller, 2004; Weinmann *et al*., 2013) reflect Simon's (1993) notions of attention economics and 'bounded rationality', where the career decision-making process appeared to have been supported by what was seen on television; they showed what was possible (Allen and Mendick, 2015; Wang and Singhal, 2018).

The scientists and science-based television programmes described above are examples of situational interest sought out for themselves, or provided at home and school (Hidi, 1990; Schraw and Lehman, 2001; Krapp, 2002; Wade, 2006), with the perceived outcome of promoting personal interest in science by enhancing and consolidating their science capital and habitus (Wong, 2012; Archer *et al*., 2013a). These participants highlighted the value of access to science role models and experiences, even fictional television programmes (Rojek, 2001; Futuyama, 2007; Russell, 2010).

During Part 2 of the interview, when student participants were explicitly asked if they had been personally influenced by celebrity scientists, responses were mixed but generally again linked to sustaining interest and raising awareness of potential career pathways in science.

On the whole, the response was ‘no’, but those that were more tentative consistently referred to the science itself, not the celebrity scientist, for example, “*in a way … the curiosity side of it*” (Y12) and “*Yes, they’re part of what got me into science in the first place, people showing that science wasn’t boring, it wasn’t irrelevant*” (PG). Below is an example from a Y12 participant of the convoluted thought process that most participants went through; there was a high degree of frowning, as they tried to answer this question, and as can be seen, interest in science came first:

> “*I think definitely, if it wasn’t for maybe television programmes and things like that, I wouldn’t have maybe got interested in it quite so much … I find it interesting anyway, so it wasn’t difficult for celebrity scientists, I suppose, to get me interested in it, because I already had an interest in the field*.” (Y12)

In addition, whilst not inspired originally by celebrity scientists to continue with science, participants recognised that they influenced specific behaviours, and as such helped to sustain interest, for example, reading more about their work, and following them on social media. These student participants appreciated how celebrity scientists and science in the media had provided situational interest to support their personal interest (Hidi, 1990; Schraw and Lehman, 2001; Krapp, 2002; Wade, 2006).

It would appear that the major influence of celebrity science and scientists was again raising awareness of career opportunities in science (Allen and Mendick, 2015; Wang and Singhal, 2018); Bandura’s (2004) “vicarious motivators” (p.84). Watching the doctor on ‘Embarrassing Bodies’ supported an interest in medicine generally, and when explicitly asked about personal celebrity influences, one participant referred to medical dramas as influential: “*I just went on and thought, ‘Oh, ‘I want to do that’*”, and as with the participant who raised this during the narrative phase, they “*opened your options*” and “*you could see what type of nurse you wanted to be*” (UG). The Y12 physicist referred to above, believed that Brian Cox and Albert Einstein, “*people like that”* (Y12), were role models, “*if you see them make discoveries … that’s kind of what has made me do it. I want to make new discoveries and stuff. I know it might not happen but it’s just like a way of fuelling you*”, and, talking about Brian Cox working at CERN, “*it’s like my dream job … learning about new particles and accelerating them to dead high electron* *volts to make new particles, yeah, that would be amazing!"* (Y12). It was the science itself that was the influence, with Brian Cox showing what one could do as a physicist; he had raised awareness of opportunities within science (Allen and Mendick, 2015; Wang and Singhal, 2018). Brian Cox was a significant person in this participant's life, modelling and defining both science and a sense of 'self' as a scientist (Sjaastad, 2012), however, he was not the reason for this participant continuing with science in the first place. The identity of these participants as scientists appeared to already be strong, with well-developed science capital and habitus (Archer *et al*., 2013a); they were inspired to be where these celebrity scientists were, not because of being on television, but because of the science content of their work; because they were successful "*academically and professionally*"; and because they had "*dream jobs*" (PG). This was also true of how a participant viewed lecturers, aspiring to be like them, but not to be them: "*I want to come into my own*" (PG).

Combining implicit and explicit responses, participants believed that although celebrity scientists present interesting and entertaining programmes, they did not influence them to choose to continue with science, but, in some cases, they did inspire a specific science pathway. Furthermore, there was a belief that they do have a role to play in sustaining interest:

> "*If you're interested initially, maybe those types of people reinforce that, it's a nice way of making it cool … or it doesn't have to be always really boring and 'Oh, let's read a text book', it could be something as simple as going on TV and seeing that*." (UG)

For these participants, there was the perception, then, that celebrity scientists and science-related programmes have the potential to act as explicit role models within a specific field, for example Brian Cox and physics, and 'Casualty' and nursing, thereby building science capital, and raising aspirations and awareness of the possibilities within science (Archer *et al*., 2013a). However, interest came first, with emphasis on the work that scientists were involved in; they demonstrated that finding their work interesting, and "*remarkable*" (PG), can inspire someone to follow the same pathway and do what they do (Jenkins and Nelson, 2005; DeWitt *et al.*, 2013a).

Finally, and contrary to the normal perception of celebrities as role models (Sjaastad, 2012), celebrity scientists were seen as modelling and defining science and science careers, they were not seen as modelling and defining what it means to be a celebrity.

Celebrity scientist participants

The final focus of this first part of the diptych draws on the voices of the celebrity scientists themselves: what was their perception of their role?

Celebrity scientist participants believed that it was part of their role to influence young people, and they all gave examples of this work; David Attenborough, however, did not think that there should be any obligation. For Steve Jones it was more about "*informing*" rather than explicitly influencing people to continue with science, asserting that he would not say *"come and do biology"*, but would say *"biology is interesting and fun to do*." He referred to Maggie Aderin-Pocock as someone who is informative and a good role model, but who also does not overtly influence, "*she doesn't say, now come and do astronomy.*" Susan Greenfield also saw this as part of her role, and is especially concerned that women and girls, and people of other ethnicities, "*mainly see scientists as white men*." Mark Miodownik wanted to be part of the media culture because he was concerned that for engineering, role models outside the classroom were limited. He compared the situation to medicine, where even if science education is weak, there are a number of "*quality*" medical dramas portraying medicine in an inspiring way (Lacayo and Singhal, 2008; Allen and Mendick, 2015; Wang and Singhal, 2018); he saw medicine as part of culture, whereas engineering is not. He was, however, concerned for the future, and the need for more scientists to get involved and maintain the profile of science, because "*if they don't get it from us, they will get it from other people, [or be] replaced by people talking about tattoos!"* Referring again to the paradigm shift in attitude by the science community, he described his "*pride*" that PhD students and postgraduates are more involved, not just in television, but through social media and You Tube. His awareness reflects the recognition that the 'Sagan Effect' is no longer a concern for scientists today (Shermer, 1999; Jensen *et al*., 2008; Fahy, 2015), and indeed that they are encouraged to communicate their work, and to engage with the general public (Russell, 2010; Fahy, 2015). Roma Agrawal went as far as saying scientists have a *"responsibility"* and a *"duty"* to portray what they do in a way that's inspiring and interesting; but more than this, they should *"portray the passion*."

Nevertheless, Steve Jones did call for "*a certain honesty by the science community*" and by the media. He was referring to biology now being a hard science, whereas it is still promoted as soft; the implication is that as students progress through their degree programme, they "*get a nasty shock, because it's hard*." He supported this by recounting a conversation with Brian Cox, who was also "*shocked*" by the limited mathematical background of his students, noting that "*you can't do physics without maths*." In addition, he argued that the science community should be more realistic about job prospects, referring to Britain having more forensic science graduates than there are forensic scientist posts. Mark Miodownik was also aware of future implications for those young people choosing science, especially as he recognised that he was not always projecting "*the downsides*." He argued that celebrity is a "*hook*", but worries about the risk that young people may be disappointed when they realise that the profession is not "*full of those type of people*." The issue here is that the notion of "name to a message" (Chouliaraki, 2012, p.3) may be invalidated if the science and science careers that celebrity scientists are promoting do not represent the reality of working in that field.

These insights from the celebrity scientists also support the validity of the subcategories of the conceptual framework.

In summary, it appears that there was little sense of the "name to a message" notion of celebrities for the student participants (Chouliaraki, 2012, p.3). The exception was the Y12 reference to Brian Cox and Stephen Hawking, but again interest in science came first; this participant ascribed significance to the celebrities as their 'audience'. Influence here appeared to be a cyclical process, akin to exemplification theory (Yoo, 2016) where someone identifies with a celebrity, develops para-social bonds (Merton, 1946; Lazarsfeld and Merton, 1948; Horton and Wohl, 1956; Pfau and Parrott, 1993; Van Norel *et al.*, 2014), begins to notice them more, and therefore they become more available to them. There was clearly a "perceived fit" between the product and the endorser (Fink *et al*., 2013, p.21). Of course, initial inspiration may not have been as a direct result of these celebrity scientists, the work of Brian Cox and Stephen Hawking could have been introduced by a science teacher as situational interest to raise science aspirations, or even a family member, simply as a family interest.

5.4 Part 2. Celebrity science culture

In this second half of the diptych, a picture of scientists as celebrities is initially discussed, before considering their potential influence.

5.4.1 Scientists as celebrities

Language used by student participants to define 'celebrity' was comparable to that used in the field of celebrity research (Boorstin, 1961; Rojek, 2001; Chouliaraki, 2012; CelebYouth, 2014; Marshall, 2014): well-known, famous, notable, in the media, renowned, noticeable, idolised by society, role models, people you look up to, someone doing good. It was generally viewed as a derogatory term, especially for those celebrities who had done nothing to deserve it, or were just related to someone else (Allen and Mendick, 2013b; Allen *et al.*, 2014; Mendick *et al.*, 2015); Boorstin (1961, p.57) calls these ‘counterfeit people’. Nevertheless, some celebrities were thought to be deserving of the title, for example, those that had been successful in sport and music; they were recognised for their achievements, rather than it being simply attributed (Rojek, 2001; Mendick *et al.,* 2015). Celebrity scientist participants were similarly uncomfortable with the term ‘celebrity’: it is “*embarrassing*” (Roma Agrawal), “*despise[d]”* (David Attenborough), with concerns about the “*baggage attached to it*” (Susan Greenfield). Mark Miodownik suggested that Brian Cox could probably be described as a “*true celebrity*”, whereas he described himself as a television scientist, because he was not well known. One Y12 participant made explicit reference to Brian Cox, arguing that he is a celebrity scientist, not only because he is well known through his science programmes, but also because of the work he does in the community, and his presence on reality television shows; this is akin to the way young people spoke about Bill Gates in the research of Mendick *et al.* (2015).

Only one reference to the potential of scientists to be celebrities in the traditional sense of ‘superstars’ was made. Here, an undergraduate participant, suggested that in the same way people might aspire to be a celebrity footballer, like Wayne Rooney, they might also be inspired to “*becom[e] a professor of physics and becom[e] a superstar!”* This was presumably a reference to Brian Cox, and is in line with Marshall’s (2014) assertion that by making the life style and rewards visible, individuals may identify with the celebrity, and therefore be influenced by them. However, participants raised concerns about privacy and “*paparazzi*” (Y12), suggesting that not all scientists would want to be a celebrity, if celebrity is based on their personal life, rather than on their science; they appreciated the issues of a celebrity lifestyle (CelebYouth, 2014) and that the media uses personality to underpin how news is presented (Fahy, 2015).

Another issue was that they struggled to name celebrity scientists, even those who presented the television programmes they named, other than Brian Cox and David Attenborough, which in a sense confirms that they were not themselves influenced. Initial responses from the student participants were well-known historical scientists, and only when explicitly asked were contemporary scientists named. It is difficult to imagine participants having a relationship with one as a significant person, if they cannot name them. The sense of “name to a message” (Chouliaraki, 2012, p.3) and wanting to be like them (Jenkins and Nelson, 2005; DeWitt *et al*., 2013a) did not appear to be relevant to this group of science students, they did, however, remember the science; this supports previous discussion about the influence of the nature of science itself. In contrast to the students, those named by the celebrity scientist participants were all contemporary, and personally known to them. Echoing the student participants, Roma Agrawal called Brian Cox the "*obvious one*", and David Attenborough the "*major one*"; Steve Jones described David Attenborough as "K*ing of them all*."

An interesting paradox was raised by a postgraduate participant, who believed that you cannot be both a scientist and a celebrity, mirroring the notion of the importance of authenticity raised by the young people in Mendick *et al's* (2016) research, suggesting that Brian Cox had "*lost his way*" as a scientist. From a science perspective this was essentially a reference to the 'Sagan Effect' (Shermer, 1999; Jensen *et al.,* 2008; Fahy, 2015), where a scientist's level of public fame was asserted to be in direct opposition to the quality of their research work. For Sagan this was false, but his fame, nevertheless, did damage his standing as a scientist (Shermer, 1999; Jensen *et al.,* 2008; Fahy, 2015). This is contrary to the views of the scientific community today, in that the 'Sagan effect' is no longer valid, and a scientist's celebrity status is now "*its own distinct source of authority*" (Fahy, 2015, p.217). Indeed, Mark Miodownik asserted that there had been a paradigm shift in the attitudes of other scientists in the field, especially as so many scientists were now involved in science communication and engagement; he suggested that if it was just Brian Cox, it would still be this *"weird, special thing*." David Attenborough also highlighted this, and, referring to Brian Cox specifically, he noted that although he was criticized, the scientific community did find that he had an "*integrated and carefully ordered educational brief*."

Interestingly, Susan Greenfield believed there had been a further paradigm shift, in that celebrity scientists now fall into two different types. The more traditional figures such as David Attenborough and Patrick Moore, describing them as "*very benign, very much loved cultural figures*", and those like herself, and Robert Winston and Richard Dawkins, who as scientists, put forward "*controversial ideas*." She asserted that the former "*explain difficult concepts simply, but offer nothing novel or original*" (Brian Cox was included here), whilst the latter "*challenge people's perceptions*." She argued that these different "*types*" of celebrity scientist have a different role to play in engaging with the general public. This sub-classification is potentially important from the perspective of developing the theoretical framework of this research (Aim 4), and informing future policy and practice: the so-called "*benign*" scientists may play a role in engaging society as a whole with science, thus promoting scientific literacy in the populace (Millar, 2006; Millar, 2012), whereas those scientists putting forward "*controversial ideas*" may have a role to play with those already engaged in science, or those considering a career in science.

In general, then, the participants were unsure about the term ‘celebrity’ because of the negative connotations associated with it, however, there was a belief that scientists should be celebrities if they wanted to be acknowledged for their work, concerned that “*you hear about what’s happening [in science] but you don’t hear about the scientists”* (UG). If this is the case, it is important next to consider how a scientist becomes a ‘celebrity scientist’.

5.4.2 Scientists and celebrity status

Participants were aware of how people become celebrities, acknowledging that it is “*the power of the media that really creates a well-known celebrity*” (PG), and they play “*a big part in deciding who gets to celebrity status*” (Y12). This is in line with Marshall (2004; 2014) who asserts that celebrities are indeed media constructs (Boorstin, 1961; Rojek, 2001; Marshall, 2014), with Rindova *et al*. (2006) arguing that the media then directs public attention to the celebrity, thereby reinforcing their celebrity status. Referring to Brian Cox, David Attenborough suggested that without television he would only be known within his own university. He went on to describe Brian Cox as a “*brilliant communicator”*, and that when he was Director of BBC2, he would look for people like Cox, “*grab [them] by the throat”,* and give them an opportunity to work in television. This is an interesting perspective, in that Sutcliffe (2010) had also suggested that with Brian Cox, the BBC may have been wanting to find something further for him to do; the content of the programme ‘Wonders of the Universe’ may have been secondary. The implication here is that the media was promoting Brian Cox’s celebrity status to draw an audience, rather than wanting to promote science; their agenda may be different to that of the scientific community. Mark Miodownik, recognising that the media had created him, talked about how the BBC had been collaborating more with the science community over the last ten years, wanting to “*project science and engineering as human, and with people more contemporary*”; this reflects the changes noted in the BBC Trust’s Science Impartiality Review Actions (BBC Trust, 2014). Clearly the media is not a philanthropic organisation, it needs to be profitable and attract a viewership, but it would appear that the notions of celebrity creation and of communicating and engaging the public in science are being assimilated and as such raising interest in science in the media.

With an increasing emphasis on science communication and engagement by the scientific community, it is possible for scientists to promote themselves with the media. Roma Agrawal described that this was how she was able to create a name for herself, and therefore be in a position to influence young people. She was confident that one can be proactive and promote oneself by finding a “*story or brand”* that catches media attention. For her it was ‘The Shard’, this was the "*hook"* that drew the media to her. Her advice to other scientists is to get involved in a project they are passionate about, find the "*hook*", and "*sell that to the media*." She believes that once in the media, "*we can play on our other messages to our hearts content*." In terms of celebrity influence, this is in the realm of individual identity (Marshall, 2014), where recognition of their work and accomplishments, and their associated capacity provides a "name to a message" (Chouliaraki, 2012, p.3): Roma has become the media's "name to a message" for female engineers.

Celebrity influence also depends on a second domain: the "realm of the supporting group or followers" (Marshall, 2014, p.25). Continuing with Roma's experiences, following appearances on television programmes such as 'The One Show', young people, parents and teachers contacted her to tell her that she has been influential in raising young people's interest in engineering; a positive example of Entertainment-Education (Singhal and Rogers, 2004; Lacayo and Singhal, 2008; Wang and Singhal, 2018). This 'audience' embedded her culturally (Boorstin, 1961), thereby reinforcing her celebrity status (Rojek, 2001), so that she remains the media's "name to a message" (Chouliaraki, 2012, p.3).

The intention is that celebrities are perceived as "people like us" (Fitzgerald and Savage, 2013, p.46), and we can identify with them (Morgan, 2011). This resonates with what the scientific community itself is trying to achieve through its scientific communication and engagement strategies, wanting young people to see science as "for me" (Jenkins and Nelson, 2005; Russell, 2010; Bucchi, 2011; DeWitt *et al*., 2013a).

Other participants referred to the importance of audience and context, suggesting that someone could be a celebrity to you even without a media presence: "*There are key scientists who haven't reached the sort of world-renowned stage, but among scientific groups they'd still be celebrities*" (PG). Mark Miodownik acknowledged this paradigm of celebrity also exists in the science community, where a scientist has a "certain seniority." This understanding reflects the 'audience-subjectivities' of Marshall (2004, p.37) where the audience ascribes significance to celebrities, within their particular social networks, in this case, science. In addition, participants acknowledged that some scientists, whilst doing important work, might not be well known, not wanting to "*tak[e] the limelight*" (Y12). The emphasis here, seems to be on the influence of the science *per se*, rather than the scientist.

This has implications for celebrity scientist influence on young people, in that they, as audience, must in some way be able to relate to them; perhaps they need to see them as significant persons in the field (Sjaastad, 2012), to see their work as authentic (Allen and Mendick, 2013b; Mendick *et al.*, 2015), before they can be influenced by them.

In summary, participants were generally reluctant to use the term ‘celebrity’ to describe scientists in the media, although they believed that scientists should be celebrities if they chose. The complexity of achieving celebrity status was acknowledged, especially the role of the media. Potential limitations were also recognised: loss of privacy and the loss of reputation within the scientific community for those scientists in the public eye. Brian Cox was ascribed celebrity status, as he bridged both the scientific world, and the world of reality television; he has been a guest on the panel shows ‘QI’, and ‘Would I lie to you’. The celebrity scientists, when considering their individual roles and influences were aware of the changing nature of their role, and the paradigm shift in attitudes within the scientific community towards scientists in the media. There was also a sense that scientists should be proactive and promote themselves with the media, and so be able to engage with the wider public.

There appears to be the potential for young people to build a relationship with celebrity scientists, and therefore be influenced by them, recognising that it is they who embed their celebrity status, and that the relationship is asymmetrical, with the building of para-social bonds. This is considered next.

5.4.3 Celebrity scientist influence

Participants could see the potential of celebrity scientists having a role in raising science aspirations. To be influential, they raised the following as important aspects of a celebrity science culture: being able to identify or relate to the science [or scientist]; to trust them and their science; and being able to see them as credible, knowledgeable voices about science and science careers.

Being able to relate to the science was considered more important than relating to the scientist, for example, a Y12 participant believed that Brian Cox would not be *“seen as a role model”* as someone who “*actually liked science … because they can relate to [the science]*” (Y12). This is contrary to the conventional view of celebrity influence, where people relate to the celebrity first, and as a result are influenced to ‘buy into’ their product or issue (Chouliaraki, 2012). Nevertheless, participants could see the potential of using celebrity scientists in this way: “*you can use them to show something to look up to*” (UG), reflecting the findings of, for example, Allen and Mendick (2015) and Wang and Singhal (2018).

Celebrity scientist participants concurred, for example, Roma Agrawal was pleased that currently in science there are "*a lot of quite young, vibrant voices*" that people can relate to. This is in line with the notion of "imitative consumption" (Rojek, 2001, p.34), and the recognised transformational power that some celebrities have (Marshall, 2014), so that their identity as a scientist, science is "for me" (Jenkins and Nelson, 2005; DeWitt *et al*., 2013a), may be enhanced. Nevertheless, one participant asserted that if someone does not want to do science, celebrity scientists will not "*push them further into [it]"*(PG). Brian Cox was cited as an example of this potential, describing him as "*very much the social face of science at the minute, because he is prominent in the media, … and when you think about physics, most people would think about him*" (Y12), and "*he's put physics on the map*" (Y12). Indeed, David Attenborough was aware that his own name had become embedded in some people's minds with natural history, and, in line with the notion of personification (Bucchi, 2011; Fahy, 2015), he suggested that "*it's easier to put a label on a face, than an idea*", referring to Brian Cox and his association with astronomy:

> *"… But do people look at Brian Cox's programmes because they're interested in astronomy, or because they're interested in Brian Cox? I would have thought that the answer is both."*

He believed that both aspects are "*intermingled, difficult to separate",* and that if a subject becomes popular, so will the name associated with it, reflecting not only the heuristics of exemplification theory (Yoo, 2016), but also, again, the notion of "name to a message" (Chouliaraki, 2012, p.3).

What participants appear to be suggesting is that through personification, young people relate to the science, and therefore are enabled to identify with the scientists, with the potential of raising science aspirations; akin to Fahy's (2015, p.207) concept of "science incarnate". Nevertheless, a postgraduate participant was aware that this personification could have a negative effect on science uptake, describing some of Brian Cox's co-hosts as "*weird people*", and although Brian Cox himself was seen as "*cool*", it was suggested that it was "*easy to come across 'not cool*."

In addition, participants extended the potential of being able to relate to celebrity scientists to science programmes including fictional dramas. An example was given of the 'CSI effect' (Kim *et al.,* 2009; Hook and Brake, 2010), noting that friends had enrolled onto a forensic science undergraduate programme because of a television show, "*things like NCIS"* (PG).

Steve Jones also referred to this, suggesting that there was now "*a plague of forensic scientists*!" This again reflects the transformational power of the media (Marshall, 2014), the role that Entertainment-Education may play (Lacayo and Singhal, 2008; Wang and Singhal, 2018), and the potential for "imitative consumption" (Rojek, 2001, p.34) by young people.

Although student participants generally believed that it is the science that scientists are engaged in that is influential, rather than their celebrity status, a postgraduate participant suggested that as scientists were considered intelligent, people would trust what they were saying, and take their advice. Here, trustworthiness can be seen as relating to McLuhan's (1964) "the medium is the message" where the message (science) will be trusted if they trust the messenger (scientist) (Van Norel *et al*., 2014, p310). According to David Attenborough, part of his role as a television producer was looking for "*someone who will make an impression on the audience in order to convey a message*." However, a postgraduate participant recognised that this "*impression*" did not necessarily lead to a positive outcome, referring to the MMR vaccination/autism controversy again, that even though Dr. Wakefield's paper was retracted, people were still trusting him, and therefore he was "*still influencing other celebrities to give opinions*" (PG).

Further references were made to the role of the media, especially the sense that "*science gets a lot of bad press*" (PG), and that it "*dilutes the importance of science by grabbing a headline*" (PG), instead of collaborating with scientists and reporting in a balanced way, citing sources; they were concerned that this "*anti-intellectualism*" (PG) might actually frighten people and damage lives. Steve Jones was also critical of the media, in that it reports science "*on the basis of press releases and quirky stories*"; this was one of the criticisms he raised within the BBC Trust report (Jones, 2011; Jones, 2012). He suggested that a key factor is failure of the media to use celebrity scientists to present contemporary science stories. As with the postgraduate participant above, although acknowledging that in one specific newspaper there is "*some very good science coverage*", he goes on to say "*in the news section there's complete crap about ghosts and 'dates cure cancer'*." He also referred to the issues surrounding MMR vaccination, noting that it was "*extraordinarily badly handled*."

Participants, then, were acknowledging the potentially damaging impact of the media (Miller, 2004; Dillon, 2011; Weinmann *et al*., 2013), as "informal science educators" (Miller, 2004, p.290) and the need for celebrity scientists to promote "*a balance between people's perceptions and scientists, because it's not supposed to be an enemy situation*" (PG).

There is the potential, then, for a negative influence on public engagement with science, which has implications on the decision-making process of young people. The choice of "name" in "name to a message" (Chouliaraki, 2012, p.3) is important if young people are to be influenced positively, particularly as David Attenborough asserted, "*But the medium and the message and messenger are all intermingled, and it's very difficult to disentangle them."*

Celebrity scientist participants were aware of the power of the media, and the impact this can have on the scientific literacy of society as a whole, thereby impacting on the science capital available to young people. With this in mind, Steve Jones believes that it is important to "*saturate society in science, as much as there is in sport*." Mark Miodownik, discussing the political agenda of science communication, was "*frustrated"* with, for example, drug and energy policies, noting that scientists are ignored. His solution was to shift the balance of power, in that "*the more power science and engineering have in the media, the greater politics I think will take note of it*", likening it to the impact that Jamie Oliver had, as a result of his "*people power*" on diet in schools. He concluded: "*So if science wants to have the power that celebrity has, it needs to have some celebrity scientists, to me that logic is inescapable*."

Here, celebrity scientists were aware of the bigger political and cultural picture of scientific literacy, and the important role that the media could play as "informal science educators" (Millar, 2004, p.290). However, David Attenborough believed that:

> "*The BBC would be very incautious to take upon itself such detailed ambitions. The BBC is not there to manipulate society, and it would be getting too big for its boots if it thought it was ... that's not the responsibility of the BBC*."

The notion of credibility was raised by Steve Jones, as he proffered two kinds of celebrity scientist: professional scientists, like Brian Cox, and professional non-scientists, like the comedian Dara Ó Briain. He described them as "*two sides of the celebrity scientist coin*", believing that both are important, but that because of the credibility of professional scientists, they probably play "*a slightly larger part with the more serious part of the audience."* Mark Miodownik also referred to Dara Ó Briain, his co-presenter on the BBCs 'Dara Ó Briain Science Club', believing that his humour and humanity are "*wholeheartedly brilliant for the subject.*" He went on to say that there are some science programmes where you can see that the presenter does not understand the science, but that this was not the case with Dara O'Briain; he described him as a "*proper celebrity*" but also a "*scientist by training, [with] a science brain*." This notion of 'proper' celebrities is reflected in the findings of Mendick *et al.*

(CelebYouth, 2014). In terms of influencing young people, although Dara Ó Briain had some credibility having a science background, he was not directly modelling and defining science; perhaps this could be described as a relationship 'by proxy'; very much reflecting the more usual role of celebrity advocacy and endorsement.

The relationship of celebrity scientists with fellow scientists was also raised by a postgraduate participant, suggesting that celebrity scientist influence would not only be about raising their interest and giving advice, but that there may be an expectation that they assume a leadership role. This would require celebrity scientists to be credible, with the "characteristics of the target population" (Yoo, 2016, p.57), that is, their field of expertise. This insight perhaps reflected the postgraduate's level of education, recognising their personal need to be credible in order to communicate their research, and engage effectively with the general public and their peers.

As well as the credibility of individual scientists, a postgraduate participant raised concern about the credibility of some science television programmes, such as '*Brainiacs*' and '*Mythbusters'*, especially those that over-rely on explosions to engage the audience. Although they do attract viewers, with the potential of raising interest, this participant was recognising one of the issues of science in the media, that is, where scientific facts and ideas are misrepresented for the purpose of entertainment (Russell, 2010); the potential here is that science may not be taken seriously (Futuyama, 2007), and the appreciation that celebrity culture has the potential to "close down" opportunities as well as "open up" (Allen and Mendick, 2015, p.18). Susan Greenfield also discussed this type of science programme, seeing their value, but again concerned that science programmes should not be "*full of sensationalism",* that they should engage young people *"in a deeper way ... showing them the relevance of science to their lives*." However, as the postgraduate stated above, this sensationalism could be the hook to gain initial interest, with the potential of raising science capital and aspirations (Archer *et al*., 2013a).

The notions of identity, relatability, trustworthiness and credibility, then, were generally seen as important features of celebrity scientist influence, however, science *per se* remained key. Participants generally believed that celebrity scientists could be influential, but that young people probably needed an interest in science first. Referring specifically to young people choosing a science career, a postgraduate participant summarised it as follows:

> "*But to be honest with you, my opinion is scientists on TV can influence people, but quite honestly anyone bright enough to get through a degree is not gonna' make a*

> *huge life-changing decision only based on a TV programme … It's yeah, TV may have an effect, but for smart intelligent people it's not going to be the same as Kim Kardashian telling someone to get a Botox. It's not going to be a snap decision. We're talking five or six years out of someone's life. I genuinely don't believe it's going to be made on the back of some celebrity going 'Ah! It's shiny science.*" (PG)

Student participants, then, generally concurred that celebrity scientists did indeed have the potential to influence young people to continue with science; and celebrity science participants believed that this was an important part of their work, one in which they were engaged. The question is: who could they influence?

5.4.5 Who could celebrity scientists influence?

The general response to who celebrity scientists could influence was children and young people, even though on the whole, paradoxically, they themselves were not; celebrity scientists were seen as having the potential to "*capture children's imagination*" (Y12). Student participants suggested targeting young people in Years 9 and 10 (age thirteen and fourteen), because they will be making GCSE choices, and are "*quite malleable*." This is contrary to the belief that aspirations are stable (Krapp, 2005; Ainley and Ainley, 2011; Krapp and Prenzel, 2011; Archer *et al*., 2014b). They recognised that by year 11 (age fifteen) pupils had already made their decisions, and at year 7 (age eleven), they were perceived to be too young. One Y12 believed that if GCSE students were targeted, it might influence them to take science at 'A' Level, thereby increasing the chance of continuing at university. This reflects the research of Archer and DeWitt (2017) where focussing on fourteen year olds is considered optimum, and indeed that the later interest in science is initiated, the less likely they are to continue with it at a post-compulsory age (Maltese *et al.*, 2014). In addition, participants believed primary school to be an important phase, in line with DeWitt *et al*. (2013a), suggesting that this would get "*their mind ticking over*" (PG), so that if they are then targeted at Year 9 they would be more interested, "*then they'll be like 'Yeah!*'" (Y12)

One way suggested of engaging children and young people with celebrity scientists was to afford the same level of publicity to the achievement of celebrity scientists as is afforded to celebrities in general, such as magazines, because "*you're not really taught about scientists today … like you learn about the older ones"* (UG); they want to learn about the science that is taking place today. In addition if science awards were televised, such as the Nobel Prize ceremonies, they suggested that science would be seen in a different light, and children might say “*Oh! I wanna’ be like Brian Cox*” (PG), rather than someone like Kim Kardashian; their aspirations might be “open[ed] up” (Allen and Mendick, 2015, p.18).

As well as children and young people, participants suggested that the general public could also be influenced by celebrity scientists, inspiring career changes, new hobbies and purchases such as telescopes. The latter a reference to the programme ‘Stargazing’, hosted by Brian Cox, which inspired people to buy telescopes, reflecting Rojek’s (2001) assertion regarding celebrities and “imitative consumption.” This could have implications on the science capital available to children through their families, friends and teachers, with the potential outcome of raising aspirations (Archer *et al*., 2013a). Fellow scientists and people in the media were also considered to have the potential to be influenced by celebrity scientists.

In summary, student participants appeared to want celebrity scientists to have a higher profile in order to raise the interest of young people in school, essentially they want them to be “opinion leaders” (Valente and Pumpuang, 2007, p.881). However, they emphasised the importance of credibility, and showing the positive nature of science (Futuyama, 2007; CelebYouth, 2014). Celebrity scientist participants concurred with this, and all gave examples of their personal involvement and influence on the science aspirations of young people. When the celebrity scientist participants were asked what they saw their role to be, they believed that as well as working directly with children and young people, their role should be to influence and support parents and teachers; this was not raised by the student participants.

5.4.6 Inspiration or entertainment?

The research question was: “Celebrity science culture: young people’s inspiration or entertainment?” As such, participants were explicitly asked to consider the nature of celebrity scientist influence, specifically whether they see them as inspiring or simply entertaining. Participants argued that it depends on the celebrity and their focus, suggesting that some programmes were “*hugely influential but not terribly entertaining*” (PG), especially if the subject was serious, such as the environment. Science *per se* was seen to be a “*kind of entertainment in itself*” but that it stayed at that level if someone was not interested in pursuing science; here again, the importance of having an interest first was raised – personal interest was key (European Commission, 2012; Maltese *et al.,* 2014). Nevertheless, participants recognised the potential to inspire someone if you were entertained and enjoyed the programme. Mark Miodownik hoped that having had positive feelings about a science programme, the next time they meet something similar, they might think "*Oh, this might also be entertaining [and] interesting, [I'm] curious.*"

David Attenborough's programmes were considered to be both entertaining and informative (PG), and he himself recognised the need to both inspire and entertain, giving an example of showing the public how wonderful elephants are as a precursor to issues surrounding their potential extinction. He argued:

> *"Nobody will care about the survival of the elephant if they didn't know something about what it was, and what it did. So the two things in my mind are inextricably linked. You needn't show them rotting corpses*."

When asked if he thought he was able to give both messages, he replied that he did, but that the issue is 'how' they are received, suggesting that "*they're received in proportion to how much people think that the person concerned is worth listening to and telling the truth*." The notion of "name to a message" (Chouliaraki, 2012, p.3) is relevant here, in that without credibility, the message may just remain at the level of entertainment. David Attenborough's "*telling the truth*", or the accurate portrayal of science, especially in factual programmes, was also raised by participants, in that programmes may be "*hugely entertaining but not terribly educational. No matter how many explosions you put in your programme, if it's not scientific method, it's not terribly useful"* (PG). This reflects the concerns of, for example, Futuyama (2007) and Russell (2010), where science may be misrepresented for purposes of entertainment. For these participants, limited 'appreciation' of the quality of science portrayed, the cognitive processing strand of 'Education-Entertainment' (Oliver and Bartsch, 2010; Weinmann *et al*., 2013), reduces the entertainment capacity of these programmes, and limits their value as opportunities to raise the accurate profile of science in society. Mark Miodownik also raised this as a potential issue within the science community itself, in that although he recognised that entertainment is the media's main focus, when he first started presenting programmes he received emails from colleagues stating that he did not explain the science properly, and that he would have to reply saying "*people are not getting facts, this is not education, this isn't like replacing a lesson*." David Attenborough also referred to the importance of accuracy even though the media's "*primary job"* is to create engaging programmes that will "*hold people's interest."* He explained that the function of the BBC was to act "*responsibly"* so that both specialists and non-specialists in the field were *"attracted."*

If the science, then, is not accurate, even though entertaining, there is the potential that it could have a negative effect on raising aspirations of young people.

The BBC programme, 'Dara Ó Briain's Science Club' was referred to by Mark Miodownik as an example of a programme seeking to both entertain and educate, to give people "*things to think about.*" He believed that it had a big impact, having received positive emails and messages from children, parents, teachers and the general public. In terms of inspiring young people to continue with science, he said, "*I think the thing is, it doesn't put you off.*" He referred again to Dara Ó Briain, his co-host, suggesting that this is where he helped, because he was a well-known comedian, and "*suddenly you can talk about the stuff he did in the 'Science Club'*."

Steve Jones also referred to the broader impact of science in the media, and the role of celebrity scientists, suggesting that they are not doing it particularly to get people into science, but to make science part of culture. He went on to say that in his experience, "*a lot of that comes from this so-called celebrity science theme. I mean Brian Cox gets huge audiences, David Attenborough gets huge audiences*." Considering the influence on non-scientists, he suggested that through watching these programmes they were educated, entertained and informed.

Russell (2010) argues that the way fiction portrays science and scientists impacts on the beliefs and behaviours of society towards science, and indeed, science in fictional programmes was also considered to be influential (Kim *et al.*, 2009; Hook and Brake, 2010; Christensen, 2011; Rutter, 2011; Orthia *et al.*, 2012; Cullen, 2016). Participants suggested that even though the intention of these programmes was to entertain, if people then ask questions about the science, it has "*done the right job*" (PG). David Attenborough also agreed that fictional programmes, as well as documentaries, can be influential, suggesting that the audience does not necessarily differentiate between them: "*they are all of a piece as far as the audience is concerned*." However, prior interest in science was again raised, referring to the '*CSI effect'* (Kim *et al*., 2009; Hook and Brake, 2010), a postgraduate participant believed that if someone did not have an interest in forensics, they would not find a programme entertaining, and, if the programme was not entertaining, they may lose interest. The programmes '*The Big Bang Theory*' and '*Pandora's Promise'*, whilst mostly seen as entertainment, were also perceived as having the potential to raise awareness of what careers in science might look like, to "*give a different view on science*" showing what goes on "*behind [the scenes].*" The film '*Interstellar*' was also cited as being important to a Y12 participant, reflecting the views of Futuyama (2007), who promoted the use of movies to clarify and deepen public understanding of science.

Overall, participants believed that both inspiration and entertainment were important facets of the role of celebrity scientists. One Y12 participant summarised this, believing that celebrity scientists should *"strive"* both to inspire and to entertain:

> *"… because you've got to entertain and get the viewership, but you've also got to hope that the percentage of them are then taking that on board, and wanting to go further with it … You can't really go one way or the other at risk of jeopardising it, because if you're not entertaining, you're not gonna get people watching, but if you're not gonna inspire anyone then there's no point doing it in the first place*." (Y12)

An undergraduate participant described this as: "*subject-specific entertainment*" that could leave people asking "*why does that happen?*" (UG). This is 'appreciation', the cognitive processing strand of 'Education-Entertainment' (Oliver and Bartsch, 2010; Weinmann *et al*., 2013), recognised as promoting an interest in science, with the potential of building science capital and habitus (Archer *et al*., 2013a). David Attenborough concurred that a programme should do both, suggesting that:

> *"If it didn't, you as a broadcaster are wasting your time. You hope to interest people into the subjects that you're dealing with. What television does … is light the flame of enthusiasm, which if it it's properly tended will then send people to the library shelves. If they [don't] then the people who put on the programme should be shot! Or at least fired because they're failing … the object of the programmes is to spark people's enthusiasm and curiosity."*

David Attenborough's notion of a *"spark"* was also used by a postgraduate student, and summarises succinctly participants' insights and perceptions: "*I think the interest helps and the entertainment helps, and between the two it could be enough to spark a passion*."

5.4.7 Brian Cox effect

'Sparking a passion' is essentially what the media was asserting when it coined the phrase the 'Brian Cox effect', and this was the final focus of the interviews.

In principle, participants thought that the 'Brian Cox effect' was plausible, recognising that individuals can "*bring about social change*", although these are usually "*on a more serious level of society, instead of just people wanting to take a subject*" (Y12). Furthermore, as previously discussed, the 'Celebrity effect' was acknowledged, with specific reference to the

‘CSI effect’ (Kim *et al*., 2009; Hook and Brake, 2010). This reflects the transformational power of the media (Marshall, 2014), and the potential for “imitative consumption” (Rojek, 2001, p.34) by young people. One of the Y12s, familiar with the work of Brian Cox, could see the potential, because:

> “*we’ve not had someone like that on a programme have we? That’s kind of new and relevant towards science, and I suppose a younger generation kinda look at him and think ‘Oh, look at all these new discoveries they’ve made and the advances in science they’ve made’, I suppose it kind of helps them to want to get on the same road towards success, and learn more about science.*” (Y12)

In addition, a specific example of his influence was given: “*I’ve heard people at school, you know since Brian Cox, they went into physics. They were unaware of how far you can go into a subject and how broad it is. He’s put that in people’s minds that you can study the stars, you can be an astroscientist*” (Y12). Here, Brian Cox was believed to have raised the aspirations of peers by modelling a career in science and enabling them to see themselves as scientists (Sjaastad, 2012); there was no sense, however, that he had been the initial inspiration to continue with science originally. Steve Jones was very clear that “*the ‘superstars’ and so on, like David Attenborough, have been very, very important in attracting people towards science*” and he also believed that this was “*probably true for people like Brian Cox*.”

Interestingly, another participant suggested that the ‘The Brian Cox effect’ is potentially bigger than just influencing individual young people to continue with science, it can impact on science itself, in that if you have more people wanting to be scientists, “*you’re gonna make headway quicker*” (Y12). Making *“headway quicker”* (Y12) could then potentially raise the profile of science itself. If this was the case, there is the possibility of a broader influence, in that the ‘Brian Cox effect’ could also increase the scientific literacy of the wider population.

One participant, however, could not see how Brian Cox could have personally influenced the uptake of science, as the age demographic did not correlate with his increased presence in the media: *“They’d already made their decision to study science further*” (PG); Imran Khan also referred to this issue of timing (Falk, 2015). Furthermore, David Attenborough, considering the ‘Brian Cox effect’ *per se*, believed that the media was “*getting hung up on that*.”

Not everyone agreed that the ‘Brian Cox effect’ was influential: “*I’ve heard of it, but as it is physics based … I don’t particularly follow”,* and although Brian Cox, with Dara Ó Briain, were watched presenting the ‘Stargazing Live’, for one participant there was lack of awareness "*of all of his work, to be honest*" (PG). Two participants remembered being told about Brian Cox and the 'Brian Cox effect': one was a physics teacher who "*mentioned him once or twice, but [I] couldn't say what he did"* (Y12), and the other a father: "*Dad was on about it, but I can't remember it"* (Y12). Whilst both of these students were scientists, neither were physicists, thereby suggesting that not only is a prior interest in science potentially a prerequisite for influence, but that this could be extended to prior interest in a specific science discipline. This reflects the assertion by Bennett and Hogarth (2009), that a positive image of scientists, in this case Brian Cox, may not actually be sufficient to promote a career in science.

The potential for a negative effect on science uptake was raised, for example, some of Brian Cox's co-hosts were described as "*weird people*", reflecting the issues raised by Mendick *et al.* (CelebYouth, 2014), and although Brian Cox was seen as "*cool*", it was suggested that it is "*easy to come across 'not cool'*" (PG), with the potential of "closing down" opportunities (Allen and Mendick, 2015, p.18). In addition, one participant raised concern for Brian Cox's reputation, in that by presenting biology-based television programmes he might be "*frowned upon*" (PG) by the scientific community. This participant went on to suggest that the media should have used a biology-based scientist, however, a dilemma was raised:

> *"… but then as people already know of Brian Cox, and they don't know of anybody that does a biology one, unless it's David Attenborough, no-one would watch it, would they? They wouldn't be interested if they didn't know who the person was, I suppose." (PG)*

Similarly, it was suggested that chemistry and biology "*need their own*" (Y12) celebrity scientist, a sentiment asserted by Haxton (2011). However, not everyone agreed, believing that Brian Cox could present in fields outside of physics "*as long as he knows what he is talking about*" (Y12). There was an awareness that his programmes are entertaining and accessible, even if someone is not particularly interested in science: "*[because] he's on the television … people have access to be inspired by him easily. But … I can't think of many that can reach out to people to inspire them*" (Y12). They were making links here with the notion of personification (Bucchi, 2011; Fahy, 2015), and the importance of "name to a message" (Chouliaraki, 2012, p.3).

In summary, the 'Brian Cox effect' could simply have been a "human pseudo-event" (Boorstin, 1961, p.11), a phenomenon constructed by the media, to capitalise on the celebrity status of Brian Cox, to sell newspapers and draw an audience; the media may have planned deliberately to have brought “new facts into being” (Boorstin, 1961, p.35) to increase their profitability, regardless of the “ambiguity” of the “underlying reality” (Boorstin, 1961, p.11). Nevertheless, however ambiguous the causal relationship between Brian Cox and the increased uptake of science might be, for these participants, even those not familiar with the ‘Brian Cox effect’, they acknowledged it to be a positive thing: “*I’m happy to get behind that … very often I find that the media is quite belittling and negative in a lot of ways, it’s very rare that you get many positive stories these days”* (PG). Participants, then, appear to want celebrity scientists to be “opinion leaders” (Valente and Pumpuang, 2007, p.881) believing that by simply watching, for example, Brian Cox’s programmes, one’s attitudes to science could be changed, potentially leading to “imitative consumption” (Rojek, 2001, p.34). Having said that, however, participants still asserted the need for personal interest as a prerequisite for influence to occur:

> *“But personally if I was in the position of wanting to take science, I don’t think someone like Brian Cox would influence me to do that, it would just be by myself, what I enjoy personally” (Y12)*

5.5 Conclusion: Theoretical framework development

In this chapter I have built a picture of who or what influences young people to continue with science, and the role of celebrity science culture in that process (Shulman, 1986; Sikes and Gale, 2006). The monologues and constructed dialogue focused this exploration (Riessman, 2003), with an emphasis on meaning-making and sense-making (Hinchman and Hinchman, 1997; Sikes and Gale, 2006; De Fina and Georgakopoulo, 2012).

Whilst confident that the conceptual framework structured this discussion chapter effectively, an ongoing reflection has been on its validity and usefulness as a model, post-data analysis and interpretation. Based on these reflections, in this concluding section I present the re-oriented conceptual framework, that is, the theoretical framework I am proposing to take forward into future academic research, potential policy development and media involvement (Aim 4). This framework is based, therefore, on the conceptual framework and research findings.

The conceptual framework consists of five ‘voices’: Personal interest; Nature of science and scientists; Science education; Family and friends; and Celebrity science and scientists. These were originally presented without placing emphasis on one over another. One of the findings of this research, however, was that ‘Personal interest’, for all participants, was the key influence; it was consistently present. This appreciation has led to a re-orientation of the framework, with ‘Personal interest’ now being placed centrally, and the remaining four voices positioned around it (Figure 5.1).

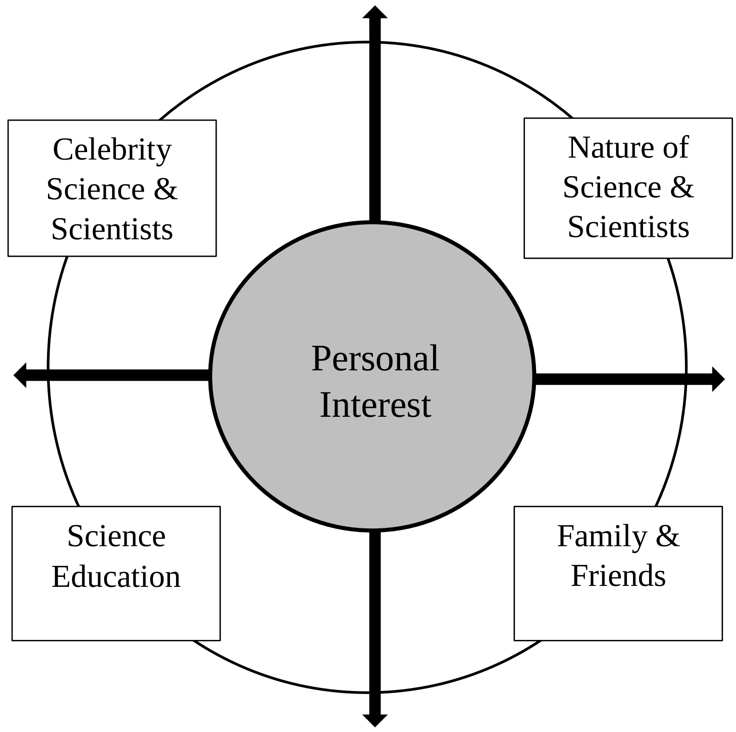

Figure 5.1: Theoretical framework showing the inter-relationships between the significant voices that influence science aspirations

These external voices can be visualised as encasing young people’s innate, intrinsic personal interest, akin to the notion of sustaining science capital (Archer *et al.*, 2013a). The sub-categories within each of these categories have remained the same, reflecting the validity and reliability of the conceptual framework.

The simplicity of this framework has its limitations, in that the reader might assume that the four external voices influence to the same degree. Data collected, however, indicated that this was not the case, with each participant placing different emphasis on the influence of the different voices; there was a sense that influence was individualistic, and, as the section on limitations argued (Section 5.2), the degree of influence may change according to audience, context and temporality (Squire, 2008; Andrews, 2012). To illustrate this, in Figures 5.2a and 5.2b, I present possible scenarios for describing the influence on two fictional individuals. In both figures the shaded areas within each quadrant represent the relative level of influence ascribed to the external factor. Greater shading equates to greater influence on the individual.

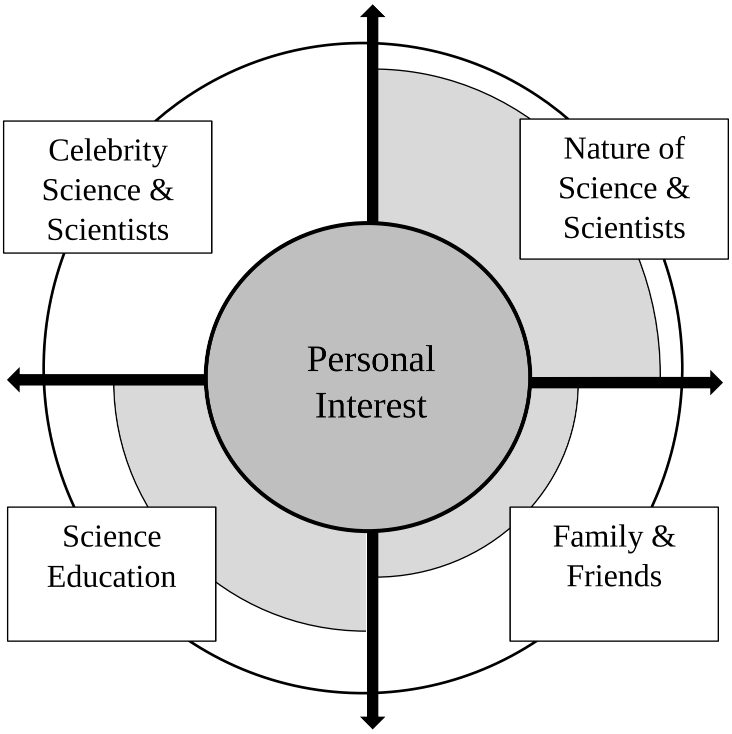

Figure 5.2a: Fictitious Person A – profile of voices influencing science aspirations

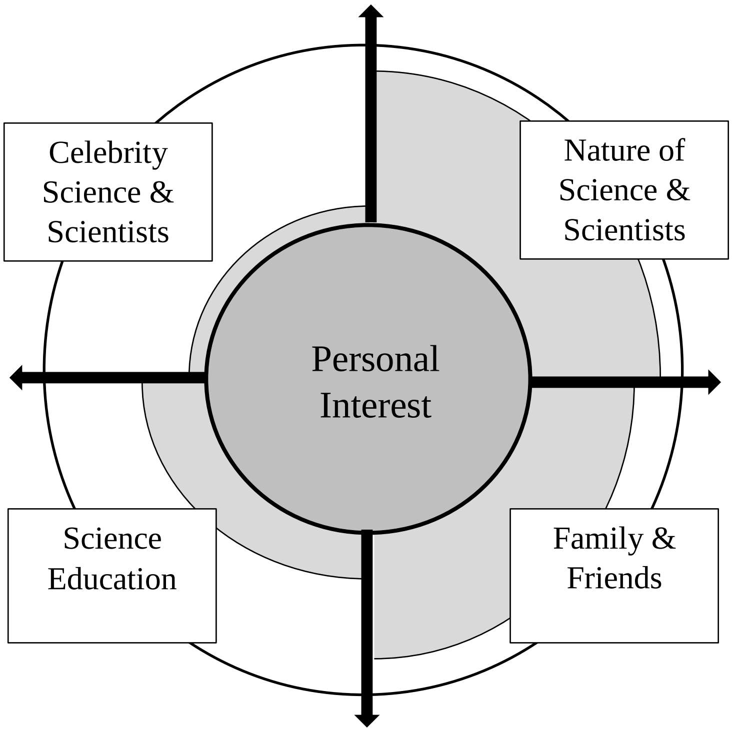

Figure 5.2b: Fictitious Person B – profile of voices influencing science aspirations

For person A (Figure 5.2a) the influence of the 'Nature of science and scientists' is high, 'Science education' to a lesser degree, 'Family and friends' of low influence, and that of 'Celebrity science and scientists' non-existent. In contrast, Person B (Figure 5.2b) also considers the 'Nature of science and scientists' to be the most influential, there is a reversal of influence for 'Science education' and 'Family and friends', and here 'Celebrity science and scientists' was considered to have some influence, albeit low. No attempt was made to quantify the level of influence in this study, however, Figures 5.2a and 5.2b show the potential that this framework has to represent influence on a sliding scale within each quadrant, from the central 'Personal interest' outwards. To this end, the dividing lines have been drawn as arrows, or, to continue with Kvale's (2007) metaphor of research as a journey, they could be viewed as the points on a compass. As such, this framework has the potential to be used to support raising the science aspirations of young people, whereby teachers and other stakeholders could look at the journey so far, map their influences onto the theoretical framework, and where influence is low, direct a personalised intervention to raise their aspirations, influencing directly and/or indirectly via the other external voices.

A further level of complexity, difficult to illustrate in a two-dimensional representation, relates to the influence and interaction that the voices have one with another. They are not independent of each other, and indeed, there are elements of mutual dependency. All combinations of influence are possible, including the influence that 'Personal interest' may have on the four external voices; it is a complex web of influence.

Within the context of this research, 'Celebrity science and scientists', whilst recognising their potential to influence young people directly, they also have the potential to influence the other 'voices', and, in turn, these voices influence children and young people directly, as significant voices (Sjaastad, 2012). Nevertheless, it is important to acknowledge that, although the external voices define and model science and science careers (Sjaastad, 2012), to a greater or lesser degree, this does not mean that this 'message' (Marshall, 2014) is received equally by the participants.

In Chapter 6, the conclusion to this thesis, I focus on the original contributions of this research and implications for future practice and policy, of which this theoretical framework plays an important part.

Chapter 6 Conclusion

6.1 Introduction

The 'Brian Cox effect' was a media construct asserting a causal relationship between the influence of celebrity scientists and the uptake of science post-compulsory age (Highfield, 2011; Townsend, 2011). It seems highly likely that he has played a part in the popularisation of science, through his presence on television, radio, and at festivals and science events, but could this be extrapolated to the increase in the uptake of science? It is recognised that celebrity status is used successfully in advertising and advocacy (Rojek, 2001; McKinnon *et al.*, 2008; Boykoff and Goodwin, 2009; Marshall, 2014), and is acknowledged as part of identity formation in young people (Giles and Maltby, 2004; Allen and Mendick, 2015). There was the potential, then, for celebrity scientists to influence the science aspirations of young people, and this was the impetus for my research:

"Celebrity science culture: Young people's inspiration or entertainment?"

This was explored through the following aims:

1. To explore the nature of the relationship between celebrity scientists and young people, and the uptake of science;
2. To explore the significant influences on young people's decisions to pursue a career in science;
3. To develop a conceptual framework to be used as the working tool to explore these influences and relationships;
4. To develop a theoretical framework that will inform future academic research, and with the potential to inform the development of science education policy and the involvement of the media (including celebrity scientists).

Narrative inquiry was the method of choice, and as such the intention was to illuminate the phenomenon of celebrity science culture (Clandinin and Connelly, 2000). Analysis of narrative biographical and semi-structured interview data from eighteen science students and five celebrity scientists, allowed an in depth focus on who or what influences young people, including the nature of their relationship with celebrity scientists.

This final chapter, the conclusion of the thesis, is structured around two key areas, and arguments are framed within the initial research parameters, boundaries and limitations:

- the original contribution to knowledge in qualitative research, and the fields of celebrity science culture and raising science aspirations; and
- exploration of future implications and applications of my research, both immediate ‘next steps’, and more distal.

6.2 Original contribution, implications and further research

As a result of this research, I offer two original contributions to knowledge: the major contribution is to the field of celebrity science culture, looking ahead to informing future research, policy and practice within science education regarding the continued uptake of science post-compulsory age. However, I also offer an original contribution within the field of narrative inquiry, specifically narrative presentation of findings; as this underpins the methods by which the phenomenon of celebrity science culture was illuminated, it is considered first.

Narrative presentation

Whilst narrative presentation of findings is a well-established methodologically (Leavy, 2009; Saldaña, 2012), this research offers an innovative approach: monologues were created from the combined transcripts of the three student cohorts, and these were used to structure and inform a constructed dialogue, where data collected from the five celebrity scientists was conjoined. This approach offers rich data, and contextualised examples of experiences and perceptions of all participants, staying ‘true’ to their voices throughout. As such, data collection and presentation were situated within, and contributed to, creative research methods, experimenting with narrative at the more playful end of the narrative research continuum (Smith, 2007). Clearly, there is the risk of this research not being taken seriously as fictional devices were used to create the narratives (Rhodes and Brown, 2005; Barone, 2007). However, they were intended to be sources of meaning, an established purpose in this field (Czarniawska, 2007; Saldaña, 2010), plus, there is methodological transparency in their creation, from the raw data collected to the final script, supporting my argument for their authenticity and validity. Furthermore, the use of “factional stories” (Kallio, 2015) in this research, was to enable the reader to “vicariously experience” the findings (Simons, 2009, p.23). In order that the reader would have confidence in the findings of this research, the conceptual framework played a key role: as well as underpinning data collection, it was also used to structure the creation of the monologues and constructed dialogue. All voices were honoured in a way that choosing examples from the data could not have done, and student participant anonymity was protected. The monologues captured the essence of their collective stories, without losing the divergent experiences and perceptions. Feedback from participants and readers of the monologues and constructed dialogue confirmed their authenticity, trustworthiness and plausibility, within the limitations outlined in Chapter 5 (p.157); this supports the confidence I have in the developmental process. Data analysis, interpretation and presentation of findings was systematic and rigorous, and achieved its purposes. Watson (2015) argues that research should also delight and spark the imagination, and I believe this to have been the case; the scripts were enjoyable to read, and 'sparked the imagination', in that readers began to talk about their own stories, that is, they were indeed "vicariously experienced" (Simons, 2009, p.23). To summarise, whilst acknowledging that producing performance texts to present findings is well-established, my research has presented a new approach to condensing, synthesising and conjoining data collected, one in which all voices are honoured, and their richness maintained. This could be of benefit to other narrative researchers who are seeking to illuminate a phenomenon, rather than developing an argument, wanting the reader/audience to "vicariously experience" the data (Simons, 2009, p.23). Using the conceptual framework to analyse and interpret the data, and to support selection of data included in the scripts, promoted confidence in the authenticity, plausibility and trustworthiness of the "virtual reality" (Kim, 2006, p.5) produced, standard criticisms of narrative approaches to data presentation.

Influence of Celebrity Science Culture

The major original contribution of this research is to the field of celebrity science and scientist's influence on the continued uptake of science by young people, post-compulsory age; the purpose of this research.

The following bullet-points summarise the new knowledge and insights relating to this field elucidated from the research; they are discussed in more detail below, and are then set in the context of the more general influences on young people, looking to inform policy and practice.

- Depth of derision about celebrity in general, and reluctance to call scientists celebrities;
- Different appreciation of the notion of 'celebrity' in science;
- Strength of their belief that celebrity science and scientists could influence young people, even though it was not true for them;
- Celebrity scientist participants saw their work as a partnership, wanting to work with teachers and parents, as well as young people and the media;
- Entertainment is important if young people are to be inspired, but the scientific content must be authentic and trustworthy;

- The notion of the ‘Brian Cox effect’ was considered plausible.

A real surprise from this research was the strength of feeling about the term ‘celebrity’, comments were derisory and participants were reluctant to refer to scientists as celebrities; the celebrity scientist participants themselves did not want to be referred to as celebrities. In a way, I believed the rhetoric that said celebrity culture is important, and young people want to be part of it. New insights, however, into celebrity culture were raised, participants saw ‘celebrity scientists’ differently to the media perspective, recognising that scientists could be a ‘celebrity’ in their own field, with their own peers, even though this may be extended to the wider public.

When participants were asked to consider if they believed that celebrity scientists had a role to play in influencing young people to continue with science, an important paradox emerged. Whilst not being directly influenced themselves, student and celebrity scientist participants believed very strongly that they could influence children and young people, describing what this does/might look like in practice, even suggesting age phases of education. They also explored celebrity scientist influence on the general public, other scientists, the more mainstream, non-scientist celebrities, and the media itself, raising concerns about the impact of this if the science presented is not accurate, credible and trustworthy. The celebrity scientists themselves gave examples of some of the issues and approaches needed to gain access to the media. Emphasis was placed on the necessity of children and young people to identify with, and relate to, the celebrity scientists, and again, accuracy, credibility and trustworthiness were considered key attributes of the science presented, both factual and fictional. Implications here relate directly to the celebrity scientists themselves and to the media. Much progress has been made in this area, especially since the BBC’s review (Jones, 2011; 2012), ensuring that the science presented comes from a range of disciplines, locations and presenters. Nevertheless, more can be done from the perspectives of the scientists themselves. Roma Agrawal suggested that scientists should be proactive, to find their specific ‘hook’ and take it to the media directly; this is what she did as a female engineer working on ‘The Shard’ in London. Mark Miodownik also encourages early career scientists to build a relationship with the media, not just getting directly involved with outreach into schools. Furthermore, both Mark Miodownik and Steve Jones raised the importance of scientists also being honest about the opportunities available to young people, and the present culture within which they work. The celebrity scientist participants also wanted to work directly with teachers and parents, actively supporting them, seeing their involvement from the perspective of a partnership; there was reference to parents by the student participants, but this was generally about informing hobbies and interests. All participants acknowledged that the ‘Brian Cox effect’ was plausible. This was based on their knowledge of, for example, the “CSI effect”, and their own memories of being inspired to follow a particular career pathway as a result of a television programme. There was recognition, though, that the “Brian Cox effect” was unlikely to have been the initial inspiration for someone to continue with science, as the media asserted, as decisions would already have been made before Brian Cox became popular, to take physics at GCSE and ‘A’ level. The notion of the “Brian Cox effect”, then, was not a reality for these participants, that is, celebrity science and scientists did not play a direct role in inspiring them to continue with science, however they did play an important role in maintaining interest and inspiring specific career pathways. A further new insight was that inspirational contexts were not the full picture, they also believed that entertainment was of equal importance; the two go hand in hand. This, however, came with the caveat that the scientific content must be authentic, credible and trustworthy.

In terms of an original contribution, regardless of whether Brian Cox himself was responsible for the wider uptake of science, all of the participants in this research believe that celebrity scientists do have a role to play in engaging young people, with the potential of raising their science aspirations. They were perceived to have the potential to both inspire and entertain.

Implications of this new knowledge

There are implications, then, in the way that celebrity scientists engage with young people, with two questions coming to mind: How might this understanding inform educational practice and policy, and, how might celebrity science culture be utilised to engage young people in science? To explore this, it is helpful to consider the above questions from the perspective of the more general influences on young people elicited from this research.

General Influences

These findings did not bring new knowledge to the field, but they do complement and support existing research (Maltese and Tai, 2010; European Commission, 2012; Archer *et al*., 2013a; DeWitt *et al*., 2013; Ipsos MORI, 2013; Maltese *et al.*, 2014), thereby bringing a confidence to the validity and reliability of participant perceptions of the influence of celebrity science culture. They can be summarised as follows.

For all participants in this research, students and celebrity scientists, it was their love and passion for science that was the most influential factor, that is, they continued with science as a result of a prior, long-standing, personal interest; there was a genuine delight in the nature of science. This personal interest motivated them to seek out opportunities to build their own science capital, and did not necessarily rely on other people. Student participants' experiences of school science emphasised the importance of trustworthy, authentic and plausible contexts, that is, they wanted their science to be purposeful. This was much more than having opportunities for 'practical work', it was a deeper understanding of what we refer to as 'real and relevant' contexts; celebrity scientists wanted to offer this to schools. Participants could see through tenuous links, and were frustrated when science was portrayed in a way that was not true or misleading, such as having explosions for the sake of them, or misrepresentation in the media. This need for authentic, purposeful science was also reflected in the relationships they had with their teachers and lecturers: they found their passion for a subject area, their advanced knowledge, even if it was not an area they were especially interested in, to be engaging and inspiring. Participants' experiences of scientists themselves were also important, again authenticity was emphasised, with the celebrity scientists also referring to the work of their peers. Whilst student participants enjoyed science visits and visitors, they were especially influenced by those who were working in a field that was seen to be making a real difference to the world; this reflected the desire of the celebrity scientists to demonstrate this. Participants could recall examples of those 'scientists' at the more entertaining end of the spectrum, but they were not considered inspirational in terms of continuing with science. All participants believed that parents were supportive, unsurprisingly wanting what was best for them, however, what was particularly interesting, from the perspective of the student participants, was the degree to which parents responded to their children's interests, rather than the other way round.

Returning, then, to the questions above (How might this understanding inform educational practice and policy, and, how might celebrity science culture be utilised to engage young people in science?), what follows are suggestions of what this could look like in practice. It is structured again using the categories of the conceptual framework, linked directly to the category 'Celebrity Science and Scientists'.

'Celebrity Science and Scientists' and 'Personal Interest'

It is important that those children and young people who already have a strong personal interest in science, those with an innate love for science, are recognised, and that their interest is deliberately nurtured. To this end, celebrity scientists could create specific events at festivals, and speaking tours/lectures, with the deliberate intention of inspiring and entertaining children and young people. On the whole, these genres are aimed at adults or families, and whilst that is important, if scientists deliberately create events for children and young people, sharing their science interests and research with them, there is the potential of raising their identity as scientists. Young people are not looking to be simply entertained, as may be the case at family events, they want authentic science and to hear about new developments. Celebrity scientists are already doing this in specific schools, this would be an extension of that role.

Television programmes could also be deliberately created by celebrity scientists and the media to engage children and young people. The Christmas Lectures are a good example of a televised event tailored specifically for this age group, plus, on the BBC programme 'Cbeebies' celebrity scientists such as Brian Cox and Maggie Aderin-Pocock read science stories for children. These examples have been presented by both male and female scientists, of different ethnicities, from a diverse range of scientific fields, thereby mitigating against issues of stereotyping. A 'diverse range' is key here, and this has implications for how the media chooses the celebrity scientists to present programmes. Whilst focussing on the mathematics aspirations of middle school girls in the USA, the work of Betz and Sekaquaptewa (2012) raises interesting insights. They found that for those girls who do not identify with mathematics, feminine role models can demotivate further, so that instead of having their minds opened, feminine STEM role models "seemed to shut them further" (p.743), or even pushed them further away. They suggest that this may be as damaging to mathematics aspirations as the 'geek' label. They warn, then, against "submitting STEM role models to Pygmalian-style feminine makeovers" in that it may actually be harmful, advocating that "a more fine-tuned approach is needed to benefit girls with different levels of STEM interest and to protect current STEM self-concepts" (p.744). As well as television, books, blogs, social media, and links on websites could also be deliberately created to engae with children and young people; this was an approach taken by the producers of '*Dara Ó Briain's Science Club'*, and Mark Miodownik referred to its success. This has the potential of young people relating to the celebrity scientists, as well as the science, and seeing them as significant voices; by identifying with them in this way, and an increased awareness of the breadth of careers available, there is the potential that young people may want to do what they do, as with the participant who wants to work at CERN because of Brian Cox's work.

It is recognised that these opportunities are likely to be sought out by those children and young people who are already interested in science, but there is the potential to raise the profile of these opportunities for those children who have not historically expressed an interest, as per Renzulli's (1998) notion of *'raising all ships'*, where focussing on those with a passion for science, giving opportunities for them to share what they have experienced, we might also raise the aspirations of their peers as well. This is explored below when considering curriculum issues.

'Celebrity Science and Scientists' and 'Science Education'

Student participants were inspired by the advanced subject knowledge and passion for science of their teachers and lecturers, and the celebrity scientists of their peers and colleagues. This appreciation adds strength to the argument for having science discipline specialists teaching in schools; this is a much debated recruitment issue, especially in the field of physics (Drori, 2000; European Commission, 2004; HM Treasury, 2006; CBI, 2012; CBI, 2014). Science educational policy and practice generally focusses, quite rightly, on three factors: that schools and teachers should provide an engaging curriculum that has the potential to inspire young people to continue with science (European Commission, 2012; Archer et al., 2013a; Ipsos MORI, 2013); on developing an understanding of how to be successful in examinations; and an emphasis on the pedagogical knowledge, understanding and skills of teachers to ensure that science is taught effectively. This is sound practice that has enabled and inspired young people to continue with science, but there is still a STEM skills-gap (European Commission, 2004; HM Treasury, 2006). The knowledge elicited from this research, however, has implications for an additional approach or emphasis, and this is where celebrity scientists could have a role to play. Here, I propose that a requirement of teachers should be to establish and maintain a specific specialism, that is, advanced subject knowledge in a specific field. Continuing professional development (CPD) for teachers could then include attendance at science conferences, at which there are generally celebrity scientists delivering keynote talks; to be members of scientific bodies, of which celebrity scientists will also be key voices; and to research as practitioner enquirers, based upon the work of celebrity scientists in their fields. This is the approach that I have taken, maintaining my knowledge and understanding of medical microbiology, recently teaching on an Oncology module, and using the work, for example, of Prof. Liz Sockett FRS, a celebrity scientist within her own field, on *Bdellovibrio bacteriovorus* with my primary phase student teachers, with the intention of encouraging them to do the same in school. There are implications here for teacher training, especially primary phase teachers who may not necessarily have a science background, but I can see the potential to formally trial this as a different perspective on engaging children in science.

In addition, continuing with this line of thought, teachers could support children and young people to find their own 'specialism', and personalise the curriculum to support this, whilst still focussing on the utilitarian aspects of passing examinations. Having this more personalised approach, the science that young people choose to explore would be innately purposeful and relevant to them. Issues regarding gender, ethnicity and social class could be negated, such that, for example, 'girly' girls (Betz and Sekaquaptewa, 2012; Archer et al., 2013b), where body image is important, may choose to become an expert in sun screens, food supplements, or nail care, thus requiring an understanding of a range of scientific principles from solar energy, nutrition to protein synthesis; the same could be true for 'masculine' boys, for example, if they like cars they could become an expert on the materials used, their design and how they are fuelled to increase speed. In both examples, children and young people would essentially be persuading themselves that they need to learn science. There is a danger of limiting their experiences here, but if children and young people shared their 'passion' and expertise with their peers, this would offer breadth as well as depth, with the potential of interests being conjoined into new projects (as in real science, for example, spinach with carbon nanotubes in their leaves to enhance photosynthesis; or microbes that produce cement-like substances embedded in the cement of buildings in earthquake zones). This would really be 'Working scientifically' in action (DfE, 2013; 2014). Furthermore, through this approach, children and young people who are not necessarily wanting to continue with science, would still become increasingly scientifically literate, as their science capital is built. Children and young people would have their awareness raised of the different careers available to them in science, whilst at the same time minimising the effect of stereotyping. Choosing their own foci, together with their teachers, children and young people would also have some control over the scientists with whom they have contact, with the hope that they would be less likely to be influenced by issues of gender, ethnicity and social class (Betz and Sekaquaptewa, 2012; Archer et al., 2013b; Wong, 2016).

In these scenarios, it is the teachers who would work with scientists, including celebrity scientists. Focussing on one area of science in depth, would enable them to find those scientists who are working at the cutting edge of their field, and as such would be able to share this with the children and young people in their classes. In addition, they would be able to directly or indirectly introduce the children and young people to those scientists working in their chosen topic, such that both the teachers and pupils would be personally and purposefully engaged in science, and be able to identify with scientists in the field. The celebrity scientist participants all wanted to be involved with teachers directly, placing great value on this relationship, and as such would be willing at some level to be involved, through direct relationships or through the development of resources that teachers could use.

‘Celebrity Science and Scientists’ and the ‘Nature of Science and Scientists’

All participants emphasised the importance of trustworthy, authentic and plausible contexts, that is, they want their science to be purposeful. In terms of influence, it would appear that the ‘Nature of science and scientists’ and ‘Personal interest’ are in a positive feedback loop, feeding and building science capital further. Alongside the more bespoke focus on advanced subject knowledge outlined above, this is something that, as practitioners, we can influence directly through the provision of purposeful curriculum opportunities, recognising that situational interest may increase personal interest, with the potential of raising science aspirations. Here, Brake’s (2010) definition of the nature of science may be helpful: teachers could plan for children and young people to engage with contemporary science, relevant to their local as well as wider communities (even global), whilst at the same time developing relevant scientific skills, with opportunities to communicate their work to others. Through engagement with celebrity scientists, young people would be able to explore new scientific methods, and have the opportunity to understand the principles behind seminal methods, rather than being limited to their repetition. In this way, by deliberately engaging with celebrity science and scientists, young people would see for themselves the importance of science in the world, its relevance, and that there is a clearly defined purpose. It would also raise awareness of the breadth of careers available.

Participants themselves consistently wanted to do something that would make a difference to the lives of others; David Attenborough used the word ‘altruistic’ when he talked about young people’s motives for continuing with science. For those who do not have an intrinsic personal interest in science, however, how do they know what ‘making a difference’ might look like for them? Could this be a limiting factor in their choice of science as a career? This appreciation, and the suggestions for practice made above, with teachers and pupils developing their own specialist knowledge, has implications for how scientists and science-based organisations and businesses engage with schools. This could require a more bespoke, personalised approach, where visits or visitors are planned from a specific area of interest to the pupils; here they would be able to see themselves working in a specific field, able to identify with the scientist, and relate to the science the scientist is talking about; direct relationships would make the career prospects more tangible, as they come to see science as “for me” (Jenkins and Nelson, 2005; DeWitt *et al.*, 2013a). Being able to ‘relate’ to the science was another interesting insight, especially important as celebrity culture *per se* is built upon ‘relating’ to the celebrity (Rojek, 2001). Many organisations and businesses are already heavily involved in this work, and have an outreach or education officer in post, for example, Rolls Royce, JCB and Thorntons locally. Although educational opportunities are advertised, engagement is often still initiated by the teacher. One approach would be for the science community to have a programme where organisations invite themselves into school, as well as holding events to invite schools to. There is good practice of this in universities, and their approach could be offered as a model for other organisations. The benefit of this would be to show young people that science is cross-disciplinary. By being able to get involved in real, purposeful science, barriers to some aspects of science could be broken down; I am thinking especially of physics, where the rhetoric 'it's too hard' is often heard. By having contact, for example, with the organisation developing microalgae to generate renewable energy, those students who call themselves biologists would see the relevance of an understanding of physics; the context itself could break down barriers. Furthermore, these organisations and businesses could be the link between schools and celebrity scientists. By deliberately building relationships with celebrity scientists in their fields they could facilitate engagement and relationships with schools directly; again, there would need to be an awareness of not only who these scientists are and the work that they do, but also their personal attributes in terms of femininity and masculinity, and the impact this may have on aspirations (Beka and Sekaquaptewa, 2012). It must be remembered, however, that this focus on inspirational science also needs to be balanced with entertainment values; the participants recognised the importance of this.

Thinking differently, then, about how science organisations and businesses work with young people and celebrity scientists, there is the possibility that they would begin to address their own concerns about the STEM skills-gap. In addition, there would be benefits to the professional development of both teachers and scientists: teachers would have opportunity to develop their subject knowledge and confidence, and scientists would have opportunity to develop their pedagogical knowledge and understanding. The scientists working within these organisations are essentially 'celebrities' within their field, if not in media circles, but by working differently, and involving the media where possible, they could become the next generation of celebrity scientists, thus perpetuating the cycle.

'Celebrity Science and Scientists' and 'Family and Friends'

This appreciation of the influence of celebrity science and scientists also has implications for how we engage with parents. The so-called 'science families' (Archer et al., 2013) have been shown to raise awareness of the opportunities available in science, but this does not necessarily inspire a career in science (Archer *et al.,* 2014). Schools themselves build relationships with these families, and through this there is the possibility of involving them in the curriculum directly, with the potential of adding value to the children in the class, if they see the work of their families being valued. An example was given by one participant from a farming family, who suggested that the family did not recognise how much science there was in farming, and how much they were working as scientists; examples like this could be capitalised upon by involvement with, for example, celebrity scientists from agrochemical companies, veterinarians, or soil scientists. Families who do not have science links could be included through specific projects, events, science club award ceremonies, even inviting them to talks and workshops given by the scientists, including celebrity scientists, the school is working with. Homework could be set that is inclusive and easily achievable, such as watching a celebrity science programme together, or doing a science experiment together; the school's virtual learning platform could hold these opportunities to ensure they are accessible to suit parents working hours.

Overall, then, the way that celebrity scientists engage with young people is multi-faceted. They can be a part of building a curriculum that focusses on advanced subject knowledge, for teachers and pupils, and they have the opportunity to show the bigger, even the global picture, of how the small steps that scientists take in developing new knowledge, understanding and skills, impacts on the wider world.

'Message to a name' and 'PASSION'

Much of the above is relevant at a local scale, with schools, families, and scientists from science organisations and businesses building relationships, and providing children and young people with real and relevant science curricula, personalised to build the advanced subject knowledge of teachers and students. Involving celebrity scientists has the potential to influence the aspirations of children and young people by direct and indirect means. My intention in this section is to introduce a different concept and a potential tool to support how stakeholders in science education work with the media and celebrity scientists to build together the science capital of children and young people; the traditional mechanisms of celebrity creation are not entirely helpful here (Rojek, 2001; Weinmann *et al*., 2013; Marshall, 2014).

If this practice is to be embedded in education policy and practice, a new mindset may be required, and this is what I propose next, through the new notion of "message to a name", the reverse of "name to a message" (Chouliaraki, 2012, p.3). Recognising that it was the science that participants remembered, rather than the scientist's name, even Brian Cox for those participants who did not have an interest in physics, the notion of "name to a message" (Chouliaraki, 2012, p.3) is not necessarily appropriate when engaging children and young people. Reversing this to "message to a name" might be more relevant. Here, we take the "message", that is, the science context that is important to the children and young people, and we bring a name to it, adding relevance through this relationship. In this way, personification develops later; I much prefer Fahy's (2015, p.207) concept of "science incarnate" which also places emphasis on the science first and the 'incarnation' or 'body' later. Steve Jones, a renowned scientist in the field of snail genetics, gave an interesting insight which supports this, arguing that as scientific knowledge is finite, in a sense waiting to be discovered, if a scientific discovery is not made by one person, it will be made by someone else; he contrasted this with the arts, where if someone did not produce a piece of music, it would not be created by someone else. It is the science, the "message", that is important.

Essentially, then, by making changes to teacher CPD, where they focus on developing their personal advanced subject knowledge, alongside that of their pupils, teachers and lecturers would automatically highlight the "message", that is the key scientific knowledge, understanding and skills. They would then find a "name", that is, a celebrity scientist to work with. From the perspective of celebrity scientists, recognising that they believe they have a role to play in raising the science aspirations of young people, and wanting to work in partnership with schools and families, they would see themselves as the "name" and actively create and look for opportunities to promote their "message"; Roma Agrawal referred to this as the approach she takes. Scientists need to see themselves as a "name to a message" and educators need to be looking to link a "message to a name." Together, I believe that the potential to raise the science aspirations of children and young people is enhanced, as exemplified by the influence of Brian Cox on the uptake of physics. You will see then, that having been sceptical of the role that celebrity scientists play in inspiring young people, I believe that by strategically working together, there is the potential to increase the uptake of science by young people, post-compulsory age.

From this new perspective, whilst not a theoretical framework, I offer a tool, a checklist based upon the experiences, influences and perceptions of all participants that they believed to be important in engaging young people in science. It is based upon the word 'PASSION', a mnemonic (Figure 6.1), a word repeatedly used by participants to express their love of science, and as such reflects the content of the checklist back to its purpose.

P	Science to be **PERSONAL** and **PURPOSEFUL**
A	Students to be **AWARE** of breadth of careers in science
S	**STEREOTYPING** to be minimized
S	**SCIENCE CAPITAL** to be developed
I	Students to **IDENTIFY** themselves as scientists
O	**OPPORTUNITIES** for students to experience real science
N	Students to explore the **NATURE OF SCIENCE and SCIENTISTS** in the real world

Figure 6.1 'PASSION' as a mnemonic to support policy and practice in science education

It draws together the key aspects of the vision outlined above of what science education could look like if science educators and celebrity scientists work together. The intention is that it be used to make the influencing factors easy to remember, thus facilitating a productive dialogue between the different stakeholders. This is one of the areas of this research that I hope to take forward into the future.

Whilst the discussion above has focussed on the implications of this research at the level of policy and practice, there are also more local implications in terms of my future research practice, extending further the influence of celebrity science culture.

It is intended that the monologues and constructed dialogue are taken to pupils and teachers in school, allowing them to map their own experiences onto the theoretical framework (Figure 5.1, p.199), and to possibly see themselves within the narratives. Young people could compare their own stories with those of their peers, to identify resonating themes, differences and similarities. This would enable them to explore their own science capital, and how they could build it further. From this point there is the possibility of trialling the personalised approach of developing advanced subject knowledge of teachers and pupils, outlined above. This in turn would allow me to explore the notion of "message to a name." By collecting narratives of pupils who had been involved in looking at their own journey, and had received direct input from scientists, and celebrity scientists indirectly, it would be interesting to see if their memories reflected an implicit or explicit influence to continue with science, that is, were they significant 'voices' on their journey?

6.3 Conclusion

Wellington *et al*. (2012) consider it important to reflect, not only upon the research itself, but also what has been learned about oneself. This journey has shaped my identity as a researcher, with a background in positivism, I am now evangelical about narrative research. I have a deeper awareness of how methodological choices determine the outcome of research, and a new vocabulary through which to explore these issues of authenticity and trustworthiness of research practices. Having to bring together diverse theories from the fields of science education, celebrity culture and media studies has been a challenge but ultimately moved my ability to think at a deeper level to create new knowledge. It has been a hard but worthwhile journey.

From the perspective of this research I have found many things fascinating: the complexity of the human being and the multifacetedness of relationships; the importance of being aware of what children's strengths and aspirations are, and the need to deliberately provide opportunities to support them along their chosen pathway; and the importance of imploring young people to do what they love, even if that is not science. But, finally, the most fascinating aspect has been the willingness and generosity of the young people and celebrity scientists to share their stories; this has not only affirmed the relevance of this research, but has also deepened my belief in the power of research to change lives.

In the section on reflexivity and power dynamics, I referred to being 'star struck' by meeting David Attenborough. His influence on our world is beyond measure, and even the other celebrity scientists interviewed referred to his importance. It is fitting then that he is given the last word; this sums up my personal ethos of science education, and draws upon the potential of the power of celebrity science culture at its best, in other words, it sums up the purpose of this research, and is the driving force behind my next steps:

> *"The function of television programmes is to spark peoples' enthusiasm and curiosity, ... to light the flames of enthusiasm ... and to send people to the library shelves."*

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Appendix 1: My personal narrative

My earliest memory of science, although I didn't think of it as science at the time, was making a museum in a tent in the garden, and taking my toys to it. I have no recollection of formal science at primary school, although I do remember a very dubious use of a red hot wire to cut polystyrene! I can remember the words 'nature walk' but I can't remember one at all. I do remember wanting to be a doctor when I was eight though, and writing to Sheffield hospital for a prospectus; they very kindly sent me one!

Science started at grammar school for me. I remember doing biology but I can't remember actually what we did, other than watching two videos, one of an amoeba moving and another of spirogyra. The amoeba was one of those 'wow' moments in my life, watching something that I couldn't see with my eyes, living and moving! This amoeba started me off on my career as a microbiologist. I hated physics, not because of the subject matter, but because of the teacher – I was scared of him, although there was no reason to be. I loved learning and wanted to do well, and I always came in the top three in the exams, but for physics I came second to last.

After two years at grammar school, our town 'went comprehensive' and we moved to the new High School. Science was now altogether, rather than separate subjects. I really enjoyed science, especially the biology, but it was mostly about knowing facts; I don't remember doing any practical work at 'O' level, but I guess we must have done. I enjoyed chemistry a bit, but found it confusing because the teacher, although lovely wasn't brilliant; she was also my form tutor which didn't help. I must have blocked anything to do with physics. I also really enjoyed studying languages, especially German, and started to think about being a travel courier. However, my German teacher left and my next one was hopeless, so that was the end of that, although I do still learn German at home. I started to think about being a physiotherapist, and knew that I needed to take biology at 'A' level. I also took chemistry and physics. I dropped physics after six weeks, because the teacher just made us copy off the blackboard, and I didn't understand it at all. I did maths instead. I don't remember anything about the chemistry but absolutely loved the biology. We dissected a dog fish, and a crab, and learned about all of the body systems in detail. This included a lot of experiments. We could also choose something to specialise in, and I chose marine biology. We went on a field trip to Anglesey for a week, and I did a project on anemone – I loved it!

After my 'A' levels I decided to do a BSc in Applied Biology. I absolutely loved that too! It was a four year sandwich course, so that we got to work in industry from April to September as *part of the course. I worked for Sandoz researching the effect of agrochemicals; for Severn-Trent monitoring pollution by pond-dipping above and below factories; and then at a hospital working as a medical microbiologist (I went on to get my first job at this hospital). The course was very practical and all about science in industry, as the title of the degree suggests. This meant that it was all relevant and at last chemistry and physics made sense, and I started to understand them. I specialised in Medical Microbiology and Clinical Chemistry.*

I remember going to a lecture about sickle cell disease and was fascinated to learn how the genes that code for this protect against malaria, and another about painkillers and the different ways that they work. It isn't hard to see that I was moving towards a career in microbiology and towards the health service.

I was offered the opportunity to stay and do a PhD in genetics, but I just wanted to get to work; I have often regretted this, and wonder what I would be doing now. As I've already said, I got a job as a medical microbiologist at the hospital. It was fascinating and important. I started to work towards my Fellowship exams for the Institute of Biomedical Science. We went to Sheffield University as a day release for this, for two years. There were exams to pass and a project to complete; I looked at the microbial content of dental abscesses.

After four years, I applied for job as a research oncologist – I loved this, it was a small team, and we were working on small projects. I looked at Natural Killer Cells and how we could cryopreserve them for returning to patients post-chemotherapy and radiotherapy. Sadly, there was interest from researchers in Japan, as the number of cancer cases increased as a result of Hiroshima and Nagasaki. With a change of director, we started to research ovarian cancer, using growth factors to limit their growth. I published four papers whilst I was there.

After about eight years, I decided to train to teach, but this wasn't the end of my passion for science. I worked in primary schools, a secondary school, and became an Advanced Skills Teacher for the local authority, before moving to become a senior lecturer at university – I am science subject leader, and now a Chartered Science Teacher. I tell my students that if I was a stick of rock, the word 'science' would be wrapped around me!

Appendix 2: Conceptual framework development & Exemplification

Appendix 2 explains how the conceptual framework needed to fulfil pluralistic functions was developed, thus fulfilling the following aim and objectives of this research:

Aim 3: To develop a conceptual framework to be used as the working tool to explore influences and relationships.

This was achieved through the following objectives:

3. To undertake a small scoping study to facilitate development of the conceptual framework;
4. Using the conceptual framework, structure the systematic review of literature and develop an appropriate methodology to explore celebrity scientist influence.

1. Conceptual framework 1

As a starting point, a very simple conceptual framework was created to illustrate the overlap between the three key themes in this field; the central region showed the perceived gap in knowledge and understanding. This was Conceptual Framework 1 (Figure 2.1), and underpinned the methodology of the scoping study as described below.

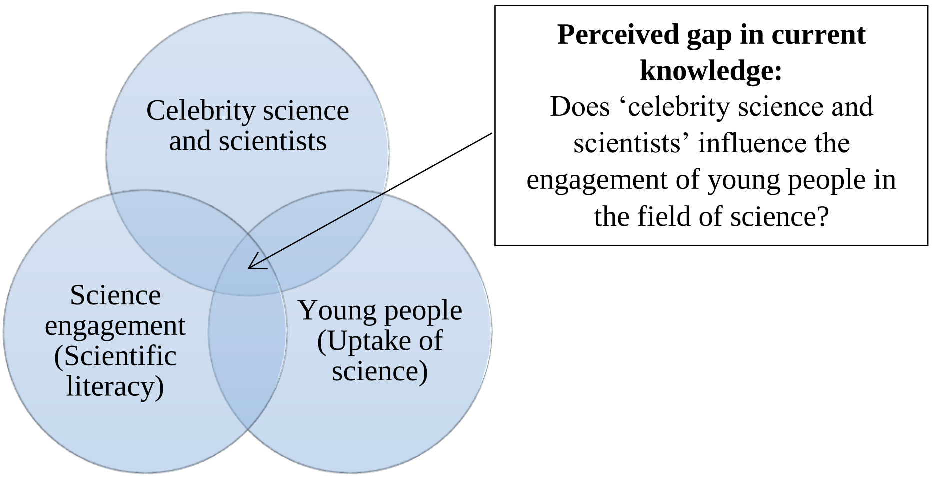


Figure 1: Conceptual Framework 1

2. Scoping study

The original conceptual framework (Figure 1) highlighted the perceived gap in knowledge and understanding of how celebrity science and scientists influence the engagement of young people in the field of science. A scoping study was designed to explore this perceived gap, to develop appropriate research methods, and to allow further development of the conceptual framework.

In summary, the aims of the scoping study were:

- To explore the factors that might influence a young person to continue with science;
- To explore the notion of celebrity, and the influences celebrity science and scientists may have on the decision-making process that underpins the uptake of science by young people;
- To develop a conceptual framework that would set boundaries to the review of literature;
- To develop a systematic and rigorous method to collect the data described above, and subsequent analysis, interpretation and presentation of findings.

An overview of the scoping study process can be seen in Table 1. It consisted of two stages, the first informing the second.

2a. Methodology explored

The theoretical perspectives underpinning the scoping study are fully explained in Chapter 4: Methodology of the thesis itself.

Research paradigm: The research paradigm was interpretivist (Bryman, 2012). The main concepts considered were the notions of celebrity and scientific literacy. These concepts were used in the sensitising tradition (Blaikie, 2009), that is, they provided initial ideas of what to look for, and these ideas were refined as the research proceeded. The initial research strategy was abductive, exploring influences on building science capital and the uptake of science. This produced “understanding rather than an explanation, by providing reasons rather than causes” (Blaikie, 2009, p.89). This strategy described perceived influences and then derived themes that formed the basis of an understanding. I was seeking to discover and describe the ‘insider’ view (Blaikie, 2009, p.90). An inductive approach was used to explore how young people felt about celebrity science and scientists (Blaikie, 2009), this enabled limited generalisations to be established; it is acknowledged that the descriptions produced were limited in time and space (Squire, 2008; Andrews, 2012).

Research stage	Participants	Interview format	Narrative	Semi-structured interview
Stage 1	Six BEd Student Teachers (Primary phase, science specialists): [BEd] One Year 9 school student (age 13): [GCSE} Three 'A'Level school students (age 18): [A1, A2, A3]	Group Individual Individual	No information given prior to interview Participants interviewed individually or in groups	Questions below Subsidiary questions were asked to draw out key themes The notion of the 'Brian Cox effect' was raised after eliciting participants' understanding of celebrity, and celebrity scientists
Stage 2	Six Year 9 school students (age 13): [Y9] Science teacher: [ST]	Group Individual	Prior to the interview, participants were told that they would be talking about their memories of science, and the people or experiences that influenced them to continue with science	

Table 1. Overview of Scoping Study Process

Participants

The intention was to talk to people who had, according to the media, been influenced, or are being influenced, to continue in the field of science post-compulsory age (Townsend, 2011; Paton, 2013). The primary participants in this scoping study were school students (aged 14 and 18), a science teacher, and BEd Primary trainee teachers (science specialists). The sampling strategy for participation, therefore, was purposive, in that I deliberately chose to interview specific people in order to "illuminate the research question at hand" (Denscombe, 2003, p.16). These participants were more likely to provide relevant and critical data regarding their influences.

Data collection and analysis

Narrative has been defined as: "discourses with a clear sequential order that connects events in a meaningful way for a definite audience and thus offer insights about the world and/or people's experiences of it" (Hinchman and Hinchman, 1997, p.xvi). Hence, a narrative biographical approach (Clandinin and Connelly, 2000) was designed to allow an appreciation of the participant's science journey, as well as exploring implicit or subconscious influences. Through a semi-structured interview, participants were asked to name key people or experiences that had influenced their continued uptake of science, and finally, the notion of celebrity was discussed, exploring their experience of celebrity science and scientists, particularly focussing on any perceived influences. Interviews were recorded and transcribed, and initial data analysis took a thematic approach (Saldaña, 2012). This process is explored and exemplified below.

Scoping study questions

Narrative biography:

- Tell me what you remember about science: what are your earliest memories, chronological, through school?
- What were the key influences to make you continue with science?

Semi-structured interview:

- What do I mean by the term 'celebrity'? What is your understanding?
- Can scientists be celebrities?
- Do you know of any? Male? Female?
- Do they influence? Have they influenced you? Who might they influence?
- [Give my research title] The media is implying a causal relationship – what do you think?

Method

- Initial part allowed you to talk about yourself, to tell your story: did you like that? Positives, negatives?
- Did you like talking about yourself?
- Is there merit in this method? Questionnaire or interview?
  What advice could you give me for future interviews?

Ethical Considerations

With narrative inquiry, the interviewer and interviewee construct understanding together, therefore, it was important to think of ethics in terms of relational matters (Clandinin and Connelly, 2000; Cohen, Manion and Morrison, 2007). Participants voluntarily agreed to 'give away' their data, and it is was my obligation to treat participants respectfully. Encouraging respondents to become more active participants in the research process, in that they were able to select what they believed to be the most important information, did not automatically result in a more ethical methodology and indeed led to the need for a greater sensitivity to the ethical issues raised by research (Elliott, 2005); the potential for exploitation was just as great as in structured interviews and survey approaches. I was cognisant of the ethical responsibilities towards all the participants, which were undertaken with due consideration, working within the University of Derby's 'Research Ethics: Code of Practice' (University of Derby, 2013), and the British Educational Research Association's (BERA, 2018) ethical guidelines. Key ethical considerations can be seen in Appendix 4.

2b. Scoping study findings

Findings are presented in three sections:

1. Methods and development of the narrative approach;
2. Narrative biographies and influences;
3. Semi-structured interviews exploring celebrity science and scientists.

1. Methods and development of narrative approach

Feedback from Stage 1 informed how the participants in Stage 2 were interviewed: this resulted in two adaptations. Firstly, the narrative biographical questions were given prior to the interviews of the year 9 group and the science teacher, in order to allow thinking time. There was agreement that this was helpful: "*I was glad of a heads up, I'd have given less of an answer and gone away and thought of things*." [ST]. Secondly, the Year 9 students were interviewed as a group, rather than individually; a strategy that the 'A' level students thought would be more supportive for younger participants. Feedback suggested that this was true, not only from a comfort perspective, but also in order to allow ideas to develop, for example, "*Topics grow more in a group*" [Y9]. However, they were aware of the potential disadvantage of not being able to say what they personally thought, suggesting that that if they were on their own, they would be able to say "*this is what I think, rather than tagging on*" [Y9].

Regarding the use of interviews, rather than questionnaires, as a means of collecting data, participants believed that they had the potential to be more helpful to me, in that I was "*more likely to get a direct answer*" [A1] and "*get a better picture of what it's like*" [A2]. The potential for me to guide the conversation was also seen as beneficial. However, this freedom raised some concerns, particularly during the narrative phase, in that "*I didn't know how far to go, or how long to talk*" [BEd].

None of the participants were aware of the focus of my research until later in the process, and this was considered to be beneficial: "*Had I been told of the question [Brian Cox effect] I would have answered more directly, but that's not so helpful to you*" [GCSE].

Finally, they all said they found the experience enjoyable, laughing when asked if they enjoyed talking about themselves; this is recognised as a benefit of narrative research (Clandinin and Connelly, 2000; Elliott, 2005).

2i. Interviews: narrative biographies

Science stories/memories

The majority of the participants remembered very little science from Primary School. Where they did remember things, it was generally the unusual, like rockets [Y9] or frog spawn [A1], or being bored by writing. Secondary school was better, with reference to Bunsen burners [A2, ST], and science being "*cooler and interesting*" [A2]. There was some talk about science in the family, and how science was around them, for example, stargazing with granddad [Y9], or older siblings becoming scientists [BEd]. Others talked about different teachers that they remembered, and the impact they had. They remembered studying the different subjects, and how they had preferences; physics was often considered to be too hard [A2, A3].

Science Influences

Personal influences were essentially pragmatic, having a specific goal. There was a high level of intrinsic motivation, with several scientific and medical careers in mind. They described some teachers as influential, and parents and friends in a supportive role. They were aware of individuals in the fields that they were specifically interested in, for example, a marine biologist [Y9]. One girl said that one motivation for studying science was that it "*looks good on your CV*" [GCSE], and that she needed a good grade to get to her university of choice; a utilitarian approach. Interestingly, another said: "*… actually, now I'm into science, I might have inspired mum!*" [A3].

2ii. Interviews: semi-structured

Notion of celebrity

The notion of celebrity was unanimously treated with derision, for example, as someone who "*Does nothing and gets a lot of money for it*" [BEd] or seen in "*trashy magazines*" [Y9]. They were described as famous people, but not necessarily by their own merit, they may just have a relationship with someone. One participant said that they "*Go to the jungle with Ant and Dec*"

[Y9]. There was also reference to something described as the "*Housewife test*" [ST], where you become a celebrity at the moment you crossover into the non-target audience.

Celebrity scientists

When participants were asked if there were celebrity scientists, they tended to pause as they considered it. One comment was: "*If you like science, you might call them a celebrity, but not other people*" [Y9]. However, they were able to name people who they thought might be considered celebrity scientists: Brian Cox, Richard Feynman, David Attenborough, Dara Ó Briain, Brian May, Stephen Hawking, Albert Einstein, Robert Winston; there was some reference to the television programmes '*Brainiacs*' and '*The Big Bang Theory'*. The science teacher described Robert Winston and Brian Cox as "*your BBC, 7-8.30 demographic scientists. They become crossover scientists: they seem sometimes to be interested in their own work, and then they're parachuted into someone else's to give it gravitas*" [ST].

Influence of Celebrity Scientists

The participants had mixed responses, some said "*definitely*" [BEd; GCSE], whereas others were more concerned about the nature of the science that was presented, for example, "*CBBC shows do big explosions, but this isn't what science is about*" [Y9], and "*Some might want to do it as a job, if it's really cool. They tell you what happens, but not why. Some see science as magic*" [Y9]. One of the participants believed that although "*they're not necessarily celebrities, Big Bang Theory has made a big impact currently*", suggesting that it was "*nice to see female scientists*" [BEd]. However, there was some concern that if they tell you what happens, but not why, some might "*see science as magic*" or even that science is a just a hobby, rather than a career, for example, through watching programmes like "Stargazing and Springwatch" [Y9].

One participant could clearly see the benefit of celebrity scientists, in that "*scientists recalibrate celebrity, they make being successful the important thing*" and that "*they are the visible face of something*" [ST]. Just as profoundly, one of the year 9 students said: "*Celebrities make friends, scientists make history*" [Y9].

Brian Cox Effect

All of the students interviewed said that they were not influenced by Brian Cox, or other celebrities. They were of the mind that: "*It's the science that gets us into science*" [A2]. One of the A' level students frowned and said: "*I can't see why! Well, I can see why, but I don't know why you would want it to*" [A2]; she talked about having passion for science, and how this makes you want to work, rather than "just following someone who was famous for it" [A2].

There was also concern that there may be a detrimental effect, in that its "*not proper science … [it's] about entertainment*" [Y9]. In addition, referring to one of Brian Cox's programmes, a participant suggested that if it looks hard, "i*t might scare some people off!*" [A3].

However, the science teacher had a different perspective, and talked about the possibility of a more subconscious effect, suggesting that the Brian Cox effect was "*probably an effect they don't equate with [their reason for doing science]*" [ST]. He also linked this to parental influence, believing that if they sit down as a family and watch science programmes together, parents might feel that they are doing something to help their children: they would all "*feel smarter when it's finished*" [ST]; he compared this to watching '*My big fat gypsy wedding'* where they would not "*feel smarter*" [ST] afterwards.

2c. Data analysis and interpretation

Although a narrative approach to reporting findings is appropriate within narrative methodologies (Clandinin and Connelly, 2000; Elliott, 2005), in order to be able to compare and contrast the stories and influences of the participants more logically and systematically, a conceptual framework was needed (Leshem and Trafford, 2007; Desjardin, 2010; Miles *et al*., 2014). The original (Figure 1) was limited in that it presented an overview of the three key areas within this research, but did not allow data analysis or interpretation; in essence, it was a summary of the research aims. Therefore, a more detailed framework was required, one that could be used to inform the methodology and support data analysis and interpretation in the main data collection phases of the research.

The next section discusses the development of the conceptual framework.

2d. Conceptual Framework Development

Conceptual framework 2 (CF2)

The first stage in the development of the conceptual framework was to draw together findings from the scoping study into key themes. Alongside some initial reading of the more general influences underpinning science uptake, an initial visualisation of what the influences on young people to continue with science could look like was created; this is presented as Conceptual framework 2 (CF2) (Figure 2). This framework was an attempt to link the research question with the potential influences on decision-making, using celebrity culture as the bridge.

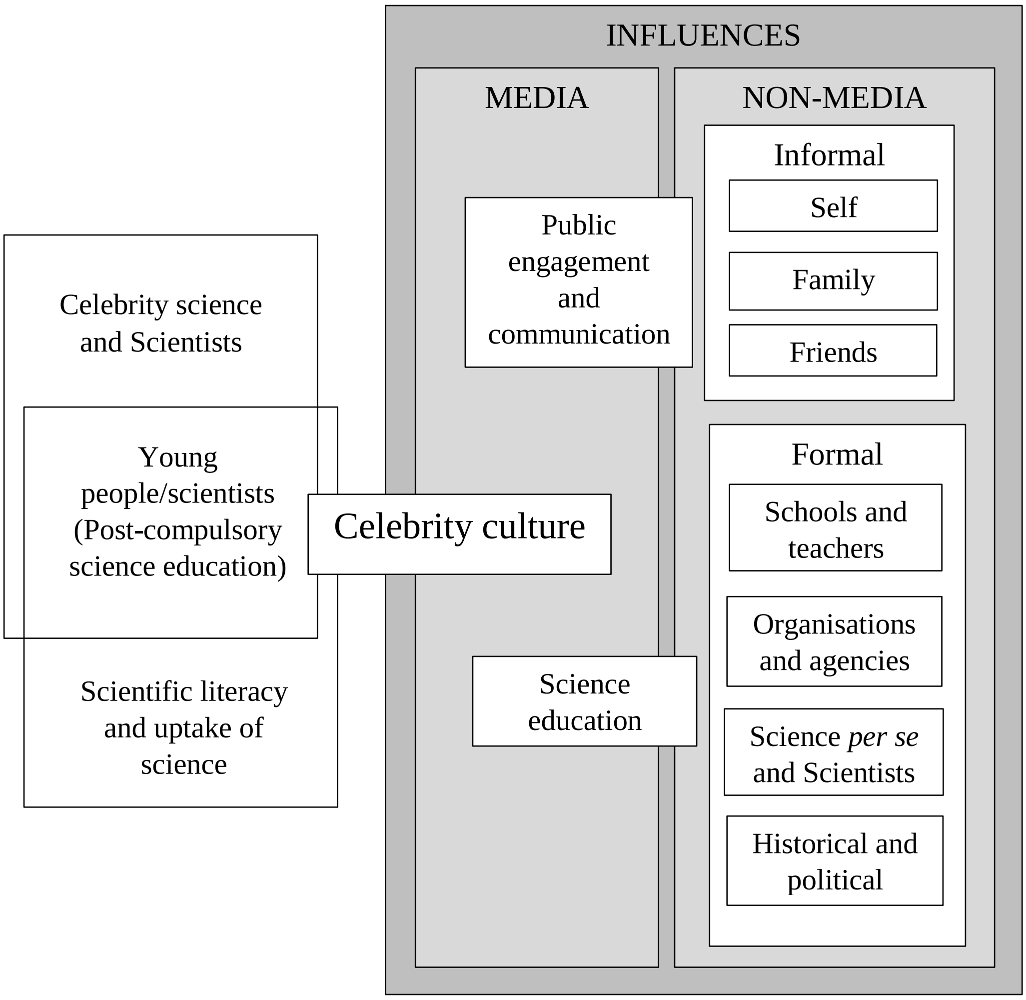


Figure 2: Conceptual Framework 2 (CF2)

CF2: Critical evaluation

Benefits:

This framework successfully allowed visualisation of the potential influences on young people, and their decision to continue with science. Links could be seen between potential influences, for example, between 'Self', 'Family' and 'Friends' as 'Informal' influences, within the 'Non-media' section. In addition, overlaps can be seen, for example, 'Science education' overlaps both 'Media' and 'Non-media', showing the complexity of the field of study. It also allowed the gap in knowledge, and originality of the research to be seen. An important benefit was that it had the potential to further inform the review of literature; an essential feature as previously discussed.

Limitations:

This framework, however, did not allow detailed analysis of science memories, in terms of drawing out any implicit influences, rather than those explicitly stated. Furthermore, as a result of the overlapping concepts, its use as a tool for data analysis was limited. A further issue was what belonged in the 'Media' box, for example, should the science organisations and agencies that use the media to communicate with the public be included? What about social media? Moreover, as teachers are encouraged to use a range of media to engage students (Millar, 2006; Millar, 2012), for example, newspaper reports, and documentary and fictional television programmes: should they also be included? Cultural perspectives were placed in the 'Formal' category, but could also be in the 'Informal' category, recognising the cultural expectations and pressures from family and friends; an influence expressed by one of the student teachers [BEd]. The wording 'Formal' and 'Informal' was also unclear; participants had referred to an intrinsic interest in science, and these headings did not allow that to be visualised. Finally, the overlapping influences described limited its use as a tool to inform future methodology; an important role of the conceptual framework (Leshem and Trafford, 2007; Desjardins, 2010; Miles *et al*., 2014).

This critique highlighted the need for a simplified conceptual framework, with the overlapping themes removed. The key themes fell into four main areas, and these formed the basis of Conceptual Framework 3, described below.

Conceptual Framework 3 (CF3)

Each box represented a perceived influence on the uptake of science by young people; the arrows ask the question: "How does the [box title] influence young people?" As the data collection process was not intended to ascertain the degree of influence, the boxes were kept the same size.

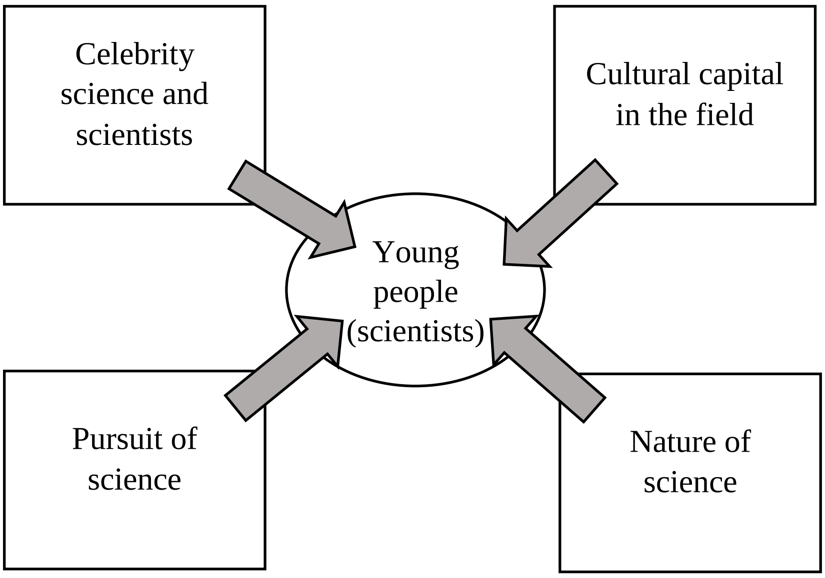


Figure 3: Conceptual Framework 3

Titles of the boxes, however, were not enough on their own to allow full analysis of data collected from the scoping study. Each box, therefore, was linked with a second box (Figure 4) that included the specific foci taken from scoping study interviews, within that category.

These subcategories were important as the conceptual framework would ultimately be used as a tool for data analysis, interpretation and presentation of findings, and as such CF3 needed to be trialled to determine if it had the potential to fulfil this purpose. This was approached by taking a hardcopy of the conceptual framework for each individual or group of participants in the scoping study and highlighting when an actual or potential influence was found in the original transcripts; going back to the transcripts ensured that no experiences or perceptions were missed. Colour-coding and annotation was used to distinguish between actual influences and the potential influence of celebrity scientists, and the different stages of the interview process, narrative biographical or semi-structured interview. The intention here was to ascertain the implicit influences on young people prior to them knowing the focus of my research. A working example of this data analysis process can be seen in Appendix 3.

Celebrity science and scientists:
What is 'celebrity'?
- Science?
- Non-scientist?

Who are these celebrities?
- Fiction?
- Non-fiction?

Who do they engage with?
- Children?
- Young people?
- Adults?

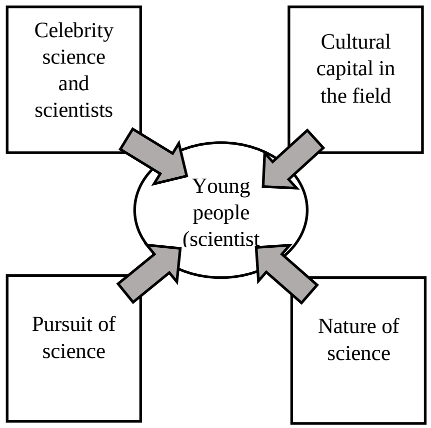
Access?
- Media?
- Social media?

Pursuit of science:
Personal interest
Family interest/involvement/experience
Good at it!
Utilitarian
- For grades
- Access to higher education

Transformational
- To make a difference
- To be a scientist

Media portrayal
- Celebrities
- TV programmes

Cultural perspectives
- Family e.g Asian doctors and dentists



Cultural capital in field:
Peers
Parents/carers
- Best interest at heart
- Aware of student's potential, ability and interests
- Own occupation/interest

Teacher
- Knowledge of science careers
- Aware of student's potential, ability and interest

Science organisations
Celebrity
- Want to be like scientist (or not)
- Geeks/nerds

Science television
- Big Bang Theory
- Forensics
  - Impact on children's understanding
  - Impact on juries
- Accessible, engaging, 'real'

Nature of science:
- Scientific literacy
- Science communication
- Parental understanding
- Young people's understanding
- Global perspectives
- Political perspectives
- Historical perspectives
- Media portrayal
- Science in education
- Science for science's sake

Figure 4: Key themes represented by boxes of Conceptual Framework 3

CF3: Critical evaluation

In order to determine effectiveness, this conceptual framework was trialled using the scoping data itself, as described above and exemplified in this Appendix, p. 22-25. Having developed it from the data, was it a true reflection? This was akin to holding up a mirror to the data (Leshem and Trafford, 2007).

Benefits:

The emergence of patterns was noted through this conceptual framework, for example, intrinsic motivations and the influence of family and friends. The place of the media in their stories began to emerge, especially with regards to how documentaries broadened their appreciation of science in the world.

Limitations:

As with CF2, however, there was some repetition and cross-over of findings, so that the framework was still limited as a data analysis tool. For example, parental influences occurred in both ‘Pursuit of Science’ and ‘Cultural Capital in Field’. In addition, it was difficult to place the influences of the media into the most appropriate box; each box included an aspect of this factor. An important limitation was that it did not allow the influence of the science curriculum itself to be shown; it was ‘lost’ within scientific literacy. Finally, there were many aspects not highlighted, indicating that the framework was too complex.

Evaluation of this conceptual framework led to an important insight in terms of influence, that is, the notion of ‘voice’. Other than ‘Pursuit of science’, the ‘voices’ influencing participants were external. This led to the development of Conceptual Framework 4, where the different ‘voices’ were separated into five new categories (Figure 5).

Conceptual Framework 4 (CF4)

This framework consists of five key areas, separating the potential influential ‘voices’ (Figure 5). The ‘Family/Friends’ section brought together subcategories from ‘Pursuit of science, ‘Nature of science’, and ‘Cultural capital in the field’. ‘Celebrity science and scientists’ was now fully self-contained, rather than within all of the boxes of Conceptual Framework 3. ‘Personal interest’ was now discrete, rather than within ‘Pursuit of science’, and the ‘Nature of science’ was divided so that ‘Science education’ *per se* could be considered explicitly, and also included teacher influence, and the curriculum itself. ‘Personal Interest’ was the only internal voice of authority.

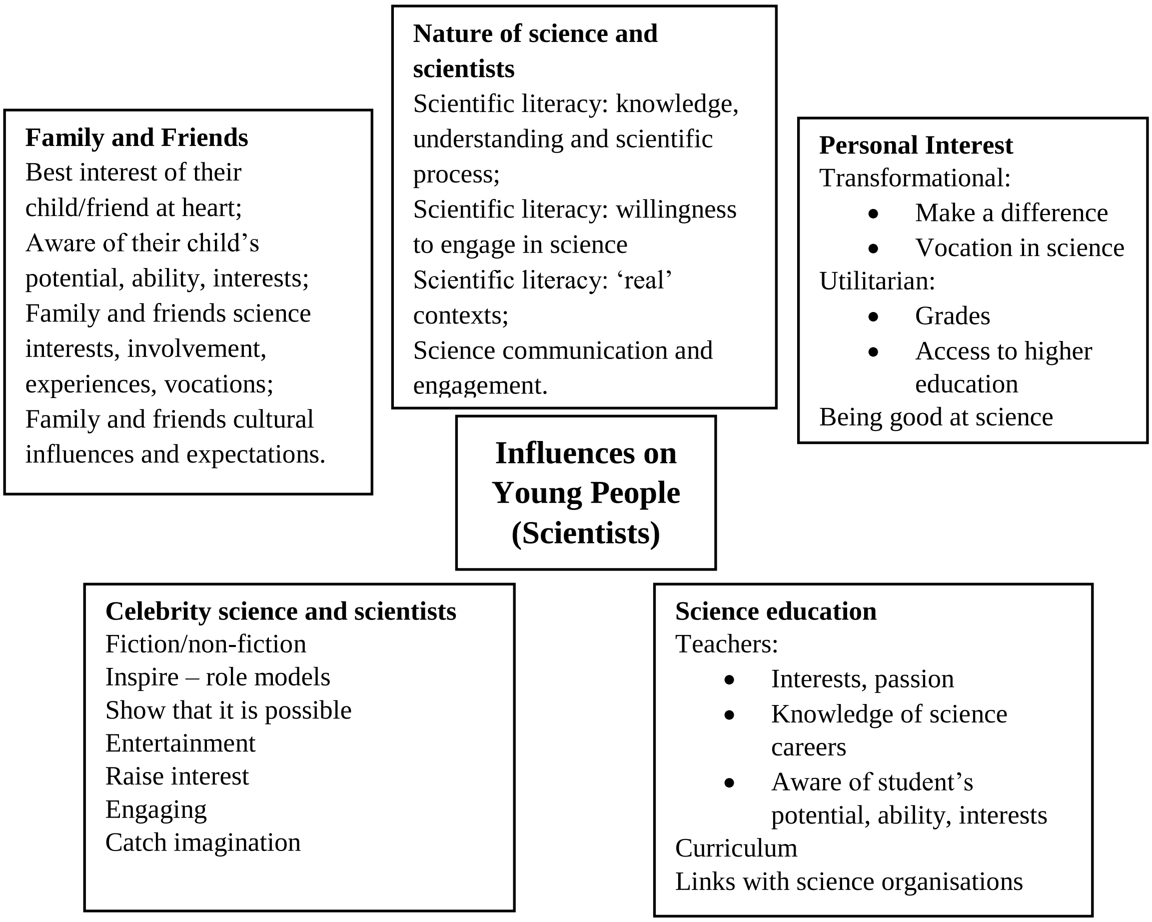


Figure 5: Conceptual Framework 4 (CF4)

This was again trialled using the original scoping study data, to assess effectiveness as a tool for data analysis.

CF4: Critical evaluation

As with CF3, this conceptual framework was trialled by overlaying scoping study participant data directly onto the framework. Analysis was again based on the three interview foci: narrative science stories; personal influences; and the exploration of celebrity science and scientists. An example of this can be seen in Appendix 2, pp.22-25.

To enable emerging patterns to be seen, within and between each of the interview foci, the individual data from participants has been drawn together into one data set, and presented in Table 2.2 (data is highlighted in yellow). Each row is one box from the conceptual framework, whilst columns are the different interview foci; presentation side by side allows direct comparisons to be made.

Narrative: Influences described within Science Stories	Narrative: Explicit Influences	Semi-structured Interview: Potential Influence of Celebrity Science and Scientists
Nature of science and scientists Scientific literacy: knowledge, understanding and scientific process; Scientific literacy: willingness to engage in science Scientific literacy: 'real' contexts; Science communication and engagement.	**Nature of science and scientists** Scientific literacy: knowledge, understanding and scientific process; Scientific literacy: willingness to engage in science Scientific literacy: 'real' contexts; Science communication and engagement.	**Nature of science and scientists** Scientific literacy: knowledge, understanding and scientific process; Scientific literacy: willingness to engage in science Scientific literacy: 'real' contexts; Science communication and engagement.
Personal Interest Transformational: • Make a difference • Vocation in science Utilitarian: • Grades • Access to higher education Being good at science!	**Personal Interest** Transformational: • Make a difference • Vocation in science Utilitarian: • Grades • Access to higher education Being good at science!	**Personal Interest** Transformational: • Make a difference • Vocation in science Utilitarian: • Grades • Access to higher education Being good at science!
Science education Teachers: • Their interests, passion • Knowledge of science careers • Aware of student's potential, ability, interests Curriculum Links with science organisations	**Science education** Teachers: • Their interests, passion • Knowledge of science careers • Aware of student's potential, ability, interests Curriculum Links with science organisations	**Science education** Teachers: • Their interests, passion • Knowledge of science careers • Aware of student's potential, ability, interests Curriculum Links with science organisations
Family/Friends Best interest of their child/friend at heart Aware of their child's potential, ability, interests Family and friends science interests, involvement, experiences, vocation Family and friends cultural influences and expectations	**Family/Friends** Best interest of their child/friend at heart Aware of their child's potential, ability, interests Family and friends science interests, involvement, experiences, vocation Family and friends cultural influences and expectations	**Family/Friends** Best interest of their child/friend at heart Aware of their child's potential, ability, interests Family and friends science interests, involvement, experiences, vocation Family and friends cultural influences and expectations
Celebrity science and scientists Fiction/non-fiction Inspire – role models Show that it is possible Entertainment Raise interest Engaging Catch imagination	**Celebrity science and scientists** Fiction/non-fiction Inspire – role models Show that it is possible Entertainment Raise interest Engaging Catch imagination	**Celebrity science and scientists** Fiction/non-fiction Inspire – role models Show that it is possible Entertainment Raise interest Engaging Catch imagination

Table 2: Themes elicited from scoping study data using CF4 (yellow highlight): Overview from combined participants

Benefits

The use of this conceptual framework to analyse data highlighted the importance of allowing participants to tell their science stories, as well as asking explicitly for specific influences. For example, 'Links with other organisations' were described in their stories, but were not raised as an influence, therefore without this narrative approach, relevant data would have been missed; this was especially important as some of the data collected related directly to celebrity science and scientists. Conversely, relying solely on their stories would also have led to gaps in the data. For example, 'Wanting to make a difference' was not raised as an influence, but came through several of their stories.

Limitations

There were still potential overlaps here, for example, should 'Science communication and engagement' within the 'Nature of science and scientists' category, also be part of 'Celebrity science and scientists'? Likewise, science organisations are involved in communication and engagement, so should they be in the 'Nature of science and scientists' category? Scientific literacy in schools is delivered via the science curriculum, but these are both in separate categories of this framework.

Nevertheless, despite these limitations, Conceptual Framework 4 was considered to have the potential to be the working conceptual framework for this research. The final stage in this discernment process, was to trial it as a tool to analyse the scoping study data, as well as presenting the findings; this is discussed below.

2.6 Analysis of scoping study data using Conceptual Framework 4

This section describes the findings when conceptual framework 4 was used to analyse data.

Personal Interest

From the highlighted areas of the framework (summarised in Table 2), it can be seen that overall, the majority of participants referred to intrinsic motivation, or studying science for transformative or utilitarian purposes, as the principal influences, whilst others were studying it just because they enjoyed the subject, or were academically strong.

Nature of Science and Scientists

All participants included at least one aspect of scientific literacy, within the 'Nature of science and scientists', both as specific influences, and as evidenced in their stories. Science communication and engagement was the only subcategory referred to from the perspective of celebrity.

Science Education

In terms of ‘Science education’, stories included teachers, but only when asked about specific influences was this qualified, and their interest and passion acknowledged. In terms of celebrity, this was linked to the use of the media to influence students who were seen to have potential or an interest in that area already. The curriculum itself was referred to, both positively and negatively, including the often limited memories of primary school age science.

Family / Friends

This section was very important in terms of influence. These included high expectations, or family involvement in science; there was also reference to cultural factors from an Asian participant, who was allowed to make up her own mind about her career path, rather than being pushed in a particular direction. They acknowledged that their family was supportive, and knew what they would enjoy doing. The influence of friends was much less critical, participants making up their own minds, rather than doing what their friends did. However, the science teacher had always been inspired by the achievements of a friend, and aspired to be like him.

Celebrity Science and Scientists

The science story of only one participant made reference to a scientist seen on television, acting as a role model (year 9 student: marine biologist). When explicitly asked about celebrity influences, although most of the participants could see the potential for raising interest, they doubted whether they would influence their career pathways. Other than one of the ‘A’ level students (A2), all participants believed that both fictional and non-fictional scientists could have an influence. This, however, could be negative, if science content was seen to be too hard to understand, or lacked rigour; they were cautious that science should be real, with appropriate explanations, to avoid it being perceived as just a hobby. Adult participants could see a wider potential, possibly due to differences in engagement with television programmes, and their experience of using science programmes in their teaching. The science teacher and student teachers all believed that celebrity science had the potential to influence from the point of view of offering career role models, showing that careers in science are achievable. There was much agreement that science programmes could be entertaining, and catch the imagination.

Conclusion

Conceptual Framework 4 enabled the scoping study data collected to be analysed effectively, allowing the emergence of themes and patterns, and as such it became the framework that supported the systematic approach to reviewing literature.

Summary

The structure and content of the literature review was built upon Conceptual Framework 4, developed though the scoping study (Chapter 2). The literature review, in turn, acted like a mirror, confirming the validity of the five categories, and informing and refining the sub-categories. As such the final Conceptual Framework (Literature review, Figure 2.1, p.69), used to underpin the methodology, including data analysis, interpretation and presentation of findings, was established. What follows is a brief description of changes made.

'Personal interest' remained essentially the same. Literature reviewed showed this to be an important category, placing emphasis on children and young people wanting to be actively involved in real science (Archer *et al*., 2013a; Ipsos MORI, 2013; Logan and Skamp, 2013; DeWitt *et al*., 2014; Kantar Public, 2017). The phrasing of 'Good at it!', taken directly from a quotation from a scoping study participant, was rewritten as 'Success academically', to clarify that this is exam- based success, rather than a feeling. 'Grades' and 'Access to Higher education' have been combined within the subcategory 'Utilitarian'; review of literature did not differentiate between these. There were no changes to 'Science education'; however, the wording has been adjusted to offer clarity. The literature review demonstrated the complexity of this category, and whilst the interests and passion for science have been shown to be important, there are strong links with the situational interest provided (Archer *et al.,* 2013a; Ipsos MORI, 2013). Literature confirms their importance as 'significant 'voices' (Sjaastad, 2012). There has been one change to 'Family and friends': an interest in science has been separated from their experiences to allow references to careers to be explicitly noted in the data collected. This was as a result of the deeper appreciation of the implications of family science capital and habitus on the science aspirations of young people (Archer *et al.*, 2012). In addition, although the influence of friends is considered to be less critical (DeWitt *et al*., 2014), there is still the potential for influence to take place, and as such this subcategory remains. The 'Nature of science and scientists', whilst remaining unchanged for the purposes of data analysis and establishing the scientific literacy of participants, has been integrated with Brake's (2010) insights on the nature of science for the purpose of discussing findings. 'Science as an

Nature of science and scientists

- Scientific literacy: knowledge, understanding and scientific processes
- Scientific literacy: willingness to engage in science
- Scientific literacy: real contexts
- Science communication and engagement

Family and friends

- Family or friend's personal interest
- Family or friend's experiences of science
- Cultural influences and expectations
- Best interest of young person at heart
- Awareness of their potential, ability and interests

Influences on Young People

Personal interest

- Interest in science *per se*
- Transformational:
  - Wanting to make a difference
  - Wanting a career in science
- Utilitarian
- Success academically

Celebrity science and scientists

- Inspire to continue with science
- Raise awareness of opportunities within science
- Raise general interest in science
- Entertain

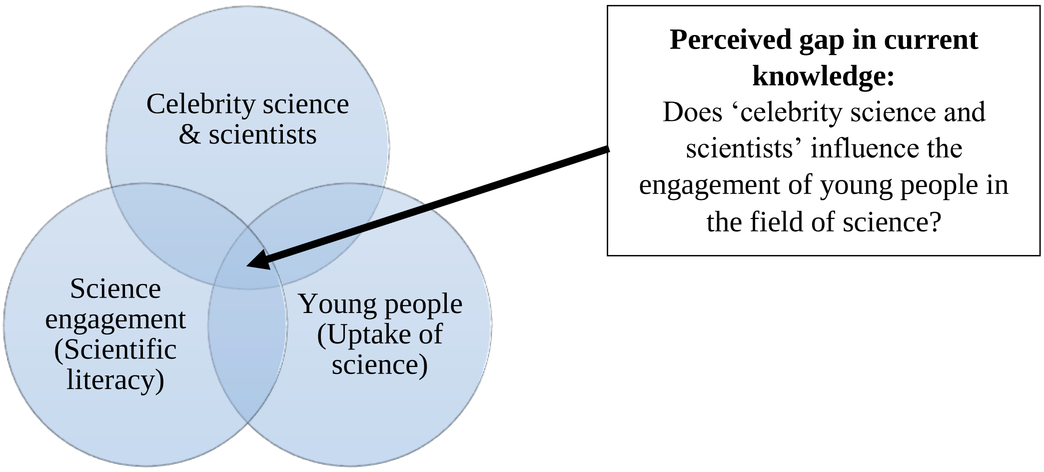
Science education

- Teacher interests, passion for science
- Teacher awareness of student's potential, ability and interests
- Teacher knowledge of science careers
- School/university science curriculum
- School/university links with external science community

Literature Review Figure 2.1 Final conceptual framework institution' and 'Science as a worldview' are key strands of the nature of science (Brake, 2010) relate directly to the role and potential influence of celebrity science and scientists; use of the definition of scientific literacy (OECD, 2006) does not allow this. The sub-categories within 'Celebrity science and scientists' have been reduced to four, encapsulating the main themes highlighted via the scoping study and literature review. Raising interest and entertaining are key elements of their role, recognising their potential to influence and inspire specific career pathways.

Exemplification of the process

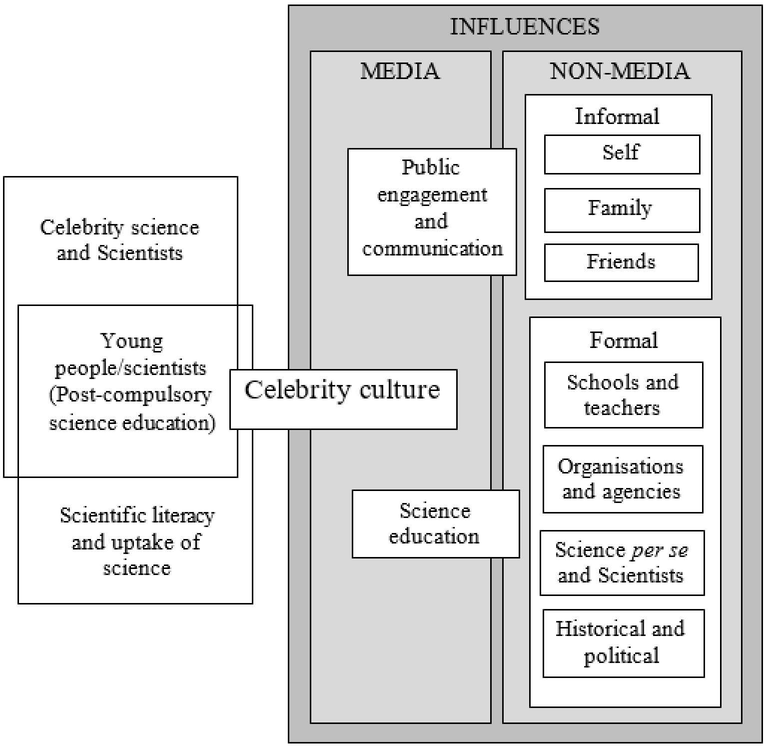
Conceptual framework 1: Simple framework showing the three key areas and the gap in knowledge.



Conceptual framework 2: Scoping study data was scrutinised for the key influences on participants' personal science journeys, and their insights into the potential influence of celebrity science and scientists; these were subsequently organised into themes to build conceptual framework 2. An example is shown below:

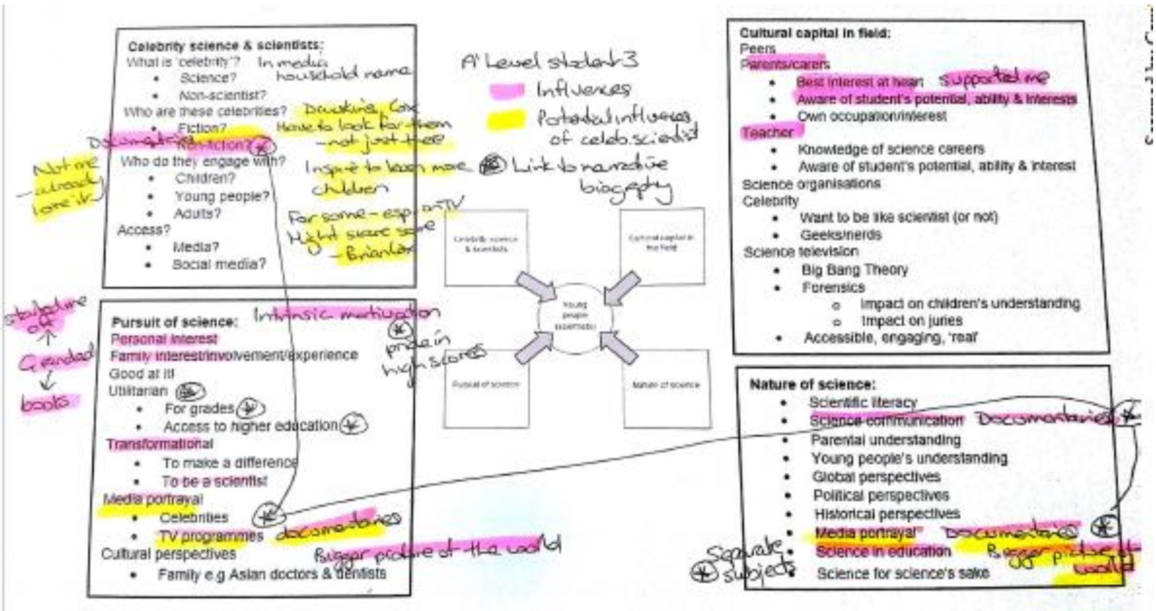
- The whole transcript was analysed to elicit key themes (small section shown below)
- These themes began to be grouped into potential categories
- These categories were used to construct conceptual framework 2

'A' level 3: **Narrative:** always been interested, used to watch documentaries on television, more recently animal science, biology and chemistry. Memories – doing experiments, being proud when got high score in tests. Looked forward to most – separate sciences, don't get spectrum of each – pick and choose which like best. Liked all, got same grades, biology, chemistry more enjoyable than physics. 'A' levels – chemistry need to go to university. Vet medicine. **Influences:** motivated self. Parents not really sciencey, my grandad a little – got me books might have started me off. Primary teacher, year 7 teacher might have, documentaries may have inspired – bigger picture of world. Parents – supported me, actually I might have inspired mum – straight into quantum physics, watching BC. Want to have life in science – parents encouraged.	Self Documentaries School science Going to university – vet: need the grades; want to make a difference Self Grandad Teachers Documentaries Parents	**Non-media:** Informal: Self Informal: Family Formal: Schools and teachers **Media:** Public engagement & communication



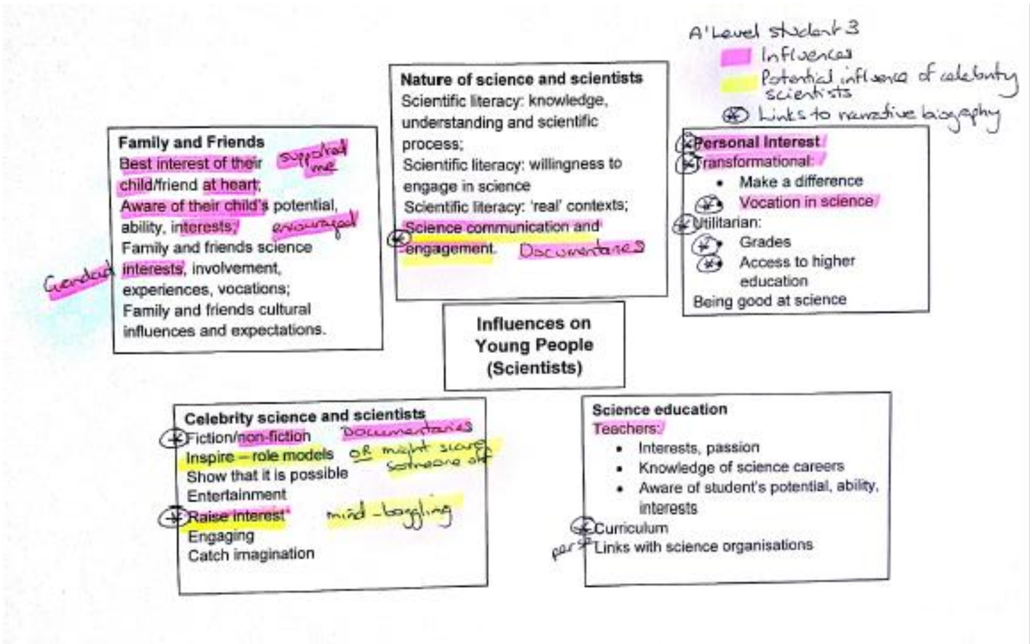
The example above showed two themes that did not fit within this framework: needing grades and wanting to make a difference. Therefore, following analysis of all data, and critical evaluation, this was re-structured to form conceptual framework 3.

Conceptual framework 3: The purpose of the conceptual framework in this research was pluralistic, underpinning all stages of the research. In order for the research to be transparent, one of its function was to be used as a tool for data analysis, interpretation and presentation of findings. This was approached by taking a hardcopy of the conceptual framework for each individual or group of participants in the scoping study, and the original transcript, and colour-coding and annotating it to distinguish between actual influences and the potential influence of celebrity scientists, and the different stages of the interview process, narrative biographical or semi-structured interview. An example is shown below:



Following full data analysis and critical evaluation, an important insight was highlighted: the categories could be re-constructed by the different types of ‘voice’: personal interest, science education, family and friends, the nature of science, and celebrity science and scientists. This reduced the number of overlapping categories; the example above shows how documentaries could be included in three of the four categories. This led to the development of conceptual framework.

Conceptual framework 4: Again this was trialled as an analytic tool by going back to the transcripts and highlighting influences found. Whilst there were still some recognised anomalies, this became the working conceptual framework for my research. An example is shown below:



This conceptual framework was subsequently validated and re-structured, and was used to fulfil the pluralistic functions outlined in Chapter 2.

Appendix 3: Exemplification of data analysis process

The intention here is to demonstrate the rigour of the data analysis process. Transparency is essential if the reader is to have confidence in the presentation of findings as monologues and constructed dialogue, and subsequent interpretation.

1. Transcript preparation

All interviews were recorded and transcribed verbatim. Transcripts were copied into a table for analysis.

Line number	Transcript	Coding
1		

Each participant within their cohort was assigned a colour, and this was used as the font colour in the 'Line number' column. The intention here was to keep track of who said what as the transcripts were disassembled. In the example below, the red font belonged to participant 'MTPG' of the postgraduate cohort.

Line	Transcript	Coding
1		

2. Coding of transcripts

Each category of the conceptual framework was assigned a different colour, and these colours were used to highlight words and phrases within these categories in the transcript.

Celebrity Science & Scientists

Science Education

Nature of Science

Personal Interest

Family & Friends

Line	Transcript	Coding
15	But my parents bought like a silk worm and	
16	t things like hat___like a dried one. So they've always been	
17	a big encouragement. Erm, I don't remember a huge	
18	amount of primary school, erm, so I don't really know what	
19	else to say on that one. (Q: Okay) Erm, my middle school	
20	had a fantastic science teacher who I got on really well	
21	with. She was a lot of fun, she'd sort of___she'd do the	
22	science lesson but at the same time she'd then go off on	
23	tangents with sort of side stories of her own and erm, it	
24	always sort of kept things interesting.	

Each subcategory of the conceptual framework was assigned a specific code.

Celebrity Science & Scientists

CS1: Inspire to continue with science
CS2: Raise awareness of opportunities within science
CS3: Raise general interest in science
CS4: Entertain

Science Education

SE1a: Teachers'/Lecturers interests, passion for science
SE1b: Teacher's/Lecturer's awareness of student's potential, ability and interests
SE1c: Teacher's/Lecturer's knowledge of science careers
SE2: School/University science curriculum
SE3: School/University links with external science community

Nature of Science

NoS1a: Scientific literacy: knowledge, understanding and scientific processes
NoS1b: Scientific literacy: willingness to engage in science
NoS1c: Scientific literacy: real contexts
NoS2: Science communication and engagement

Personal Interest

P1: Personal interest
P2a: Transformational: Wanting to make a difference
P2b: Transformational: Wanting a career in science
P3: Utilitarian
P4: Success academically

Family (Fa) & Friends (Fr)

Fa1a / Fr1a: Family or friend's personal interest
Fa1b / Fr1b: Family or friend's experiences of science
Fa2 / Fr2: Cultural influences and expectations
Fa3 / Fr3: Best interest of young person at heart
Fa4 / Fr4: Awareness of their potential, ability and interests

These codes were used to identify the subcategories referred to by participants, and were noted in the right-hand column. Further first cycle, *in vivo* coding (Saldaña, 2012) took place, and these were also noted in the right-hand column.

Line	Transcript	Coding
	But my parents bought like a silk worm and	Fa3; Fa4
	t things like hat___like a dried one. So they've always been	
	a big encouragement. Erm, I don't remember a huge	SE2(-) at primary
	amount of primary school, erm, so I don't really know what	
	else to say on that one. (Q: Okay) Erm, my middle school	SE1 at middle
	had a fantastic science teacher who I got on really well	school
	with. She was a lot of fun, she'd sort of___she'd do the	
	science lesson but at the same time she'd then go off on	
	tangents with sort of side stories of her own and erm, it	
	always sort of kept things interesting.	

3. Creating the Monologues

- Each transcript was cut up into the colour-coded sections, that is, according to the categories of the conceptual framework.
- These colour-coded sections were combined with those from the other participants within their cohort.
- They were further sorted into the subcategories of the conceptual framework.

Below are examples of the coded sections from each postgraduate student participant's transcript that refers to the influence of teachers, brought together through the sorting process described above.

Participant APPG

A: No, we only ever had teachers and they did their best to make things interesting. Erm, we went through quite a few science teachers actually, they never seemed to hang around, (laughter) (Q: Okay, laughter) which I don't think helped but I went to a school in quite a deprived area and I think if you weren't teaching top set it probably wasn't such an enjoyable experience. (Q: Right) So we got through a lot of science (laughter) teachers, which I don't think helped either, there was no consistency. Every now and then you'd get a brilliant one who was obviously like determined to make it work and you did a lot of experiments, lots of hands on stuff. Erm, no I don't think we went on any trips. (Q: Right) No, I can't think of anything.	SE1a SE1- science teacher retention SE1a
A: [..] She was the influence probably from year seven through to year thirteen. (Q: Right) She was she was never my tutor but she was my "go to" teacher. (Q: Okay) She was absolutely brilliant, just really passionate about what she did. I did work experience with	SE1a

Participant AWPG

biology and chemistry. So that's kind of where it went on	
from there and my teachers that I had throughout GCSE and then at 'A' level in biology were amazing. They were really good teachers and they would spend hours with you after lessons going through and making sure that you've got all your answers correct ready in preparation for exams 'cause the exam boards were quite harsh with their marking when it came to it so it __ you didn't get the mark if you didn't get specific sentences with a specific word in it so it	SE1b
was hours and hours of practising. And, I'd always ask them advice about what they thought was the best university to go to and things like that when I was applying for UCAS. Erm, and I actually applied for [university] and	SE1c

didn't know exactly what I wanted to do so I chose molecular biology because I thought it's __ it'll challenge me because it's quite hard and you have to be quite persistent	
in the lab with it and I find it interesting. So that's how I met	P1
Dr [lecturer] and she became my supervisor and she's now my supervisor at my MRes level as well and she has been the major influence in it because she's been so supportive. She knows everything (laughter) about every virus that you could ever think of, so, yeah she's been very, very supportive. And that's how I went to do Merkel Cell	SE1a
Polyomavirus was through her. It was actually my idea to do it because I didn't wanna' continue with HPV, but that was only from doing a little bit of research in erm, my oncology module. I had an essay on Oncoviruses so I did a little bit of research on five different Oncoviruses and Merkel Cell was very new at that point so I onl __ just got a little bit	SE2
of a taster into it and I thought "that's what I want to study", and I am (laughter).	P1

Participant JDPG

A: I'd say my primary school teacher.	SE1
Q: Right.	
A: Erm, there is one note on one of my erm, [.] basic erm, reports that said "she can do whatever she wants to do".	SE1b

A: Not so much, no. (Q: No?) They weren't __ not to be dis __ they weren't the best teachers in the world.	SE1- for secondary science
Q: Okay.	
A: But, you know, they always __ they always pushed me. They always made sure I got everything done and	SE1b
whatever, but they never like told me I had to do [.] (Q: No?) biology or that I needed to do it or whatever. It was just my decision.	P1

Participant MTPG

a big encouragement. Erm, I don't remember a huge amount of primary school, erm, so I don't really know what else to say on that one. (Q: Okay) Erm, my middle school had a fantastic science teacher who I got on really well with. She was a lot of fun, she'd sort of___she'd do the science lesson but at the same time she'd then go off on tangents with sort of side stories of her own and erm, it always sort of kept things interesting. Erm, I'm not sure how she did it, it was just a particular way of teaching that she did that erm, it just sort of fitted really well. Erm, I did___I was part of the three school system so I did a primary, secondary and then erm, another school was sixth form there. Er, through that I___obviously that's where I sort of chose my GCSEs and my 'A' levels, things to actually go into and at that point it was really a sort of [.] "well what is it I like doing? I___I'm good at science, so why not, we'll do that". Erm, [.] yeah and then I did the	SE2(-) at primary SE1 at middle school P1,4

A: Erm, not massively to be perfectly honest. Erm, it is more just down to the teachers that I've had. As I say there was a teacher in secondary school who was absolutely fantastic and I had a few in erm,___a few in my third school who I got on really well with and it was___I don't know if it's just because I was___I've always been slightly better at science than I perhaps was at some other subjects. Erm, I've just always got on really well with science teachers and the technicians and everything and [.] they've just always been really nice people, so…	SE6- SE1 Technicians

Participant NPPG

A: Umm, [..] I don't know, I suppose throughout doing my undergrad they erm,___my two sort of erm,___sort of my main___the main er, lecturers I was in contact with, they were very influential and er, I don't know, I suppose an___an influ___sort of motivating in___in erm, persisting with this___this sort of thing. Erm, [.] and then, yeah I suppose it would just be the___the lecturers throughout my time at___at erm, doing my undergrad. They were very good at sort of giving you direction of where you want to go and sort___they asked the right questions for you to___to find the right answer, to sort of channel you to___where it's best for you to learn, what to do next and how to best er, sort of prepare you for the career that you want. Erm, [.] yeah I suppose that's what's, you know, really sort of pushed me in this direction to___to carry on studying it, yeah.	SE1b Lecturers SE1c

Participant SBPG

wanted to do science in university and I had some very good teachers at ___ at ___ on the access course. They were very enthusiastic and very dedicated and they knew what they were talking about. And then I got to university and it	SE1a

there's quite a lot of politics involved. Then again a lot of the science is [.]___I won't say all of the teachers, but a lot of the teachers are quite poorly educated when it comes to science. They don't quite understand anything past the basics and that can be frustrating when a student goes ___ a student goes into a class and knows more about the class than their teachers, it can be extremely frustrating (laughter). So, that's ___ that's sort of the long and short of it.	SE1(-) Poorly educated as science teachers Frustrating

a ___ the leader of my erm group er my [.]___my degree was named Dr [name], he's still at the university of [city] and he was amazing. He's one of these mad scientist types and he's so enthusiastic when he talks about it. The ___ the staff there were so enthusiastic and I think that's what kind of kept me in is how [.] happy people are once they get into science to stay there. I've never met ___ I've met people who've been frustrated. I've met people who have been angry. But I've never met a scientist who's been bored! (Q&A Laughter) They may be bored with their current project. They may be bored with routine wo ___ lab work that's temporary, but they're never bored with the science. And that's what kind of fascinates me and makes me want to do more. Does that make sense?	SE1a NoS Scientists not bored P1

Continuing with the example of influence of teachers, quotations illustrating both convergence and divergence of perceptions were copied and pasted into a Word document. At this point, in order not to lose the identity of the individual participant, the font colour of the quotation was changed to that ascribed to the participant:

Participant SBPG: They were very enthusiastic and very dedicated.

Participant APPG: She was absolutely brilliant, just really passionate about what she did.

Participant APPG: You did a lot of experiments, lots of hands on stuff.

Participant MTPG: At middle school I had a fantastic science teacher … she'd do the science lesson but at the same time she'd then go off on tangents with sort of side stories of her own and erm, it always sort of kept things interesting.

Participant AWPG: They made sure that you've got all your answers correct ready in preparation for exams … I'd always ask them advice about what they thought was the best university to go to and things like that when I was applying for UCAS.

Participant JDPG: I'd say my primary school teacher … there is one note on one of my reports that said "she can do whatever she wants to do".

Participant JDPG: They weren't the best teachers in the world, but, they always pushed me. They always made sure I got everything done and whatever, but they never like told me I had to do biology or that I needed to do it or whatever. It was just my decision.

Participant MTPG: I've just always got on really well with science teachers and the technicians and everything, they've just always been really nice people.

Participant APPG: We went through quite a few science teachers actually, they never seemed to hang around, which I don't think helped but I went to a school in quite a deprived area and I think if you weren't teaching top set it probably wasn't such an enjoyable experience.

Participant SBPG: I won't say all of the teachers, but a lot of the teachers are quite poorly educated when it comes to science. They don't quite understand anything past the basics and that can be frustrating when a student knows more about the class than their teachers, it can be extremely frustrating.

Participant AWPG: She has been the major influence in it because she's been so supportive. She knows everything about every virus that you could ever think of. And that's how I went to do Merkel Cell Polyomavirus was through her.

Participant NPPG: I suppose throughout doing my undergrad, the main lecturers I was in contact with were very influential and sort of motivating in persisting with this sort of thing. They were very good at sort of giving you direction of where you want to go and they asked the right questions for you to find the right answer, to sort of channel you to where it's best for you to learn, what to do next and how to best prepare you for the career that you want.

Participant SBPG: The staff there were so enthusiastic and I think that's what kind of kept me in is how happy people are once they get into science to stay there. I've met people who've been frustrated. I've met people who have been angry. But I've never met a scientist who's been bored! They may be bored with their current project. They may be bored with routine lab work that's temporary, but they're never bored with the science.

These quotations were joined and re-written to create the completed section of the postgraduate monologue. Colours identify individual participants; words in the black font are those I added to summarise areas of convergence, and to enable the monologue to flow well. Reference to 'friend' is the literary tool used to highlight areas of divergence and/or new examples. This ensured that the voices of all participants were included, thus avoiding only including the "juicy bits" (Saldaña, 1998, p.181).

My teachers were important too: they were enthusiastic, dedicated, and absolutely brilliant, just really passionate about what they did. I had a fantastic science teacher who would do the science lesson, with lots of hands-on experiments, but she'd go off on tangents with side stories of her own…it always kept things interesting. They made sure that you got your answers correct in preparation for exams, and asked their advice about the best university to go to. I remember my primary school teacher writing a note on one of my reports that said "she can do whatever she wants to do," isn't that amazing? At secondary school, even those that weren't the best teachers in the world, they always pushed me, but they never like told me I had to do biology, or that I needed to do 'whatever', it was always my decision. It wasn't just the science teachers either, it was the technicians too, they were always really nice people. At my friend's school, they went through quite a few science teachers, they never seemed to hang around, which I don't think helped, but it was a school in quite a deprived area and I think if you weren't teaching top set it probably wasn't such an enjoyable experience! Another was educated abroad as a teenager, and says that a lot of the teachers there were quite poorly educated when it came to science, and how frustrating it was when a student went into a class knowing more than their teachers…especially when one was an evolution denialist…that was extremely frustrating! But these friends still went on to be scientists. At university, one of my lecturers has been the major influence. She knows everything about every virus that you could ever think of, so yes, she's been very, very supportive. In fact, it was through her that I started my Merkel Cell Polyomavirus research. Throughout my undergrad though, all the lecturers were influential and motivating, very good at giving you directions of where you might want to go, asking the right questions for you to find the right answer, and channelling you towards where it's best for you to learn, what to do next, and how to best prepare you for the career you want. They were all so enthusiastic and I think that's what kind of kept me in science, is how happy people are, once they get into science, to stay there! And you know, I've met scientists who've been frustrated, or who have been angry. But I've never met a scientist who's been bored! They may be bored with their current project, they may be bored with routine lab work, that's temporary, but they're never bored with the science.

Creation of Constructed Dialogue

1. Celebrity scientist transcripts were coded as per the student participants.

2. These were cut up and cross-referenced with those of the student participants. For example, below are the quotations from the celebrity scientist participants that refer to the influence of teachers.

Mark Miodownik: *Teachers and their parents have the most influence, but they need help.*

Mark Miodownik: *And then I think the other thing is just the constant feeding of interesting things into the classroom and things that are not about passing an exam, they're about, you know, understanding the world and that stuff.*

Mark Miodownik: *Well I have a dad who is a scientist so that helps and I think that's often true of my generation of people who, they had some family relationships. It's hard to know, 'cause I didn't have a very good education let's say.*

Steve Jones: *Oh, I think any one of those anyway I was fortunate apart from the fact that my school inspiration, with one or two exceptions was very, very weak.*

Steve Jones: *But teachers obviously do. I mean yeah I'm confident that I have, that we have a big impact on teachers, I think that we know that. And probably on some of the better students too, their students. But I think, I hope it goes deeper than that.*

Roma Agrawal: *Yeah. And so that's why when I'm saying about sort of being on the television, I think and I hope that people like you say, like teachers would also watch that kind of thing. Now that's really interesting, maybe I should tell my kids about.*

Roma Agrawal: *I expect most kids are quite influenced by parents and teachers and I think there would be a small number of kids that, despite what their parents and teachers tell them, they still want to do what they want to do.*

Susan Greenfield: *I think that would be a very good thing to do, for the media to take that on because on the whole the teacher is already overworked, underpaid, stressed out, you know, and asking them to take on promoting celebrities, I don't think it, well that's not the right channel I don't think.*

Susan Greenfield: *I think often it's the, well in the old days it was the teacher, you know, everyone remembers a good teacher, everyone remembers the mentor who believed in them and excited them. I don't know if that's as true now because the screen is dominating so much, but I hope it's not just you know the majority of people or you know the consensus view on Facebook and so on. I would hope there's still a place for young people, for the teacher who believes in them more than they believe in themselves which, you know, is a lovely definition of a mentor … Yeah, exactly who gets you excited in the way an IPad never can, yeah.*

3. These quotations were re-written to form the following section of the constructed dialogue:

Mark: *It isn't just our role though, other people have an influence. The students were clear that parents and teachers were significant influences ...* [section removed]

Mark: *… especially as I didn't have a very good education, but like Beta, it didn't stop me either.*

Steve: *My school inspiration was also very weak …*

Susan: *I have to say that I hoped that there was still a place for the teacher who believed in their pupils more than they believed in themselves, who got them excited in the way an iPad never could. And that's what I have seen in school. But their influence was more than the 'science', and 'sparking' an interest, their teachers wanted the best for them, regardless of whether they chose science.*

Steve: *I'm confident that we do have a big impact on teachers … and probably on some of their better students, but I hope it goes deeper than that.*

Mark: *Yes but I think teachers need our help too, we could constantly feed interesting things into their classrooms, things that are not just about passing an exam. I loved Gamma's comment about teachers, that "there's a difference between watching someone who could be faking it, to having someone in front of you with a chunk of sodium going 'stand back!"*

Susan: *Yes, I think that would be a good thing for the media to take on, because on the whole the teacher is overworked, underpaid, stressed out, so asking them to take on promoting celebrities as well? That's not the right channel I don't think. We should support them.*

Roma: *That's what I'm saying about being on the television, I hope that teachers would also watch that kind of thing and think "That's really interesting, maybe I should tell my kids about it." But of course there will be a small number of kids that despite what their parents and teachers tell them, will still want to do what they want to do. So does interest come first? And what if that isn't science?*

Appendix 4: Student Participant Request for Ethical Approval

<table>
<tr><td>1. Your Name:</td><td>Maria Dent</td><td>2. Programme name and code
PGR03: Postgraduate Research - EHS</td></tr>
<tr><td>3. Contact Info</td><td colspan="2"></td></tr>
<tr><td>4. Module name and code</td><td colspan="2"></td></tr>
<tr><td colspan="3">5. Name of project supervisor (Director of Studies)</td></tr>
<tr><td colspan="3">Dr. Neil Radford</td></tr>
<tr><td colspan="3">6. Title or topic area of proposed study</td></tr>
<tr><td colspan="3">Celebrity Science Culture: Young People's Inspiration or Entertainment?</td></tr>
<tr><td colspan="3">7. What is the aim and objectives of your study?</td></tr>
<tr><td colspan="3">Aims of the proposed investigation:
What are young people's perceptions of celebrity science and scientists?
Do these perceptions align themselves with current rhetoric regarding the positive influence of these scientists on the uptake of science by young people, and their understanding of scientific literacy?

Objectives of the proposed investigation:
To explore historical perspectives on the engagement in, and communication of, science;
To explore how young people feel about the media and celebrity culture generally, and science celebrities specifically;
To explore the influence of celebrity science and scientists on scientific literacy;
To develop a theoretical framework that will inform further academic research, science education policy makers and the media (including celebrity scientists).</td></tr>
<tr><td colspan="3">8. Brief review of relevant literature and rationale for study (attach on a separate sheet references of approximately 6 key publications, it is not necessary to attach copies of the publications)</td></tr>
<tr><td colspan="3">There is much rhetoric today regarding effective science education, including the use of entertainment mass media (Osborne and Dillon, 2008). There is an explicit focus on contemporary science and citizenship, the development of scientific literacy, and the encouragement of young people to continue with science post-GCSE (The Telegraph, 2011; Daily Mail, 2012). Science in the media is not new: Sir David Attenborough has been presenting since the 1950s, and BBC Radio has consistently included science in its programming schedules. Science today, however, is competing with celebrity and reality television; advertising, politics, and popular culture are all touched by the notion of celebrity; some scientists are even searching for celebrity scientist advocates to promote and highlight their own field of work (Haxton, 2011). In 2006, the potential of celebrity was recognised by the then Prime minister, Tony Blair, who is quoted as saying: "We need celebrity scientists to inspire young people." (The Times, 2006). The potential for this has been more widely recognised, as evidenced by the media coining the phrase the "Brian Cox effect" to describe the impact of celebrity scientists on public engagement with science. There is an emerging belief that celebrity is important in the popularisation of science and scientific issues (The Telegraph, 2011; Daily Mail, 2012).

Key literature
Scientific Literacy
The definition of scientific literacy is contested (Millar, 2006), however, for the purpose of this research, the working definition will align itself with that of the Programme for International Student Assessment (PISA): an individual's scientific knowledge and understanding; awareness of how it shapes our environments; and willingness to engage in science (Organisation for Economic Co-operation and Development (OECD), 2006, 2009, cited in Bybee and McCrae, 2011). Justification for this decision is based on the collaborative nature of PISA: science experts from OECD member countries serve on working groups to ensure that the frameworks and assessment instruments are internationally valid, taking into account cultural and curricular contexts. Bybee</td></tr>
</table>

and McCrae (2011, p8) warn that just by studying science, an individual is not "transformed from a passive recipient of information to an active and discerning consumer of information"; They recognise the importance of a focus on interests, attitudes, beliefs and values, key features of scientific literacy, to promote science engagement, a key focus of this study.

Celebrity Science and Scientists

Celebrities in advertising, including celebrity advocacy and political advertising in politics are common place; the notion of celebrities evoking an emotional response, and therefore having the potential to influence issues, people, organizations, etc., even if they are not favourable, is recognised (Boykoff and Goodman, 2009; Giles and Maltby, 2004; Simonson, 2006). This may be underpinning the current focus on celebrity scientists: The Institute of Physics refers to the influence of Brian Cox, and a causal relationship has even been suggested between fictional scientists, e.g. Sheldon Cooper in 'The Big Bang Theory', and the positive uptake of science (The Observer, 2011). However, there is currently no empirical evidence: most is anecdotal, presented by the media itself. Current literature focusses on entertainment-based media, rather than celebrities themselves, generally supporting their value for developing scientific literacy (Millar, 2006). Other literature concerns itself with the use of these media in science lessons, e.g., Rutter (2011) describes the use of The Simpsons to teach forensic science. In terms of research exploring their influence on science engagement, Orthea et al. (2012) investigated responses, again to The Simpsons, seeking to find out if and how it influenced participants' perceptions of science. Their results varied widely, with sometimes contradictory outcomes: some people saw no science, whilst others saw science as underpinning the whole story. They found that their results actually problematized the very notion of influence. There has also been a focus on the influence of media on children's scientific knowledge, for example, forensic science programmes and understanding of genetics (Donovan and Venville, 2012); they acknowledged the potential for misconceptions to arise due to the presentation of inaccurate scientific knowledge.

9. Outline of study design and methods

The overall research approach is qualitative, with multiple case studies. Data collected is not intended to be representative across the population, therefore individual case studies are appropriate; these will enable the researcher to look in depth at individual stories, influences and their understanding of science and celebrity scientists (i.e. a series of vignettes). Narrative biography will be the initial method: participants will recount their memories of science, and the influences that have informed their choices regarding their continued uptake of science. This will lead into a semi-structured interview, allowing the researcher to focus on the participant's notions of science, celebrity and celebrity scientists. Initial sampling for participation in these narratives will, therefore, be specifically purposive: they will be engaged in post-compulsory science education, and comprise students from year 13 ('A' Level), and undergraduate and postgraduate science students. The notion of theoretical saturation will underpin this study, so that initially six participants from each group will be interviewed; a future ethical approval application may be necessary if the researcher does not consider that saturation has been reached. This sampling strategy will allow the researcher to focus on students described in the media as being influenced by celebrity scientists, specifically in terms of science uptake.

Practicalities (supported by pilot study findings)

The initial narrative biography will be supported by written guidance (see Appendix 2: Interview, Part A only), which the participant will have received prior to the interview (minimum of 24 hours). This will be followed by an in-depth, semi-structured interview to look at issues raised in the narrative biography, and to explore the notion of celebrity science (Part B of the Interview schedule will be used). The interview will last no longer than 45 minutes. Each interview will be recorded, and transcripts prepared.

Overall, then, data collection will primarily be narrative biography plus semi-structured interviews, providing qualitative data from multiple case studies. Analysis will take a thematic approach, linked to the conceptual framework, allowing emergence of theory from a data saturation perspective.

Objectives	Methodology
Historical perspectives	Literature review: secondary data; media reports
To explore how young people feel about celebrities	Use of narrative: biographical approach, recorded to allow young people to speak more freely; the researcher will be looking for perceptions. The subjective nature, and the reflexive role of the researcher, will be acknowledged.
To explore the influence of celebrity science and scientists on scientific literacy	Definition of scientific literacy: Literature review (secondary data) Literature review used to establish 'indicators' of scientific literacy

10. Research Ethics

I will be working within the University of Derby's 'Research Ethics: Code of Practice'; the British Educational Research Association's (BERA) (2011) and the British Sociological Association's (BSA) (2002) ethical guidelines.

The beneficence of this research is primarily to allow participants to explore the nature of their influences and attitudes towards science. The primary research method is narrative inquiry: interviewer and interviewee constructing understanding together. With structured interviews the format is set by the researcher, however, through narrative, participants are more active, in that they select what they believe to be the most important information: in a sense, they define the format. This gives the impression of participant control, which could be manipulated, therefore it does not necessarily result in a more ethical methodology; the same issues of non-maleficence are present.

Key ethical considerations (these are fully expanded within the subheadings below):

Consent will be sought, and participants assured of their right to withdraw prior to final integration of the data and dissemination; a final date will be given. A statement will be provided outlining generic research intentions; because of the nature of narrative, a detailed description is not possible. Anonymity and confidentiality are considered norms, however, within a narrative approach, it is acknowledged that participants will not be anonymous to the researcher. It is also possible that following dissemination, they may still be identifiable, even if a pseudonym is used. Therefore, participants will check their own transcripts, and dissemination of the research will be discussed. The researcher also has a responsibility to others who cannot be made anonymous: participants may describe others, potentially affecting relationships post-dissemination, therefore, the researcher will retain the right to censor and anonymise those referred to. The Data Protection Act (1998) will be adhered to. Personal narratives are linked to personal identity, therefore, interpretation and analysis must be performed with integrity; researcher bias will be acknowledged and participants will check their own data. There is also the potential for the research to be a transformative experience, e.g. influencing decision-making in terms of uptake of science; the research statement will clarify that this is not the intention. Even though the focus is not of a sensitive nature, they may be self-conscious about science experiences or influences, or may feel uncomfortable about, e.g., limited access to a television; these issues should be avoided through purposive sampling. If something of a personal nature is disclosed, raising a safeguarding issue, correct procedures will be followed, and a statement will be included in the consent form relating to the researcher's need to breach confidentiality.

11. Ethical Considerations: Please indicate how you intend to address each of the following in your study. Points a - i relate particularly to projects involving human participants.

) Consent
From: Headteacher of school and Head of Faculty; direct consent will be obtained from participants aged over 18, plus parental consent, if aged under 18;

The purpose and process of the research will be explained (orally and written);
It will also be explained why their participation is necessary, why it is beneficial, how it will be used, and how and to whom it will be reported;
The researcher will confirm the participants wish to continue prior to data collection;
Participants will be informed of their right to withdraw from the research prior to completed analysis; they will be notified of the date.

) Deception

Every effort will be made to accurately portray the data, e.g. by respondent validation of participants own transcripts. As a result, the investigation will be transparent, with no attempt to deceive.

) Debriefing

This will take place during research development and prior to dissemination;
Information will be sought regarding issues that proved difficult for either researcher or participant, with the aim of improving the research instruments and procedures;
Respondent validation of transcripts will take place, plus there will be the opportunity for participants to re-interpret the transcripts for me in the light of my analysis.

) Withdrawal from the investigation

The researcher recognises the right of any participant to withdraw from the research: they will be informed of this at the outset. This will be prior to final integration of the data and dissemination - a date for final withdrawal will be given;
Raw data will be destroyed, but analysed/integrated data will not be destroyed: it will be kept on a password protected USB memory stick.

) Confidentiality

Only the researcher will have access to transcripts and recordings;
Respondent validation of transcripts to ensure confidentiality not breached;
Researcher will remain alert to any issues participants may wish to keep confidential;
Real names and identities of participants to be confidential and anonymous; pseudonyms to be used, however, the researcher is prepared to use real names if requested;
Direct quotations and attributed judgements in reports will require prior consent from the participant;
There will be a caveat in the Participant Information statement allowing the researcher to break confidentiality if a safeguarding issue is disclosed.

Protection of participants

Researcher will comply with United Nations articles 3 and 12, and Child Protection Act (2003) for school students;
Any indication of discomfort, or sense of intrusion, and the interview will be stopped;
Participants should not be harmed when they see their transcripts and the researcher’s analysis; they retain the right to edit or expand their data prior to final integration and dissemination (final date will be given);
Participants should not be influenced to make decisions about science uptake; this will be acknowledged in the research statement;
Researcher CRB checked (enhanced disclosure);
Protection of non-participants within the institutions from which participants are sampled: the names of the schools and higher education institution will not be disclosed, nor the names of people within these organisations. They will be anonymised, and pseudonyms used if data is relevant to data analysis. The researcher retains the right to censor content;
Observations will not be shared with teachers, lecturers, or parents;
As an outsider researcher, I have no authority over the participants, and as such pose no threat.

) Observation research [complete if applicable]

) Giving advice

As an outsider researcher, and having had no prior relationship with the participants, I have no authority to offer advice;
Participants will not be influenced to make decisions about science uptake; this will be acknowledged in the

research statement;

There is a caveat in the Participant Information allowing the researcher to break confidentiality if a safeguarding issue is disclosed. In such circumstances, information will be referred to the named safeguarding personnel at the participants' institution;

Participants will be referred to suitably qualified and appropriate professionals, if appropriate.

Research undertaken in public places [complete if applicable]

Details of the Risk Element	Potential risk rating prior to controls	Controls in place to reduce likelihood	Residual risk rating afte after controls
Physical/verbal abuse from student in 1:1 and focus group sessions	Tolerable	Ensure third party aware of meeting time, place, etc., through informed consent	Tolerable
Emotional impact of possible disclosure	Tolerable	Researcher is highly experienced in the field of Child Protection	Tolerable
Travel to off-site institutions	Tolerable	Aware of University travel policy	Tolerable
Risk of harm on premises of off-site institution	Tolerable	Be aware of Health and Safety policies of off-site institution	Tolerable

) Data protection

Data Protection Act (1998) will be adhered to;

The Participant Information sheet will include a 'fair processing statement' providing information on what the research is for, who will conduct the research, how the personal information will be used, who will have access to the information and how long the information will be kept for;

Consent will be obtained for audio recording;

A password protected USB memory stick will be used to store data;

The researcher will remain alert to issues participants may wish to keep confidential;

The real names and identities of participants to be kept confidential and anonymous. Pseudonyms to be used, however the researcher is prepared to use real names if requested;

Consent forms and data will be stored separately and securely in a locked filing cabinet;

Use of direct quotations and attributed judgements in reports will require prior informed consent from the participant;

There will be a caveat in the Participant Information allowing the researcher to break confidentiality if a safeguarding issue is disclosed. In such circumstances, information will be referred to the named safeguarding personnel at the participants' institution;

Animal Rights [complete if applicable]

) Environmental protection [complete if applicable]

12. Sample: Please provide a detailed description of the study sample, covering selection, number, age, and if appropriate, inclusion and exclusion criteria.

The primary participants in this research will be young people from two Secondary Schools (year 13), and from Higher Education Institutions (science undergraduate and postgraduate students). The sampling strategy for participation in this study will be purposive, and initially comprise of six, year 13 school students, six undergraduates, and six postgraduate scientists. They will all be engaged in post-compulsory science education.

13. Are payments or rewards/incentives going to be made to the participants? If so, please give details below.
No
14. What study materials will you use? (Please give full details here of validated scales, bespoke questionnaires, interview schedules, focus group schedules etc and attach all materials to the application)
Interview schedules: narrative biographical and semi-structured
15. What resources will you require? (e.g. psychometric scales, equipment, such as video camera, specialised software, access to specialist facilities, such as microbiological containment laboratories).
Voice recorder
16. Have / Do you intend to request ethical approval from any other body/organisation ? No (please circle as appropriate). If 'Yes' – please give details below.
17. The information supplied is, to the best of my knowledge and belief, accurate. I clearly understand my obligations and the rights of the participants. I agree to act at all times in accordance with University of Derby Code of Practice on Research Ethics http://www.derby.ac.uk/research/ethics/policy-document Date of submission 10 March, 2014 Signature of applicant Signature of project supervisor (Director of Studies) Signatures removed for copyright reasons
For Committee Use Reference Number (Subject area initials/year/ID number)…………………. Date received…10 March 2014 Date approved 1 April 2014 Signed Signature removed for copyright reasons Comments: APPROVED WITH RECOMMENDATIONS:

Interview schedule: Student participants

<u>Part A.</u> Narrative Biography: These questions are to be given before the interview to allow thinking time.

- Tell me your science story. What are your earliest memories connected to science? What sparked your interest? What motivated you to continue with science?
- What were the key influences to make you continue with science?

<u>Part B.</u> Semi-structured Interview:

- What is science about for you? Possible prompts: What makes a good scientist? How does it link with society? Is it important? What is scientific literacy?
- What do you understand by the term 'celebrity'?
- Can scientists be celebrities?
- Do you know of any? Male? Female?
- Do they influence? Have they influenced you? Who might they influence?

Give my research title and aims, explaining that the media is implying a causal relationship:

- What do you think?
- Have you heard of the 'Brian Cox Effect'?

Student Participant Information & Consent Form

My name is Maria Dent, and I am a PhD student at the University of Derby.

Rationale and aims of this research:

The number of students choosing to study science at A'level, under-graduate and post-graduate levels has been seen to increase over the last few years. Educationalists, Government departments, Scientific bodies and the media have different views regarding what is influencing this increased interest. This research aims to explore individual science histories, drawing out individual student's motivation for continuing to study science past the compulsory phase. This knowledge will be used to develop a theoretical framework that will inform further academic research, and potentially influencing science policy makers and the scientific media.

It is hoped that you will enjoy the opportunity to talk about yourself, reflecting on your 'science journey', by exploring your influences and attitudes to science.

Interview process:

You will be expected to attend an interview where you will have the opportunity to initially talk freely about your memories of science, including any influences, followed by specific interview questions. The process will take no longer than 45 minutes.

- The interview will be recorded and subsequently transcribed.
- All data will be anonymised and stored securely and confidentially; I am the only person with access to your data. Please note, however, that if a safeguarding issue is disclosed during an interview then the researcher has a duty to report it.
- You will be given a copy of your recording, plus transcript, to check for accuracy.

- By agreeing to this research, you are giving me permission to use direct quotations in reports; a pseudonym will be used to ensure confidentiality, however, I am prepared to use your real name if requested.
- You have the right to withdraw your interview from this research up to [date to be confirmed], and you will not need to give a reason why.

This research has been designed in accordance with the University of Derby and BERA (2011) ethical guidelines, and has gained ethical approval from the Social Sciences and Postgraduate Research Ethics Committee.

Thank you for your interest in my research.

Maria Dent

Student Interview Consent Form

Name:
I have read the Participant's Information and acknowledge my rights within this research.
I consent to the researcher using direct quotations in the report.
Signed:
Date:

Student Participant Letter of Consent: Headteacher/Programme leader

University of Derby
Room E110, EHS
Kedleston Road
Derby
DE22 1GB

Address of School/Faculty

m.dent@derby.ac.uk

Date

Dear (Name of Headteacher/Programme Leader),

My name is Maria Dent, and I am a Senior Lecturer in Initial Teacher Training at the University of Derby, studying for a PhD. My research involves an exploration of the attitudes and motivations of students towards science, i.e. what influences them to continue with science post-compulsory age?

I am writing to ask your permission to interview a selection of your students. I have attached a copy of the 'Participants Information' to give you a fuller picture of what this involves. These students will volunteer themselves; the only requirement is that they are studying science.

I can assure you that the identity of non-participants will be protected by removing any reference to the names and identifying characteristics of the school and staff.

I would be very happy to meet with you to discuss this further.

Thank you for your interest in my research.

Yours sincerely,

Maria Dent

Senior Lecturer ITT

Recommendation: Approved with Recommendations

Comments from the reviewing team:
Maria should be commended on the very well thought out proposal.

- She states throughout that '*I am the only person with access to your data.*' I wonder if this should be amended in order to acknowledge that she will be discussing the data with her supervisor. I presume this will be the case.
- Within the information letter and the proposal form she may want to clarify that '*Participation in this research is voluntary.*'
- In the Information letter it states '*By agreeing to this research, you are giving me permission to use direct quotations in reports.*' If the aim is to use quotes only in reports, then this fine, but she may wish to publish some of this work in journal articles. If this is the case, it's best to clarify this early on.
- Maria will need to adapt the Information letter in order to gain Parental Consent.
- There is no means for the setting to give consent, at least as is presented in the Letter of Consent. She may wish to clarify how the settings will give consent: Does she plan on gaining verbal or written consent?

The following sentence is unclear (section 11, second paragraph):

- *This gives the impression of participant control, which could be manipulated, therefore it does not necessarily result in a more ethical methodology; the same issues of non-maleficence are present.*
- Ethically, what point are you making here?

Section 9; Objective:

- *To explore the influence of celebrity science and scientists on scientific literacy*
- Ethically, to explore the influence of celebrity science and scientists on scientific literacy, would it be prudent to seek data from 'celebrity scientists' on scientific literacy, either through an interaction with some example celebrity scientists – email, telephone, interview – or via analysis of their specific publications – this would require identification of a body of 'celebrity scientists'.

Section 11 e: Confidentiality

- *Real names and identities of participants to be confidential and anonymous; pseudonyms to be used, however, the researcher is prepared to use real names if requested;*
- Ethically, should decide to adopt the same approach for all research participants

Section 11 f: Protection of participants

- *Protection of non-participants within the institutions from which participants are sampled: the names of the schools and higher education institution will not be disclosed, nor the names of people within these organisations. They will be anonymised, and pseudonyms used if data is relevant to data analysis. The researcher retains the right to censor content;*
- Ethically, all data is relevant. Once collected, the data forms part of the data set.
- *Observations will not be shared with teachers, lecturers, or parents*;
- Ethically unclear – are you referring to a research method or observations made by research participants?

Section 11 i Research undertaken in public places

- *Physical/verbal abuse from student in 1:1 and focus group sessions*
- Ethically, focus groups as a form of data collection have not been previously outlined

Appendix 5: Request for Ethical Approval for Individual Study / Programme of Research by University Students

1. Your Name:	Maria Dent	2. Programme name and code PGR03: Postgraduate Research - EHS	
3. Contact Info			
4. Module name and code			
5. Name of project supervisor (Director of Studies)			
Dr. Neil Radford			
6. Title or topic area of proposed study			
Celebrity Science Culture: Young People's Inspiration or Entertainment?			
7. What is the aim and objectives of your study?			
Phase 2 :To explore the perceptions of celebrity scientists and science journalists on the uptake of science post-GCSE.			
8. Brief review of relevant literature and rationale for study (attach on a separate sheet references of approximately 6 key publications, it is not necessary to attach copies of the publications)			

Phase 1: Ethical approval 1st April, 2014

Phase 2:

My research to date has explored student motivation for continuing to study science post-GCSE, through analysis of student biographies and semi-structured interviews. This led to the development of a conceptual framework of influences, including the role played by celebrity scientists. Participants generally believe that scientists on television could have an influence on young people by raising awareness and interest, and by defining and modelling what a career in science could look like. They believe this even though they themselves were not influenced; they were already interested in science, and had courses and careers in mind.

The next phase of research is to capture the voice of celebrity scientists, exploring perceptions of their role in engaging young people in science, and the role that the media plays in creating celebrity per se, and specifically in science. This knowledge will be used to enable triangulation with the perceptions of student participants, and to develop a theoretical framework that will inform further academic research, and potentially influence science policy makers and the scientific media.

Key literature

The notion of celebrities evoking an emotional response, and therefore having the potential to influence issues, people, organizations, etc., even if they are not favourable, is recognised (Boykoff and Goodman, 2009; Giles and Maltby, 2004; Simonson, 2006); this may be underpinning the current focus on celebrity scientists. The Institute of Physics refers to the influence of Brian Cox, and a causal relationship has even been suggested between fictional scientists, e.g. Sheldon Cooper in 'The Big Bang Theory', and the positive uptake of science (The Observer, 2011). However, there is currently limited empirical evidence: most is anecdotal, presented by the media itself. Current literature generally focusses on entertainment-based media, rather than celebrities themselves (Millar, 2006), use of these media in science lessons (Rutter, 2011), and to explore their influence on perceptions of science (Donovan and Venville, 2012; Orthea et al., 2012).

There has been some reference to celebrity within generic research on influences. For example, in Sjaastad (2012) celebrities were reported as having minor influences; in 5% of responses to an open question participants attributed publicly known people in the media (1% closed questions). The Wellcome Trust report (2011) acknowledges the rise of television scientists and science programmes that have helped to support teachers, however, within the report, there is no mention of the scientists themselves having an influence. Interestingly, Rodd, Reiss and Mujtaba (2013) note the potential for identification existing in the imagination, and that this could be a television science presenter, referring explicitly to the 'Brian Cox effect'.

9. Outline of study design and methods

The overall research approach is qualitative. The research method will be semi-structured interview, allowing the researcher to focus on the participant's ideas of their roles as celebrity scientists. Sampling for participation will, therefore, be specifically purposive: they will have been named by the initial student participants as celebrity scientists, and/or be working in the field of science with some public engagement as science specialists; including working in television. This sampling strategy will allow the researcher to focus on scientists involved in public engagement with science, and described in the media as having an influence on the uptake of science, post-GCSE. Number of participants is expected to be 3 or 4, to enable data saturation and triangulation with Phase 1 data.

Practicalities (supported by pilot study findings)
The semi-structured interviews will be supported by written guidance (see Appendix 2: Interview schedule), which the participant will have received prior to the interview (minimum of 24 hours). An overview of these questions will be included on initial contact, through Participant Information, to enable the celebrity scientists to make an informed judgement regarding their response. That is, they would be able to offer their thoughts immediately via email, or contact me to arrange an interview.

Length of interview: the intention is to aim for 30 minutes, but will be guided by participants. Each interview will be recorded, and transcripts prepared.

To summarise, data collection will primarily be semi-structured interviews, providing qualitative data. Analysis will take a thematic approach, linked to the conceptual framework, allowing emergence of theory from a data saturation approach.

Objectives	Methodology
To explore the perceptions of celebrity scientists and science journalists on the uptake of science post-GCSE.	• Literature review: secondary data; media reports and interviews • Use of semi-structured interview, or email response to questions, recorded and transcribed; the researcher will be looking for percept • The subjective nature, and the reflexive role of the researcher, will acknowledged.

10. Research ethics
I will be working within the University of Derby's 'Research Ethics: Code of Practice' and the British Educational Research Association's (BERA) (2011). The beneficence of this research is primarily to give celebrity scientists a 'voice' about their role, allowing them to explore the nature of their influences on the uptake of science by young people, post-GCSE. This will allow triangulation with

data collected from young people reflecting on their memories of science education and specific influences to continue with science. The primary research method is semi-structured interviews, although there is an option for participants to respond via email.

Key ethical considerations (these are fully expanded within the subheadings below):

Consent will be sought, and participants assured of their right to withdraw prior to final integration of the data and dissemination; a final date will be given. A statement will be provided outlining generic research intentions. Anonymity and confidentiality are considered norms, however, within the notion of celebrity status, this will be discussed and agreed with participants. It is desirable for the purpose of this study that data collected be attributed to the individual scientists, plus it would be very difficult to ensure that participants were not identifiable, if anonymity were requested. Therefore, consent to attribute data, including direct quotations, will be requested. The safeguards of respondent validation of transcripts prior to analysis, and discussion regarding dissemination of the research will be in place. The Data Protection Act (1998) will be adhered to. Any personal narratives or anecdotes are linked to personal identity, therefore, interpretation and analysis must be performed with integrity; researcher bias will be acknowledged.

11. Ethical Considerations: Please indicate how you intend to address each of the following in your study. Points a - i relate particularly to projects involving human participants.

n) Consent
- The purpose and process of the research will be explained (written, and orally if interviews take place);
- It will also be explained why their participation is necessary, why it is beneficial, how it will be used, and how and to whom it will be reported;
- The researcher will confirm the participants wish to continue prior to data collection;
- Participants will be informed of their right to withdraw from the research prior to completed analysis; they will be notified of the date.

o) Deception
- Every effort will be made to accurately portray the data, e.g. by respondent validation of participants own transcripts. As a result, the investigation will be transparent, with no attempt to deceive.

p) Debriefing
- This will take place during research development and prior to dissemination;
- Information will be sought regarding issues that proved difficult for either researcher or participant, with the aim of improving the research instruments and procedures;
- Respondent validation of transcripts will take place, plus there will be the opportunity for participants to re-interpret the transcripts for me in the light of my analysis.

q) Withdrawal from the investigation
- The researcher recognises the right of any participant to withdraw from the research: they will be informed of this at the outset. This will be prior to final integration of the data and dissemination - a date for final withdrawal will be given;
- Raw data will be destroyed, but analysed/integrated data will not be destroyed: it will be kept on a password protected USB memory stick for six years.

r) Confidentiality
- Only the researcher will have access to transcripts and recordings;
- It is desirable that real names and identities of participants will be used. The safeguards

of respondent validation of transcripts prior to analysis, and discussion regarding dissemination of the research will be in place;
- Direct quotations and attributed judgements in reports will require prior consent from the participant;
- Researcher will remain alert to any issues participants may wish to keep confidential.

s) Protection of participants
- Any indication of discomfort, or sense of intrusion, and the interview will be stopped;
- Participants should not be harmed when they see their transcripts and the researcher's analysis; they retain the right to edit or expand their data prior to final integration and dissemination (final date will be given).

t) Observation research [complete if applicable]

u) Giving advice
- As an outsider researcher, and having had no prior relationship with the participants, I have no authority to offer advice.

v) Research undertaken in public places [complete if applicable]

Details of the Risk Element	Potential risk rating prior to controls	Controls in place to reduce likelihood	Residual risk rating after controls
Physical/verbal abuse from participant	Tolerable	Ensure third party aware of meeting time, place, etc., through informed consent	Tolerable
Travel to off-site institutions	Tolerable	Aware of University travel policy	Tolerable
Risk of harm on premises of off-site institution	Tolerable	Be aware of Health and Safety policies of off-site institution	Tolerable

w) Data protection
- Data Protection Act (1998) will be adhered to;
- The Participant Information sheet will include a 'fair processing statement' providing information on what the research is for, who will conduct the research, how the personal information will be used, who will have access to the information and how long the information will be kept for;
- Consent will be obtained for audio recording;
- A password protected USB memory stick will be used to store data;
- The researcher will remain alert to issues participants may wish to keep confidential;
- It is desirable that real names and identities of participants will be used. The safeguards of respondent validation of transcripts prior to analysis, and discussion regarding dissemination of the research will be in place;
- Consent forms and data will be stored separately and securely in a locked filing cabinet;
- Use of direct quotations and attributed judgements in reports will require prior informed consent from the participant.

x) Animal Rights [complete if applicable]

y) Environmental protection [complete if applicable]

12. Sample: Please provide a detailed description of the study sample, covering selection, number, age, and if appropriate, inclusion and exclusion criteria.
The primary participants in this research will be celebrity scientists and science journalists. Sampling for participation will be specifically purposive: they will have been named by the initial student participants as celebrity scientists, and/or be working in the field of science with some public engagement as science specialists; including working in television. Initially Professor Brian Cox, Professor Alice Roberts, and Sir David Attenborough will be contacted. Professor Steve Jones will also be contacted, as a celebrity scientist himself, but also in view of his commission to write an independent report of the 'Review of impartiality and accuracy of the BBC's coverage of science'. Beyond these, Dr Stephen Hawking, Dr Ben Goldacre, Dr Christian Jessen and Lord Professor Robert Winston are potential contacts.
13. Are payments or rewards/incentives going to be made to the participants? If so, please give details below.
No
14. What study materials will you use? (Please give full details here of validated scales, bespoke questionnaires, interview schedules, focus group schedules etc and attach all materials to the application)
Semi-structured interview schedules
15. What resources will you require? (e.g. psychometric scales, equipment, such as video camera, specialised software, access to specialist facilities, such as microbiological containment laboratories).
Voice recorder
16. Have / Do you intend to request ethical approval from any other body/organisation ? No (please circle as appropriate). If 'Yes' – please give details below.
17. The information supplied is, to the best of my knowledge and belief, accurate. I clearly understand my obligations and the rights of the participants. I agree to act at all times in accordance with University of Derby Code of Practice on Research Ethics http://www.derby.ac.uk/research/ethics/policy-document Date of submission 27.11.15 Signature of applicant Signatures removed for copyright reasons Signature of project supervisor (Director of Studies)

Interview schedule: Celebrity scientist participants

- What do you perceive as your role in engaging young people in science? Do you have any examples of your influence?
- How effective do you think this is?
    - In terms of student's continuing uptake of science?
    - Student's interest in science?
- What role does the media play in creating celebrity *per se*, and specifically in science?
- What is the role of the different media in engaging young people in science? For example, blogs, Facebook, Twitter, television and radio
- What is your view of other influences on young people's decision-making, e.g. parents, teachers, friends?
- Who do you think has the most influence?
- Why do you think children and young people choose science?
- What were your own influences to follow science careers?
- Do you have any specific memories of being influenced by science in the media yourself?

Participant Information & Consent Form

My name is Maria Dent, I am a Senior Lecturer in Initial Teacher Education (Science subject leader) at the University of Derby, studying for a PhD: 'Celebrity Science Culture: Young People's Inspiration or Entertainment?'

The research includes an exploration of the attitudes and motivations of students towards science, their perceptions of celebrity science and scientists, and a consideration of what influences them to continue with science post-compulsory age.

Rationale and aims of this research:

The number of students choosing to study science at 'A' level, under-graduate and post-graduate levels has been seen to increase over the last few years. Educationalists, Government departments, Science bodies and organisations, and the media have views, sometimes differing, regarding what is influencing this increased uptake.

The notion of celebrities evoking an emotional response, and therefore having the potential to influence issues, people, organizations, etc., even if they are not favourable, is recognised; this may be underpinning the current focus by the media on celebrity scientists and the positive uptake of science by young people.

My research to date has focussed on the science memories of students, exploring their motivation for continuing to study science post-GCSE. This led to the development of a conceptual framework of influences, including the role played by celebrity scientists. Participants generally believe that scientists on television could have an influence on young people by raising awareness and interest, and by defining and modelling what a career in science could look like. They believe this even though they themselves were not influenced; they were already interested in science, and had courses and careers in mind.

The next phase of my research, then, is to capture the voice of celebrity scientists and science journalists. This will involve an exploration of:

- Perceptions of their role in engaging young people in science;

- How effective they think this is;
- The role that the media plays in creating celebrity *per se*, and specifically in science;
- The role of the different media in engaging young people in science, e.g blogs, Facebook, Twitter, as well as traditional television and radio;
- Other influences on young people's decision-making, e.g. parents, teachers, friends;
- Why children and young people choose science;
- Participants own influences to follow science careers;
- Specific memories of being influenced by science in the media themselves;
- Examples of their own influence on students.

This knowledge will be used to develop a theoretical framework that will inform further academic research, and potentially influence science policy makers and the scientific media.

Interview process:

This process could be via email, responding directly to the foci above, or interviews via telephone / Skype, or in person; I would be aiming for an interview of 30 minutes, but this is negotiable.

Anonymity and confidentiality are considered norms, however, within the notion of celebrity status, this will be discussed and agreed with participants. It is desirable for the purpose of this study that data collected be attributed to the individual scientists, plus it would be very difficult to ensure that participants were not identifiable, if anonymity was requested. Therefore, consent to attribute data, including direct quotations, will be requested. The safeguards of respondent validation of transcripts prior to analysis, and discussion regarding dissemination of the research will be in place. The Data Protection Act (1998) will be adhered to. Any personal narratives or anecdotes are linked to personal identity, therefore, interpretation and analysis must be performed with integrity; researcher bias will be acknowledged.

From an ethical perspective, this would involve:

- Recording the interview, followed by transcription;
- Forwarding participants a copy of their recording, plus transcript, to check for accuracy;
- Permission to attribute data collected to named scientist;
- Permission to be able to use direct quotations in reports, academic papers and my final submission;
- Storing data securely; password protected
- Giving participants the right to withdraw their interview from this research up to [tbc], without needing to give a reason why.

This research has been designed in accordance with the University of Derby and BERA (2011) ethical guidelines, and has gained ethical approval from the Social Sciences and Postgraduate Research Ethics Committee.

Thank you for your interest in my research.

Maria Dent

Interview Consent Form

Name: Signature: Date:

I have read the Participant's Information and acknowledge my rights within this research.
I consent to the researcher attributing data collected to my name.
I consent to the researcher using direct quotations in the report.

Re: Request for ethical approval for study entitled; 'Celebrity Science Culture: Young People's Inspiration or Entertainment?'

Date: 17th December 2015

Name: Maria Dent

Dear Maria

Thank you for submitting your application for the above mentioned study which was considered by 3 reviewers and ratified by Chairs' action on behalf of the College of Education Research Ethics Committee (CEREC) on 17th December 2015. The reviewers considered that ethical issues connected with this study have been considered well. They considered it a low risk project in terms of ethics. As a consequence, the decision of the reviewers is that your study has been **approved with recommendations**; please see the comments below. No additional submission will be required for Phase 1 (survey) of this study, unless methods change significantly. Further approval will need to be sought for further phases of data collection.

Recommendations:

- Consider whether it is necessary to 'name' the celebrities in the study or whether you might ask participants what they would prefer. Offering anonymity may result in a larger number of participants.
- It is advisable to keep the recordings until completion of the Viva since external examiners sometimes ask for raw data and to inform the participants that interviews might take up to an hour so as to allow time for sufficient data collection. Consider whether you will back up the data and where any notes from interviews will be stored.
- Think about whether the respondent validation process could be designed so that participants are not editing the raw data but adding reflections to it. Some might question whether 'edits' made by celebrities concerned with their status might result in some invalidity.
- The survey introduction email should contain more detailed informed consent. How will confidentiality be ensured? How will the data be used and what will happen to the data after the analysis, how will it be stored and who will have access? Also there should be some indication to potential participants of what the benefit to them or others or to knowledge is of doing this research. You may also need to consider that you might access celebrities via an agent.
- Consider what the timeline will be for withdrawal (by when?)

The reviewers commended the study as well considered, current and interesting. I wish you all the best for your studies.

Yours Sincerely

Signature removed for copyright reasons

Chair of the College of Education Research Ethics Committee

Revised Participant Information & Consent Form following Ethics Committee recommendations:

Celebrity Science Culture: Young People's Inspiration or Entertainment?

Participant Information

My name is Maria Dent, I am a Senior Lecturer in Initial Teacher Education (Science subject leader) at the University of Derby, studying for a PhD: 'Celebrity Science Culture: Young People's Inspiration or Entertainment?'

My research includes an exploration of the attitudes and motivations of students towards science, their perceptions of celebrity science and scientists, and a consideration of what influences them to continue with science post-compulsory age.

Rationale and aims of this research:

The number of students choosing to study science at 'A' level, under-graduate and post-graduate levels has been seen to increase over the last few years. Educationalists, Government departments, Science bodies and organisations, and the media have views, sometimes differing, regarding what is influencing this increased uptake.

The notion of celebrities evoking an emotional response, and therefore having the potential to influence issues, people, organizations, etc., even if they are not favourable, is recognised; this may be underpinning the current focus by the media on celebrity scientists and the positive uptake of science by young people.

My research to date has focussed on the science memories of students, exploring their motivation for continuing to study science post-GCSE. This led to the development of a conceptual framework of influences, including the role played by celebrity scientists. Participants generally believe that scientists on television could have an influence on young people by raising awareness and interest, and by defining and modelling what a career in science could look like. They believe this even though they themselves were not influenced; they were already interested in science, and had courses and careers in mind.

The next phase of my research, then, is to capture the voice of celebrity scientists and science journalists. This will involve an exploration of:

- Perceptions of their role in engaging young people in science;
- How effective they think this is;
- The role that the media plays in creating celebrity *per se*, and specifically in science;
- The role of the different media in engaging young people in science, e.g blogs, Facebook, Twitter, as well as traditional television and radio;
- Other influences on young people's decision-making, e.g. parents, teachers, friends;
- Why children and young people choose science;
- Participants own influences to follow science careers;
- Specific memories of being influenced by science in the media themselves;
- Examples of their own influence on students.

Data collected by semi-structured interview will be analysed and coded using the conceptual framework developed by analysis of student perceptions. This knowledge will be used to enable triangulation with the perceptions of student participants, and to develop a theoretical framework that will inform further academic research, and potentially influence science policy makers and the scientific media regarding their promotion of science as a career choice for young people. Findings from this research also have the potential to inform the way that celebrity participant's engage with young people, especially how they model and define what it means to be a scientist.

Interview process:

This process could be via email, responding directly to the foci above, or interviews via telephone / Skype, or in person; I would be aiming for an interview between 30 and 60 minutes, but this is negotiable.

Anonymity and confidentiality are considered norms, however, within the notion of celebrity status, this will be discussed and agreed with participants. It is desirable for the purpose of this study that data collected be attributed to the individual scientists, plus it would be very difficult to ensure that participants were not identifiable, if anonymity was requested. Therefore, consent to attribute data, including direct quotations, will be negotiated. The safeguards of respondent validation of transcripts prior to analysis, and discussion regarding dissemination of the research will be in place. The Data Protection Act (1998) will be adhered to. Any personal narratives or anecdotes are linked to personal identity, therefore, interpretation and analysis must be performed with integrity; researcher bias will be acknowledged.

From an ethical perspective, this would involve:

- Recording the interview, followed by transcription;
- Forwarding participants a copy of their recording, plus transcript, to add their reflections to it;
- Permission to attribute data collected to named scientist;
- Permission to be able to use direct quotations in reports, academic papers and my final submission;
- Storing data securely on personal laptop and memory stick (data back-up); hardware and folders password protected. This includes recordings, transcripts and notes from interviews;
- After analysis, the raw data will be stored securely until completion of the Viva Voce, after which it will be destroyed;
- Giving participants the right to withdraw their interview from this research up to May 31st, 2016, without needing to give a reason why.

This research has been designed in accordance with the University of Derby and BERA (2011) ethical guidelines, and has gained ethical approval from the Social Sciences and Postgraduate Research Ethics Committee.

Thank you for your interest in my research.

Signatures removed for copyright reasons

Maria Dent

Interview Consent Form

Name: Signature: Dare:

I have read the Participant's Information and acknowledge my rights within this research.
I consent to the researcher attributing data collected to my name.
I consent to the researcher using direct quotations in reports, academic papers and my final submission.