Department for Business, Energy & Industrial Strategy

# PUBLIC ATTITUDES TO SCIENCE 2018-9 LITERATURE REVIEW

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# Contents

# Key findings of the literature review

This literature review has been produced as part of the 2018-9 UK Public Attitudes to Science (PAS) study, funded by the UK Department for Business, Energy, and Industrial Strategy (BEIS). Responding to ongoing interest in public support for science and technology in the UK and other technologically-advanced countries, this round of the UK research follows earlier studies in 2000, 2005, 2008, 2011 and 2014, and is part of a growing international body of national PAS studies and academic work. The objective of this literature review is to identify and present broad-based narratives from the public attitudes to science, technology and engineering literature. The review focuses on the UK, within the context of other technologically-advanced countries. The review particularly emphasises studies that were conducted since 2010. The review methodology drew on the principles of Rapid Evidence Assessments.

## Key findings

1. The literature review reveals a contrast between public attitudes towards science and scientists, in general, and attitudes to the ways in which particular manifestations of science and technology are managed by government and other institutions. While the former tend to be very positive, the latter are much more mixed. This is a key issue for policy-makers.
2. In this context, Smallman's (2018) empirically-grounded concept of 'contingent progress', to encapsulate public attitudes, is helpful: 'science and technology are seen not only as producing goods and solutions but also as producing (unforeseen) problems, problems which are as inherent to the technologies as the benefits they bring, where industry is a necessary but distorting influence that needs to be managed by the state' (p670). Equally helpful is her empirically-grounded encapsulation of the policy and expert view as 'Science to the Rescue': 'science is a driver of our economy and competitiveness and can solve our problems and deliver social goods; social and ethical issues are public matters relating to risk and understanding that stand aside from the technologies themselves and can be quantified and resolved by more research or information' (pp669-70). The review draws attention to the disjuncture between these attitudes as a factor in determining public attitudes to science. This is also a key issue for policy-makers to consider.
3. Scientists, researchers and engineers are among the most publicly trusted individuals and professions in technologically-advanced countries. Some UK evidence indicates that this trust increased between 2011 and 2014. Scientists working in universities are more trusted than scientists working for environmental groups and charities, and these in turn are more trusted than scientists working for the government and in the private sector.
4. However, there is evidence that UK public trust in the management of science and technology is more mixed and contingent. Here, terms such as 'resigned trust' have been used in reports, and trust in the government to respond to public interests and values (as opposed to government and commercial interests) does not appear to be secure. This is clearly an important issue for policy-makers to consider.
5. Research often shows that, although faith in the idea that people with more knowledge about science and technology will be more supportive has been officially rejected, in practice information provision is often the dominant tool for the promotion of novel technologies.
6. In addition to trustworthiness, publics in the UK and other technologically-advanced countries tend to attribute a range of other positive characteristics – such as respect and prestige – to scientists and

engineers. When compared with other professions, science and engineering tend to fare relatively well. There are indications that engineering continues to be perceived as a male profession.

7. Science, technology and engineering are recognised by publics in technologically-advanced countries as important to society, including when compared to other professions.
8. That said, there is evidence in one report that science and technology is not seen as important to society at the local and community level. This may be a key point for policy-makers to consider.
9. Given this widespread acknowledgement of the importance of science and technology, it is notable that studies in technologically-developed countries often show that sizeable minorities among the public feel that the pace of technological change is too fast and that more reliance on faith is important as opposed to science (there are sometimes small majorities with respect to the pace of change).
10. Young people in the UK appear to be broadly satisfied with their science education. Although the science career aspirations of young people in the UK appear to be lower than some other professions – such as business, and art and design – there is also evidence that they compare favourably to other technologically-advanced countries.
11. Publics in the UK and other technologically-advanced countries are more familiar with science and technology, as professions or practices, than they are with engineering.
12. A majority of people in the UK and other technologically-advanced countries are interested in science and technology. The highest level of interest is in the medical and health-related sciences. Interest in engineering is lower when compared with science and medicine.
13. In the UK and most other technologically-advanced countries in which this question has been asked, although the internet is an increasingly important source of information about science and technology, TV and newspaper still appear to be more important. In the US, the internet is the most important source. In the UK, levels of public concern about media reporting of science issues are high.
14. In the UK, around half of the public feel informed about science and technology (this is replicated in some other technologically-advanced countries) and around half do not feel capable of understanding science and technology. In the UK, many people express difficulties about establishing ‘the facts’ about science and technology;
15. More than half of people in the UK have participated in a science-related activity (this refers to activities that are undertaken outside of school/college or work, such as visiting museums and attending science festivals) in the past year (2014 and 2011). Participation levels are similar in a number of other technologically-advanced countries for which data are available.
16. Consistently, more positive attitudes to science, technology and engineering – for example trust and support – are to be found among men. This is also the case with respect to judgements of the importance of, and interest in, science and technology. An exception to this is that interest in medical science is higher among women;
17. More positive attitudes are also consistently reported among people from higher socio-economic groups (variously measured). This latter point has prompted some – both recently and in the late 20th Century – to emphasise the role of inequality and exclusion in shaping less positive public attitudes to science. This may be an important point for consideration by policy-makers;
18. Based on the limited number of international studies available, the literature suggest the UK is broadly similar to other technologically-advanced countries in terms of public attitudes to science, technology and engineering;
19. Generally-speaking, following shifts towards more positive UK attitudes to science, technology and engineering between 2000 and 2011, attitudes appear to be more stable between 2011 and 2014;

20. The literature raises a number of conceptual and methodological challenges that characterise international work on public attitudes to science. Conceptually, these include the observation that, although attitudes to different technologies vary widely and are highly context-dependent, national PAS research tends to focus on core sets of questions about ‘science’ as a unitary object. Methodologically, these include poorly written questions (which are sometimes perpetuated to maintain the trend data). Although qualitative research is now a feature of the national UK studies, the importance of context presents a methodological challenge to move away from general survey questions about ‘science’ and towards more nuanced qualitative research into the contexts within which people experience technologies.

# Chapter 1 Introduction

## Public Attitudes to Science (PAS) research: 2018-9

The institutions that govern UK science have paid considerable attention to the relationships between science and society, in all their myriad forms, for almost 35 years. Responding to emerging concerns in the early 1980s, this attention was invigorated by the Public Understanding of Science report (Bodmer, 1985), which identified a lack of public knowledge about and public support for science as significant threats to UK science and economic prosperity. Although institutional understandings of the roots of public concerns about science have shifted somewhat since 1985, the broad-based concern about public support remains.

In response to these concerns, the institutions of UK science have supported a range of efforts to understand UK public attitudes to science since 2000 (including Government funded studies in 2000, 2005, 2008, 2011 and 2014, and studies by Wellcome Trust and Royal Society), and have implemented extensive public engagement strategies. Understanding UK public attitudes to science is seen as important because it enables Government to:

- Understand and respond to public aspirations and concerns relating to science, technology, and engineering;
- Support policies that look to increase the 'science capital' of the UK public (that is, the science-related knowledge, attitudes, experiences and resources possessed by the individual);
- Understand public acceptability of new technologies;
- Inform public engagement strategies.

This literature review has been produced to accompany new quantitative, qualitative and social listening research as part of the 2018 Public Attitudes to Science (PAS) study. The 2018 UK research was funded and managed by the UK Department for Business, Energy and Industrial Strategy (BEIS). The BEIS team was supported by a project Advisory Group. The objective of this new primary research is to understand contemporary public attitudes to: science, scientists, science education and careers, science regulation and policy, public engagement with science, and several key emerging technologies and technology-related issues.

## Objectives and scope of the literature review

The objective of this literature review is to present a review of the PAS literature. Within the context of the national UK PAS research and in this review, the word 'science' broadly encompasses the following:

- Research and practice in the medical, biological, physical and natural sciences;
- Technologies, technological projects and technological applications;
- All forms of engineering research and practice[1].

In the UK national PAS research, and in this review, the word 'attitudes' is typically used to imply:

[1] The UK PAS research also touches on maths in the context of the value of maths education.

- Trust in individuals (e.g. scientists, researchers and engineers) and professions or careers (e.g. science, research and engineering);
- Trust in the regulation and management of science and technology;
- The extent to which a range of other characteristics are attributed to scientists and engineers;
- The importance or value of science, technology and engineering;
- Support for science, technology and engineering in terms of funding;
- Attitudes to a range of concerns and issues, such as the speed of scientific developments, and the relationships between science, and faith or religion;
- Perspectives on science education and science careers;
- Public interest in science;
- Issues related to information about science, such as information sources;
- Issues related to public engagement with science, technology and engineering.

In addition to these objectives, the review also addresses the wide range of factors that are understood to shape attitudes to science and technology, from knowledge about science and demographic attributes, to the ways in which science and technology are managed to worldviews. There does not appear to be a literature on this with respect to engineering.

Drawing on a range of quantitative and qualitative research, as well as some research that is more theoretical or critical in nature, the objective of the review is to identify and present broad-based narratives within the research on these topics. At the same time, within the context of a large and diverse literature, the review is inevitably selective and cannot hope to cover all aspects of these issues. In addition, it is inevitable that themes are presented here in more simple terms than they are in the source materials. Apologies if we have omitted or over-simplified your work!

The review focuses on the attitudes of adults, except Chapter 8 which examines the attitudes of young people to science education and careers. The literature review takes an international approach, focusing on the UK and placing the UK within the context of other technologically-advanced countries (the OECD member country have been used as a proxy for technologically-advanced countries)[2], to the extent to which this is possible (the challenges of doing this are discussed in Chapter 2). The review focuses on English language materials only. The implication of this is that national studies that are not available in English are not included in this review; this may result in bias. With particular reference to the UK, again to the extent to which it is possible, the review comments on trends over time, and on social contexts that might explain trends.

The literature review primarily draws on empirical studies that were carried out since 2010 (the last UK literature review was undertaken in 2011). That said, for the UK, trends over a longer period are reported. In addition, in some chapters – in particular, Chapter 3, which focuses on theories and empirical work on what shapes attitudes to science and technology – the review also draws on empirical, theoretical and critical materials over a longer period. The review draws on both academic and non-academic (or grey) sources. Secondary analysis of raw data was not an objective of this review; that said, in a number of cases, the review draws upon cross-tabulations (some published, some unpublished) as well as study reports.

[2] The 34 OECD countries have been used as a proxy for technologically-advanced, these are: Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

# Methodology

The methodology drew on the principles of Rapid Evidence Assessments, with the aim of creating a rigorous and comprehensive review – in terms of its scope and the depth of engagement with the materials – across a wide range of topics.

## Identifying the literature

The relevant literature was identified via the following methods:

1. The author's already-existing knowledge of the literature;
2. Liaison with experts, such as: academics (John Besley (Michigan State University), Martin Bauer (LSE), and Mike Schäfer and Tobias Füchslin (University of Zurich)), the BEIS and Kantar teams, and members of the Advisory Group;
3. Issue-by-issue search of the key academic journal, *Public Understanding of Science*;
4. Google and Google Scholar were used to in the following ways:
    - To purposively follow-up 'leads' from: the author's own knowledge of the literature; the advice of the experts mentioned above; and for snowballing (i.e. to find potentially useful materials that were cited in materials that were already held);
    - Although most of the literature in the review was sourced using the foregoing methods, Google and Google Scholar were also used to conduct original literature searches using search terms. Key search terms were derived from the objectives of the review and were employed in multiple formats.

## Quality control

Quality control was undertaken within the following contexts:

1. The literature on the methodological challenges associated with the large-scale national and international PAS studies is reviewed in full in Chapter 2. Key among these challenges are: the lack of context and contingency that is implied by a focus in survey questions on a unitary subject 'science'; concerns about poorly-worded questions; and concerns about the use of quota samples (which are less rigorous than probability samples. All of the national and international PAS studies in this review are subject to these challenges to some extent. In addition, with respect to some studies, the review author felt that some of the reported interpretations were inappropriate given the questions on which they were based. The key implication of this is that it is perhaps inappropriate in many cases to conclude that materials are either of 'good enough' quality or 'not good enough' quality. Instead, it is more appropriate to consider that while some aspects of studies are of 'good enough' quality, others may not be;
2. Within the context that this is an international literature review, it is useful to note that some of the national PAS survey English translations are in summary form only and do not provide much information – beyond the sample size – on the methodology.

Within these contexts – and drawing on the experience and expertise of the review author – quality control was applied by triangulating the following approaches:

1. The methodologies that were available – quantitative and qualitative – were reviewed for signs of 'not good enough' quality;
2. Academic journal articles were assumed to be of 'good enough' quality';

3. Materials that were recommended by academic and other experts, or are cited in materials by academic experts, were assumed to be of 'good enough' quality
4. Each question within each survey was assessed in terms of its quality. Survey questions that were considered to be of insufficient quality were not used in the review
5. As is discussed elsewhere in the report, a key finding of the review is a noticeable homogeneity in the quantitative findings between the UK studies, and many or most of the other national and international studies. Broadly speaking, as this phenomenon emerged during the preparation of the report, this was reassuring with respect to the quality of the individual materials.

On the basis of this triangulation, all of the materials in the review can be considered to be of sufficient quality.

## Analysis

The materials were analysed through close reading of and the extraction of statistical data (typically percentages) and qualitative themes from reports and papers, and very often from cross-tabulations that are publicly available or were helpfully provided by the original researchers and authors. No secondary data analysis has been undertaken. Reading and data extraction followed the themes that are identified in the objectives of the review. The statistical data was used to identify and present broad-based qualitative narratives.

As it was developed, the review was discussed with members of the Kantar team, the BEIS policy and social research teams, the Advisory Group and other key experts and stakeholders on an ongoing basis. In addition to regular updates and discussion, formal and detailed discussion of the literature review took place at the Kantar/BEIS inception meeting (19 July, 2018) and at an Advisory Group meeting (7 August, 2018). Early drafts of the review were reviewed by Kantar and full drafts were reviewed by BEIS and by the Advisory group.

## Structure of the report

The report is presented in a series of relatively short chapters. The report opens with a summary of the key findings, followed by this introductory chapter (Chapter 1) and a background chapter on international efforts to understand public attitudes to science, and some of the methodological challenges therein (Chapter 2). The report then – in Chapter 3 – moves on to a review of the key theories relating to how attitudes to science and technology are shaped (this chapter draws on materials that pre-date the post-2010 empirical focus of the review).

Following this, in four sections, the report examines public attitudes to science, technology and engineering as broad social projects. In Chapter 4, the focus is on trust in individuals (e.g. scientists, researchers and engineers) and professions or careers (e.g. science, research and engineering); here, comparisons are made with other professions where possible. In the same chapter, trust in the regulation and management of science and technology is also discussed; this an important element of the report because it raises a number of challenging issues. Chapter 5 focuses on a range of other attributes or characteristics of scientists and engineers; again, comparisons with other professions are provided where possible. The report then moves on to a discussion of the public's understandings of the importance or value of science, technology and engineering, and public support in terms of funding (Chapter 6). Chapter 7 focuses on a range of concerns and issues that often feature in studies of public attitudes to science (such as the speed of scientific developments, and science and religion).

Thereafter, in three further empirical chapters, the report examines several issues that are more related to people's direct relationships with science, technology and engineering. Initially, perspectives on science education and science careers are examined (Chapter 8). Then, in Chapter 9, the focus moves to the public's interest in science, often in comparison with other topics or pursuits, and then to issues relating to information about and participation in activities relating to science, technology and engineering (Chapter 10). Finally, Chapter 11 offers a discussion of the key issues that have been raised in the review, as well as some proposals for policy.

## The social context for the 2018-9 research

In many respects, the social context within which science operates has not changed: novel technologies are emerging (e.g. artificial intelligence and quantum technologies), public engagement activity is likely to increase further, and certain technologies and practices are likely to remain contentious (e.g. genetic technologies, and the security and use of personal data). At the same time, it is important to highlight some broader and interrelated contexts that were not present – or were only nascent – when the 2014 survey was carried out. These can be explored in the 2018-9 research and – to a much lesser extent – in this literature review.

The first relates to the increasingly-held contention that we are living in a post-truth age, in which emotion plays an enhanced role in establishing 'truth' or 'fact', society has an increasing disregard for experts and political debate is compromised (Kakutani, 2018). Related to this, it is widely accepted that the increasing proliferation of social media (beyond what was present in 2014) has been a key facilitator of the post-truth era, due to its role in the easy dissemination of disinformation (either to encourage clicks in pursuit of advertising revenue or to influence debates); though of course it is also important to note that social media can be an incredible boon to public engagement with science. Further linked to this, there has also been an increasing focus on the protection of personal data, especially with the advent of GDPR. Recent media coverage around the unauthorised sharing of social media data for profiling and targeting is also highly relevant here.

# Chapter 2 Background

## International PAS research

As Besley (2013; also see Pardo and Caldo, 2002) reports, international attention regarding public attitudes to – and sometimes understanding or literacy relating to – science and technology began in the US in the late 1950s. Since then, many countries – and particularly technologically-advanced countries and groups of countries, such as the European Union – have undertaken regular, periodic or one-off research into aspects of this issue. Both as part of these large-scale projects and as separate projects, many countries have also conducted research into public attitudes to specific technologies or applications, as well as particular approaches to research (such as animal research or research using stem cells). Alongside this so-called 'grey' literature, there is a longstanding academic literature that examines public attitudes to technological projects. This work also places the public attitudes to science research agenda within a broader social and political context, examines the findings of the national studies, and addresses the methodological challenges inherent in such an ambitious undertaking. There is relatively little literature on public attitudes to engineering. This is addressed in some of the national PAS studies, and – more significantly – the Queen Elizabeth Prize for Engineering Foundation conducts public attitudes to engineering research across ten countries.

This attention reflects the perceived importance in technologically-advanced societies of science, engineering and technology, and a public culture that is supportive of government objectives in this domain. On the basis of such research, countries are able to assess national attitudes (and typically break this down by demographic attributes and other attitudinal measures) and – to varying extents – examine trends over time and make comparisons between countries.

## Emerging conceptual frameworks

In recent years, two conceptual frameworks have emerged to describe, codify and measure the characteristics of individuals with respect to science, technology and engineering. In the UK, BEIS has begun to use the 'science capital' concept. Developed within the context of science education (Archer et al., 2015), science capital focuses on eight dimensions: scientific literacy; science-related attitudes, values and dispositions; knowledge about the transferability of science; science media consumption; participation in out-of-school science learning contexts; family science skills, knowledge and qualifications; knowing people in science-related roles; and talking about science in everyday life (Archer et al., 2016). For the UK Government, enhancing science capital is seen as important in terms of *both* providing the skills to support economic growth through science *and* maintaining science's social 'licence' to operate (BEIS, 2018, *pers. comm.*). The 2018 iteration of the PAS research will, for the first time, explicitly draw on the science capital concept.

In Canada, the concept of 'science culture' has been employed within the context of public attitudes to science research (Council of Canadian Academies, 2014). This concept features similar concepts to 'science capital' and is consolidated into four key dimensions: public attitudes towards science and technology; public engagement in science; public science knowledge; and, science and technology skills.

## Conceptual and methodological challenges

The task of understanding international public attitudes to science is methodologically complex and challenging. Most national research relies upon large-scale population surveys. In the UK, these are now complemented by qualitative and/or deliberative approaches (especially in the context of specific technologies) and – most recently – by 'social listening' approaches which focus on social media. The academic work in this area typically relies upon smaller scale surveys and qualitative approaches.

The conceptual and methodological challenges in this area fall into a number of interlinked categories:

- As Osborne et al. (2003) state, attitudes are not a single construct, but rather several or many subconstructs all of which contribute in varying proportions towards an individual's overall attitude towards a specific topic. Although these subconstructs can be separately identified in many projects, Besley (2013) notes that they can be under-theorised or elaborated.
- Similarly, 'science' is not a single entity or object, but rather a wide range of situated disciplines, technologies, practices, regulatory contexts and specific situations. Also, as discussed in more detail in Chapter 3, attitudes are contingent, typically varying from context to context (Wynne, 1991). However, most national surveys rely upon and place great store in a core section on attitudes to a single topic, namely 'science'. As a result of this challenge, Wynne (1991: 112) warns of, 'simplistic over-interpretation of large-scale surveys' and the 'ordinary fact that "science" (in general) enjoys high public esteem and interest in surveys yet suffers apathy and worse in many specific encounters'.
- As a related matter, although large-scale surveys can claim to be representative of and therefore generalisable to a population, they also yield somewhat superficial information that does not reveal depth, context or contingency (Osborne et al., 2003). Although triangulation with in-depth qualitative approaches can address this issue to some extent, it is notable that most national research on public attitudes to science rely on survey data alone or foreground survey results at the expense of qualitative data.
- Questionnaire surveys in this domain often suffer from poorly worded questions, for example: a surfeit of double-barrelled or even triple-barrelled questions (i.e. questions that ask about two or even three things at once); other examples of unsatisfactory questions; and unclear and under-theorised relationships between questions and underlying constructs (Besley, 2013). In addition, there is always an ongoing tension between the desire to update and improve questions and to keep questions consistently worded to allow tracking of trends over time.
- In the context of quantitative analysis, challenges relating to sampling (particularly the use of quota samples, which are less rigorous and reliable than probability samples) and the proper use of inferential statistical tests have been identified (Smith and Jensen, 2016).
- Importantly for this review, international comparisons are often made difficult by variations between individual country studies relating to: conceptual approaches and research methods; questions and response scales; and study frequencies, timescales and timings (Besley, 2013). In addition, a lack of or very limited English language translations also limits the scope. Two major international studies have been helpful in this review: in the context of science and technology, *Special Eurobarometer 401: Responsible Research and Innovation (RRI), Science and Technology* (EC, 2013) and, in the context of engineering, *Create the Future Report 2017* (Queen Elizabeth Prize for Engineering, 2017); these are described further in the next section. Within this context, further efforts to produce internationally comparable data – such as the Wellcome Trust Global Monitor[3] (due in 2019) – will be very helpful.

[3] https://wellcome.ac.uk/what-we-do/our-work/public-views-science-and-health#wellcome-global-monitor.

# Chapter 3 What shapes attitudes to science?

## Key findings

- The relationship between knowledge and attitudes is complex. There is little evidence to support the theories that greater levels of knowledge are associated with more positive attitudes and that the provision of information will positively change attitudes;
- Among demographic characteristics, there is consistent evidence that more positive attitudes towards science tend to be found among men and people in higher socio-economic groups. This prompts some to identify unequal levels of societal power and control, and the unequal distribution of benefits and risks, as determinants of attitudes. The role of age and ethnicity in terms of shaping attitudes is less clear-cut and often context-dependent;
- Attitudes are also shaped by people's experiences and understandings of the ways in which technological projects are managed. Among other things, the public is likely to respond positively to: processes for meaningful public involvement; an absence of hype; openness and transparency, especially with respect to uncertainties and gaps in knowledge; and, clear lines of accountability when things go wrong;
- Technologies that offer clear and equitably-distributed benefits that respond to or advance public interests (as opposed to those of government or the private profit) are more likely be accepted;
- Technologies are less likely to be accepted when its risks are: new, not observable, delayed, not well understood by science, not controllable, evoke a sense of dread, catastrophic, increasing, involuntary, not in the control of the individual and not easily-reduced;
- Attitudes are shaped in a variety of ways by broader worldviews, such as: faith or religion, political dispositions and others;
- On the basis of the national PAS surveys that are reviewed here, the UK is not particularly distinctive among technologically-advanced countries in terms of attitudes – such as trust, importance and interest – to science and technology.

## Introduction

The literature contains many ideas about what shapes attitudes – such as trust, support and acceptance – to science, technology and engineering. The objective of this section is to review some of the key themes within this literature. Within social psychology, attitudes are typically understood to be the outcomes of past experiences. Attitudes are typically understood to be relatively settled, but also contingent and context-dependent. Key themes in the literature are: knowledge about science, demographic attributes, characteristics of the technology and the risks that it presents, values and worldviews, and the ways in which science and technologies are managed. Although the focus of this literature review is on post-2010 empirical studies, this chapter draws on theoretical and empirical material from before this date as these contain themes that remain relevant.

## Knowledge about science

Due to its ongoing influence, it makes sense to start with the seemingly logical idea that people who know more about science will have a range of more supportive and positive attitudes towards it (and *vice versa*). This idea was elaborated in the UK Public Understanding of Science report (Bodmer, 1985), and has shaped a longstanding and ongoing focus on pedagogically-inspired science communication and public understanding of science (PUS) activities across the globe. However, the relatively small associations that are typically noted between knowledge about and attitudes towards science, and the fact that associations are both positive and negative (Sturgis et al., 2010), suggests that this is a much more complex issue than Bodmer assumed[4]. Although the idea of an unproblematic link between knowledge and attitudes is now officially rejected as a flawed 'information deficit model'[5] (House of Lords, 2000), critics have argued that its influence remains strong in many contexts (Irwin, 2006; Wynne, 2006; Levidow, 2014). See the special issue of *Public Understanding of Science* for a series of essays that examine why this is (Bauer, 2015).

## Demographic characteristics

Research also examines the proposition that attitudes to science are related to demographic characteristics such as: gender, age, education, socio-economic status (e.g. professional status and income), ethnicity, political affiliation, religion and nationality. These are very broad descriptions, and counter examples can always be identified, but the national PAS studies that have been analysed for this review and a range of other materials suggest the following general patterns both within the UK and internationally:

- **Gender**: PAS studies have long suggested that men tend to hold more positive attitudes to science and technology than women[6]. For instance, the 2014 UK PAS study consistently refers to a 'gender divide' (Ipsos MORI, 2014). For instance, in general, men are more likely: to trust and support scientists and engineers, and the ways in which technological projects are governed and managed; to associate a range of other positive attributes to scientists; to be interested in science and technology issues; to feel well-informed about science and technology; and to engage with science and technology activities. In addition, studies suggest that the boys are more likely to have positive views of their science education and aspirations to a career in science (Archer et al., 2013);
- **Socio-economic status and education**: PAS studies, including the 2014 UK study (Ipsos MORI, 2014) also consistently suggest that people from higher educational, socio-economic or income groups are more likely to express positive attitudes to science and technology[7]. Archer et al.'s (2013) work also suggests that young people from lower socio-economic groups are more likely to express lower aspirations to a career in science. These findings have prompted authors to suggest tackling inequality as part of the route to more positive attitudes to science (Flynn et al., 1994; Davidson and Freudenburg, 1996) and to diversifying the group of individuals aspiring to science (Archer et al., 2013).
- **Ethnicity**: Work on risk perception in the US also identifies 'white' people as a third key group more likely to hold a range of more positive attitudes to science and technology (Slovic, 1997). In the UK, Dawson (2018) discusses the ways in which people from low-income, minority ethnic backgrounds are excluded

[4] For instance, in a study of attitudes to biotechnology, Simon (2010) noted a positive relationship between knowledge and attitudes for men, but a negative relationship for women (see Section 3.4 on gender).
[5] Information deficit model (or just deficit model) is a term that was introduced into debates about public understanding of science in the late 1980s and early 1990s (e.g. Wynne, 1991; 1992). The term is intended to encapsulate – with critical intent – the notion that attitudes to science and technology are determined by knowledge about science and technology.
[6] This is also a key finding in US work on risk perception in the 1990s (Slovic, 1997).
[7] Again, this is also a key finding in US work on risk perception in the 1990s (Slovic, 1997).

from science-related activities, such as museums. Importantly, exclusion does not only take place through barriers such as cost, but also through cultural barriers, such as experience-based understandings of who such spaces are for and who they are not for.

- **Age**: The literature suggests that age is sometimes a determinant of attitudes to science and technology, but this variable appears to work in different directions in different contexts;

## Worldviews

The term 'worldviews' is used here to encapsulate the idea of pre-existing, relatively stable and over-arching 'orienting dispositions', lenses or filters (Slovic, 1997), 'perceptual filters' (Allum et al. 2014) or systems of belief (Dake, 1992). Worldviews are important because we use them as short cuts to sense-making and attitude formation, in the context of all manner of complex issues, including those relating to science and technology. Political dispositions or religion and faith might be considered as worldviews. In addition, researchers have used empirical and analytical techniques to identify worldviews from data.

- **Political dispositions**: Work in the US often associates liberal political views with greater concern about the risks that are presented by technology (Slovic, 1997), while other research highlights links between conservative politics and scepticism about climate change (especially in the US) (e.g. Unsworth and Fielding, 2014; Ziegler, 2017)[8].
- **Religion or faith**: Here, research has highlighted the positive associations between certain religious perspectives and antipathy towards some developments in the life sciences (such as reproductive technologies, stem cell research and genetic technologies) as well as science and technology in general (Allum et al., 2014; national PAS surveys). Ipsos MORI (2014) contains evidence that many people accommodate both evolution and creationism in their understandings of the origins of the world.
- **Cultural theory worldviews**: On the basis of quantitative empirical work, US work on risk perception has identified four archetypal worldviews that shape attitudes towards developments in science and technology (Dake, 1992; Slovic, 1997). These are presented in Table 1. In broad terms, this work suggests that those expressing egalitarian worldviews are less likely to be accepting of technological projects; this might be due to environmental concerns or scepticism about the motives of government. Meanwhile, those endorsing the other three worldviews are likely to be more accepting of technological developments. For instance, fatalists might take the view that they have no control anyway, hierarchists are likely to be highly trusting of the management of technology, and individualists are likely to be less concerned about the environment and more concerned about 'excessive' regulation.

## Risks and benefits of the technology

This section focuses on the ways in which the risks and benefits of technologies shape attitudes. Based on his work on risk perception, Slovic (1992; 1997) begins by challenging the idea of 'objective' risk assessments, pointing out the extent to which they are theoretical, uncertain, subjective and assumption-laden. Slovic also discusses the models that the public uses to understand the risks presented by technologies. In particular, this work suggests that public concerns are likely to be greater when the technology presents risks that are: new, not observable, delayed, not well understood by science, not controllable, evoke a sense of dread, catastrophic, increasing, involuntary, not in the control of the individual and not easily reduced. This work also emphasises the importance of notions of the 'common good'. This is

[8] As an associated point, Kahan et al (2017) have shown that science curiosity promotes open-minded engagement with information that is contrary to individuals' political predispositions.

Table 1. Cultural theory worldviews (based on Adams, 1995).

| | Worldview | Attitude to nature |
|---|---|---|
| **Individualists** | Enterprising "self-made" people, relatively free from control by others, strive to control their environment and the people in it. Their success is often measured by wealth and the number of followers they can command. They tend to believe that, in a fair system, people with more ability should earn more. They tend to be sceptical of the need for regulation. | Nature benign: nature is predictable, bountiful, robust, stable, and forgiving of anything humankind might inflict upon it. Nature is the benign context of human activity, not something that need to be managed. |
| **Egalitarians** | Have strong group loyalties but little respect for externally imposed rules, other than those imposed by nature. Group decisions are arrived at democratically and leaders rule by force of personality and persuasion. They tend to believe that society's problems lie in inequality. They tend to be support of regulation, especially the precautionary principle. | Nature ephemeral: nature is fragile, precarious and unforgiving. It is in danger of being provoked by humans' carelessness into catastrophic collapse. People must tread lightly on the Earth. |
| **Hierarchists** | Inhabit a world with strong group boundaries and prescribing restrictions. Social relationships in this world are hierarchical, with everyone knowing his or her place. Hierarchists believe that decisions about management and regulation should be left to experts. | Nature perverse/tolerant: a combination of the first two myths. Within limits, nature can be relied upon to behave predictably. It is forgiving of modest shocks to the system, but this has limits. |
| **Fatalists** | Have minimal control over their lives. They belong to no groups responsible for the decisions that rule their lives. They are resigned to their fate and they see no point in attempting to change it. | Nature capricious: nature is unpredictable. Whereas the myth of 'nature benign' trusts nature to be kind and generous, 'nature capricious' is agnostic; the future may well turn out well or badly, but it is beyond his or her control. |

shown in the extent to which inequity in the distribution of negative impacts – either within society or between generations – negatively effects public attitudes towards technologies (Slovic, 1992; 1997). We return to this issue below in the context of expert systems.

Growing appreciation of these issues in the 1980s, especially in the US, are associated with a growing focus on risk communication (the communication to the public of information about technological risks). The risk communication approach holds that attitudes are influenced by the way in which issues are framed or presented, the sources of information and the channels of communication (Barben, 2010). Despite these efforts, Barben (2010) concludes that the impact of risk communication is limited because it tends to be conceived and produced from the perspective of the advocate of the technology and fails to properly engage with concerns as expressed by publics (also see the comment on public engagement below).

## Expert systems

In this section, the attention shifts from individuals, science, technology and risk *per se*, and onto 'expert systems'. Drawing on Giddens (1990), the term expert system is used here to refer to the networks of expertise, institutions and regulatory processes (of markets, technologies and practices) that people rely on to manage science and technology. Forms of expertise might include scientific, legal and regulatory. Relevant institutions might include: Government, parliament, government departments and bodies (e.g. BEIS, UK Research and Innovation, Sciencewise[9]) and other scientific institutions and funders (e.g. Royal Society and Wellcome Trust). Regulatory processes might include: public consultations, expert advisory groups, deliberative processes, and Governmental and parliamentary processes).

In this section, the focus is on the idea that people's trust in and support for specific technological projects is related to their experiences and understandings of expert systems. To put this another way, this is the idea that any lack of trust in and support for expert systems – and the technologies that they promote – is shaped by the fact that expert systems themselves do not manage science and technology in ways that public recognises as trustworthy. Putting this a slightly different way, Engdahl and Lidskog (2014: 714) have suggested that trust accrues when 'citizens, in some sense, are able to recognize themselves in the recipient of their trust'[10].

These ideas are prominent within critical work on science and society or PUS issues by scholars in science and technology studies (Irwin 2006; Wynne, 2006). This critique suggests that people observe that:

- Governmental technological objectives are often pursued in the face of widespread public opposition;
- The benefits of new technologies often turn out to be overstated;
- The distribution of the risks and benefits of technologies are not regulated and managed in equitable ways;
- Despite the presence of risk assessments, and claims of control and certainty, unforeseen consequences often occur;
- When technologies lead to negative consequences, systems for responsibility, accountability and recompense tend to not operate effectively;

[9] Sciencewise, a public dialogue programme funded by the UK Government was established in 2005 as part of the response to earlier science policy controversies such as that surrounding GM crops. Sciencewise supports government bodies to commission deliberative public dialogue projects with the objective of enabling policy makers to develop socially informed policy with a particular emphasis on science and technology. See: https://sciencewise.org.uk/.

[10] There is a more detailed discussion of trust in the next chapter.

- Despite claims to the contrary, public concerns are still often interpreted within expert systems as public deficits of one kind or another;
- Thus, institutional approaches to public acceptability still rely upon the provision of information (for instance, see Williams et al., 2017 on shale gas extraction, or fracking)

The emphasis since 2000 on public engagement and public deliberation about science and technology is also critiqued in this work. Scholars acknowledge the value of the stated objectives – and very early promise – of these activities as means to open-up science and technology to public values and visions. However, the critique suggests that these have taken the form of governmental tools designed to legitimise and promote public acceptance of its preferred technological projects (Irwin 2006; Wynne, 2006; Thorpe and Gregory, 2010; Macnaghten and Chilvers, 2014; and see the special issue of *Public Understanding of Science*, edited by Bauer, 2014). The 2014 UK national research indicates that many in the UK agree with this assessment, suggesting that 52% (consistent since 2008) agree with the statement, 'Public consultation events are just public relations activities and don't make any difference to policy' (Ipsos MORI, 2014).

This theme is reflected in slightly different ways in some of the recent deliberative projects on science and technology (BBSRC-EPSRC, 2011; OPM, 2015; Hopkins Van Mil, 2017) and in Macnaghten and Chilvers' (2014) analysis of seventeen Sciencewise-supported deliberative projects on science and technology between 2005 and 2011. For instance, this work suggests that people are likely to be more supportive of technologies when expert systems manage them in ways that:

- Involve the public at an early or appropriate stage, and take the public's input seriously;
- Appear to reflect broad public interests and desires rather than governmental or commercial objectives;
- Offer a clear and necessary benefit;
- Ensure that technologies and their benefits are widely available and affordable;
- Ensure timely, robust, transparent and independent regulation, including with respect to unforeseen and negative consequences;
- Ensure that communications are honest, avoid hype, and acknowledge uncertainty and gaps in knowledge;
- Finally, a striking conclusion of BBSRC-EPSRC (2011) is the importance of appropriate future leadership within expert systems.

## Technologically-advanced countries

On the basis of the international PAS surveys that are reviewed here, it would appear that attitudes to science and technology *in general* do not vary significantly across technologically-advanced countries; it is certainly not the case that the UK can be reliably identified as an outlier in any particular regard. In the context of engineering, there is also evidence that UK attitudes are similar to international attitudinal norms (EC, 2014; QE Prize, 2017). Illustrating the significance of Wynne's (1991) caution with respect to surveys about *"science" in general*, studies often show cross-country differences with respect to specific technologies, applications and contexts.

Although this review focuses on technologically-advanced, and therefore highly developed, countries, it is worth noting that there is evidence that attitudes towards science and technology are often more positive in less developed countries and in less developed regions within countries (see the summary of Sanz-Menéndez and Van Ryzin, 2015).

## Changing economic conditions

Research in Spain, involving secondary analysis of national PAS surveys in 2006 and 2010 – i.e. just before and just after the global economic crisis in 2008 – also suggests that more positive attitudes to science and technology can be associated with declining economic conditions. Sanz-Menéndez and Van Ryzin (2015) suggest that, in the regions hit hardest by the crisis (compared to less-affected regions), trust in the benefits of science and technology increased substantially, as did general public interest in science and technology. Similarly, residents of the hardest-hit regions were more likely after the crisis to choose science and technology (out of a list of policy areas) as a priority for government, and somewhat more likely to express support for increases in government spending on science and technology.

## Media coverage

Within the context of controversial technologies, research of trends over time has shown a relationship between public attitudes to the technology and the amount of media coverage of the controversy (although this relationship is typically understood be the result of media influence on attitudes, this is not straightforward to confirm) (see the summary of Marques et al., 2015). For instance, based on trend data relating to media coverage and public attitudes with respect to GM food, from 2003-2012, Marques et al. (2015) report a significant increase in support for GM food when there was less media coverage, with support being at its lowest in those years where media reports were at their highest.

# Chapter 4 Trust

## Key findings

- The recent literature consistently shows that scientists, researchers and engineers are among the most trusted professions in technologically-advanced countries; university scientists attract a higher level of trust than scientists working in private sector, campaigning or government settings.
- Levels of trust associated with scientists and engineers are broadly comparable with other technologically-advanced countries.
- Although some recent (post-2014) increases in levels of trust can be identified, this broadly positive situation for science has not shifted meaningfully since 2010;
- Reflecting the demographic variation noted in Chapter 3, trust is often greater among higher social economic groups, those with higher levels of education, and males.
- However, there is evidence in the UK literature that public trust in the management of science and technology is more mixed. Here, terms such as 'resigned trust' have been used and the public does not always trust the government to respond to public values and the public interest.

## Introduction

Giddens (1990: 34) has defined trust as 'confidence in the reliability of a person or system, regarding a given set of outcomes or events'. Giddens argues that trust is a key requisite in technologically-advanced societies because of the distance – in terms of both time and space – between expert systems[11], and those who are subject to the decisions and practices of 'expert systems'. Slovic (1992) has noted that trust is difficult to build and easy to destroy. Drawing on a wide range of research, and significantly for adherents to the deficit-model[12], Engdahl and Lidskog (2014) assert that, trust does not develop through passively being fed information and the uptake of knowledge. Rather, they suggest, it is developed through citizens' emotional involvement, taking part, having a say and – as suggested earlier – being able to recognize themselves in the recipient of their trust.

In terms of the relationship between science and the public or society, trust becomes central to official discourses in the context of the Science and Society report (House of Lords, 2000). Moving on from the deficit-model rhetoric (though not necessarily practice) of public understanding of science approaches (Bodmer, 1985), this report identifies a 'crisis of trust', and proposes that trust be restored through engagement and dialogue. More recently, in the context of aforementioned concerns about the extent to which we might be entering a 'post-truth' era (Kakutani, 2018), issues around trust have taken on further significance for BEIS and the other institutions of UK science, technology and engineering.

In this chapter, we examine the most recent UK and international literature on trust in scientists, researchers and engineers as professional categories, and we examine trust in expert systems or regulation. In summary, the literature suggests that scientists, researchers and engineers are among the most trusted

[11] As discussed, 'expert systems' refers to the networks of expertise, institutions and regulatory processes (of markets, technologies and practices) that people rely on or are subject to in the context of science and technology.

[12] As mentioned earlier, the term 'deficit-model' is intended to encapsulate – with critical intent – the notion that attitudes to science and technology are determined by knowledge about science and technology.

professions; and some data indicates that this trust is increasing. Indeed, this may imply that 'post-truth' concerns are positively affecting trust in scientists (see Bauer, 2017 on this). For instance, this might be the case if scientists are understood as a beacon of trustworthiness within a broader post-truth or untrustworthy world. However, a different picture emerges with respect to expert systems; here the term resigned trust (see section 4.4 below) has been used and the tension between public interests, and governmental and commercial objectives is highlighted.

# Trust in scientists and engineers

## UK and international studies

In this section, we address UK studies and international studies that include the UK. In the UK, the recent literature indicates that trust in scientists, engineers, researchers (as a broader category than scientists) and medical practitioners is high, and that it is higher with respect to those working in universities than it is to those working in charitable/campaigning contexts and in private/commercial contexts. Starting with scientists, the British 'veracity index' (Ipsos MORI, 2017) indicates that 83% of British adults (up from 80% in 2016) trust scientists to tell the truth (and 85% trust professors)[13]. Only nurses (94%), doctors (91%) and teachers (87%) are more trusted in Britain, according to this research, while nineteen professions – including judges, the police and clergy – are less trusted than scientists to tell the truth. The Wellcome Trust Monitor Report (Wellcome Trust, 2016) focuses on science and biomedical research. This UK survey reinforces this picture, noting that doctors, nurses, and other medical practitioners (64%) and scientists working in universities (59%) are the most trusted professions to provide accurate and reliable information about medical research.

The two most recent UK national PAS surveys examine trust in scientists, researchers and engineers 'to follow rules and regulations' (Ipsos MORI, 2011; 2014). This research is useful because it differentiates between scientists working in different contexts. Most trusted in this regard are scientists (90% in 2014; up from 84% in 2011), researchers (90%; 84%) and engineers (89%; 84%) working in universities. The least trusted are scientists (60%, 56%) and engineers (74%; 70%) working in the private sector, and in between are scientists working in charities (88%, 77%), environmental groups (79%; 72%) and government (74%; 72%)[14]. This study also suggests that 69% (up from 64% in 2011) are confident that scientists have considered the risks of new technologies before they are used. All of these measures show increases in trust between 2011 and 2014. At the same time, these findings are somewhat contradicted by the fact that – in 2014, the first year in which the question was asked – more people agree than disagree with the statement that rules will not stop scientists doing what they want behind closed doors (55% versus 25%).

European Commission (EC, 2013) is very useful throughout this report because the data allows the UK to be easily compared with two averages:

- For the 28 members of the European Union (EU28), most of which are also members of the OECD[15];

[13] It is perhaps worth noting that the professions that are mentioned in this section are typically not defined in questionnaires.
[14] Providing a further level of detail, Critchley and Nicol (2010) suggest that privately funded research in a university is more likely to be trusted than research in a private organisation.
[15] The 28 members of the EU in 2013 (and 2018, when this report was written) were: Austria, Belgium, Bulgaria, Croatia, Republic of Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the UK. The following seven countries are members of the EU but not the OECD: Bulgaria, Croatia, Cyprus, Latvia, Lithuania, Malta, Romania. Iceland, Norway and Switzerland are European OECD members, but not members of the EU.

- For the 15 countries that were members of the EU prior to its enlargement in 2004 (EU15), all of which are members of the OECD[16].

EC (2013) does not mention trust specifically, but instead asks, across a number of professional categories, 'do you think that [professional category] try to behave responsibly towards society by paying attention to the impact of their science and technology related activities?' It seems reasonable to suggest that the word 'think' could be replaced by the word 'trust' in this question. This study reproduces the patterns of trust discussed above in scientists working in: universities (UK: 86%; EU28: 82%; EU15: 83%), what are referred to here as 'private company laboratories' (UK: 64%; EU28: 66%; EU15: 65%) and environmental organisations (UK: 81%; EU28: 81%; EU15: 82%). These findings suggest that the UK is broadly similar to other technologically-advanced countries in this regard.

UK research by Shuckburgh et al. (2013) suggests that only 38% trusted climate scientists to tell the truth about climate change. Further, trust to tell the truth was negatively associated with scepticism about climate change. Although direct comparisons between studies are not possible, it is striking that this figure is so much lower than those cited above. In this context, these findings are significant for three reasons. Firstly, they illustrate that differing levels of trust may be accorded to scientists who are working on different topics. Secondly, they illustrate that public scepticism towards a particular topic influences public attitudes towards scientists working on that topic. Finally, in the wake of the 2009 'climategate' controversy (The Guardian, 2010), in which scientists were accused of falsifying data, these findings perhaps reflect the effect of such events on public trust[17].

Turning to engineering, Queen Elizabeth Prize for Engineering (QE Prize) (2017) is an international study, covering the UK and nine other countries, that focuses on engineers and engineering. Although three of the countries are not in the OECD, this study is useful because it facilitates international comparison[18]. The study examines the extent to which people in the UK trust seven professions to do what is right. In a similar vein, engineering scores highest (84%), followed by medicine (83%) and education (77%), and then law (58%), business (47%), entertainment (47%) and politics (24%). Again, in the context of medical research, Wellcome Trust (2016) reinforces this picture, reporting that levels of trust to provide accurate and reliable information about medical research are lower in medical research charities (37%)[19], pharmaceutical companies (32%) and journalists (4%).

Further confirmation is provided in ComRES (2017), which focuses on research and researchers. This survey found that the most trusted sources of information about research are two sometimes overlapping groups: university academics and researchers (80%), and prominent TV presenters (such as David Attenborough or Mary Beard) (80%). These are all more trusted than charities and not-for-profit groups (71%) and experts working in the private sector (70%). The ComRES (2017) work also illustrates how trust

[16] The 15 countries that were members of the EU prior to its enlargement in 2004 were: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the UK. All 15 countries are members of the OECD.

[17] Reflecting earlier comments, qualitative research in rural Australia reports, 'Politicians, government, and the media were described as untrustworthy sources of information about climate change, with independent scientists being the most trusted. The vested interests of information providers appeared to be a key reason for their distrust' (Buys et al., 2014).

[18] QE Prize (2017) addresses: UK, US, Germany, Turkey, India, China, South Korea, Japan, South Africa and Brazil. Although India, China and South Africa are not OECD countries, this study is useful because it offers the opportunity to place the UK in an international context. The main report (QE Prize, 2017) does not contain data broken down by country, this was kindly provided by Jo Trigg (Royal Academy of Engineering), Jonathan Narbett (QE Prize) and Meije Gernez (Edelmann Intelligence).

[19] This figure was lower than expected and in previous studies. This may be because the fieldwork took place around one month after concerns about the fund-raising methods of charities became a matter of public debate (The Guardian, 2016).

varies by issue. Here trust in the information provided by researchers declines in the context of controversial or political issues, such as the economy (61%), Brexit or climate change (52%), and politics itself (46%). The qualitative research that was undertaken in this project emphasises the importance of the independence of the research and of a quoted source.

### Other single country studies

The available material on trust in other national PAS surveys reinforces this picture in many cases. In the most recent Finnish survey (Tieteen Tiedotus (TT), 2016), 66% trust science, research, and the academic community. While this is lower than trust in the police, armed forces and universities, it is higher than in 11 other categories. Swedish (Vetenskap & Allmänhet (VA), 2017) research indicates that 83% have confidence in researchers in universities (55% in companies) and 60% have confidence in research. The 83% figure is interesting because – in contradiction of recent UK research, in particular – it represents a statistically significant drop from 89% the previous year (no reason for this is offered). Finally, in Canada (Council of Canadian Academies (CCA), 2015), reflecting concerns about privately-funded science, 41% agreed with a statement of concern relating to the influence of industry funding in science.

Results from Germany (Wissenschaft im Dialog (WD), 2017) and Switzerland (Schäfer et al., 2018)[20] are slightly different. In these countries, 50% and 57%, respectively, say that they trust science (unfortunately, no professional comparators are provided). While these figures are certainly lower than those in some other countries – and are therefore worthy of further attention – due to the variations in question wording between the national surveys, it would be inappropriate to automatically attribute these differences to culture.

With respect to engineering specifically, QE Prize (2017) reinforces this positive picture across ten countries; here, engineering (84%, the same as in the UK) emerges as the most trusted of the seven professions noted above to do what's right. However, in Canada, Engineers Canada (2017) found engineers (64%) to be not as highly trusted as nurses (86%), doctors (82%) and electricians (73%), on a par with architects (62%) and accountants (63%), and more trusted than lawyers (47%).

## UK expert systems: regulation and governance

The UK literature suggests that, although trust in scientists themselves is high, trust in 'expert systems' – or the management of regulation of science and technology – is less so. In the 2014 UK national PAS survey (Ipsos MORI, 2014), the term 'resigned trust' is used to encapsulate two key trends. First, in keeping with the 2011 iteration (Ipsos MORI, 2011), the 2014 study suggests that more people agree than disagree with the statement that, 'the speed of development in science and technology means that they cannot be properly controlled by government' (41% versus 32%). Second, and perhaps more tellingly, the proportion who feel they have 'no option but to trust those governing science' has increased markedly since 2005 (by 18 percentage points from 49% to 67%).

Bauer et al. (2016) pick up on this finding. They also note that the UK national surveys suggest that, from 2011 to 2014, agreement with the statements, 'scientists should listen more what ordinary people think' and 'the government should act in accordance with public concerns about science and technology', has declined significantly (from 74% to 67% and from 81% to 75%, respectively). On the basis of these three observations, Bauer et al. (2016) use the more positive term, 'tolerance of technocracy', to encapsulate this phenomenon.

Reinforcing the findings on expert systems in Chapter 3, Macnaghten and Chilvers (2014) analysed the qualitative findings of the seventeen public dialogue projects that Sciencewise-ERC co-sponsored between

[20] The data cited in this report does not feature in this paper but was very kindly supplied in English translation by Mike Schäfer and Tobias Füchslin (University of Zurich).

2005 and 2010. Chiming with the 2014 UK PAS survey and Bauer et al. (2016), Macnaghten and Chilvers (2014) report that ‘participants felt compelled to trust scientists’, but ultimately had no control over ‘expert systems’. They also note that – broadly speaking, and with the exception of the health-related dialogues – people rarely trusted the government to act in the public interest especially when governmental and commercial objectives are at stake. A similar phenomenon is implied in ComRES (2016); here, only 45% trusted the UK government when providing information about research (compared to 80% with respect to university academics and researchers, and top TV presenters).

More recently, Smallman (2018) has also undertaken an analysis of 18 Sciencewise projects, conducted between 2002 and 2011. Smallman reaches different but associated conclusions. First, she uses the term ‘Contingent Progress’ to encapsulate public views of technological developments. According to Smallman, the ‘Contingent Progress’ view has two key elements to it. First, science and technology are understood as producing not only benefits and solutions but also problems and risks. Importantly, these problems are seen to be often unforeseen or downplayed. As discussed earlier, critics have also pointed out that these benefits and problems are experienced unequally across society. Second, industry and commercial interests are understood as a necessary but distorting influence that needs to be managed by the state (see p670). Crucial to this understanding are the mixed and interrelated outcomes – benefits and problems – that emerge from technological developments, and the public’s discomfort with the role of the private sector.

On the other hand, on the basis of her analysis of a wide range of government policy documents and expert reviews, she encapsulates the policy and expert view as ‘Science to the Rescue’. Here, ‘science is a driver of our economy and competitiveness and can solve our problems and deliver social goods; social and ethical issues are public matters relating to risk and understanding that stand aside from the technologies themselves and can be quantified and resolved by more research or information’ (pp669-70). When we recall Engdahl and Lidskog’s (2014) assertion that trust becomes more possible when people are able to recognize themselves in the recipient of their trust, we can see the significance of this disjuncture in terms of the creation of misgivings about the ways in which ‘expert systems’ operate

# Chapter 5 Other professional attributes

## Key findings

- In addition to trustworthiness, publics in the UK and other technologically-advanced countries tend to attribute a range of other positive characteristics to scientists and engineers with high proportions considering them to be ethical, honest and creative. However, scientists and engineers score less well in relation to communication and transparency (though engineers are more highly regarded than scientists on these latter measures);
- When compared with other professions, science and engineering tend to fare well; although they are not quite as well-respected as medicine and law, they are better respected than many other sectors (business, education, politics etc.)
- However, there are indications in the literature that engineering is seen as a “male” profession, both in the UK and in other technologically-advanced countries[21].

## UK and international studies

In this section, we address UK studies and international studies that include the UK. The 2014 UK PAS research suggests that many people attach a range of positive attributes to scientists and engineers: interesting (scientists 82% and engineers 79%), open-minded (79% and 81%), creative (89% and 90%), honest (71% and 78%) and ethical (65% and 73%). Scientists and engineers scored less well on two attributes: good at communication (48% and 59%) and open (37% and 55%) (Ipsos MORI, 2014). It is notable that engineers score more favourably than scientists with respect to honesty, ethics, communication and transparency. When asked to state which one or two of these attributes is most important, the most prominent three responses were: for scientists, honest, ethical and open-minded, and for engineers, creative, open-minded and honest (all above 30%). Looking at the total percentages across the two sets of three most prominent desirable attributes, it is again notable that engineers (249%) score more highly than scientists (215%). These questions did not feature prior to 2014.

Turning to careers and professions, the 2014 and 2011 UK PAS studies also suggest that science and engineering are felt by many to be very interesting jobs (Ipsos MORI, 2011; 2014). In the case of science, 73% agreed with this statement (68% in 2011) and, in the case of engineering, 68% (61%) agreed. These studies do not provide comparisons with other professions.

QE Prize (2017) does compare engineering (and sometimes science) with other professions, and suggests that science in particular is one of the most highly regarded professions. QE Prize (2017) compares public attitudes across ten countries, including the UK, towards engineering (and sometimes science). Among a set of seven professions (engineering, medicine, law, business, education, politics and entertainment), engineering appears to be understood in the UK as a profession that offers relatively high levels of both job security (81%, second to medicine on 82%) and earning potential (80%, very slightly less than medicine and law). The UK is very close to the international average in both these respects. Looking at engineering alone, it is also understood by many in the UK to be: respectable (82%), prestigious (75%) and fulfilling (80%). Again, the UK and international figures are very similar. Both engineering and science are also compared

[21] This perception is borne out by the fact that males accounted for 88% of engineers in 2016 (Engineering UK, 2018).

with eleven other professions[22] in several respects. In this case, respondents were asked to identify the three professions that they feel each attribute is most relevant to. In this context, scientists (selected by 39%) were said to be the third most prestigious profession, after medical doctor (58%) and lawyer (46%), while engineers (19%) were only sixth.

At the same time, QE Prize (2017) also reiterates concerns about female participation in engineering, both in the UK and internationally. While 52% in the UK (and 60% across the ten countries) agree that engineering is a diverse profession (with respect to race, gender, religion and sexual orientation), this is somewhat contradicted by the fact that 60% agree that engineering is more accessible to men than women (both in the UK and across the ten countries). It is estimated that just 11% of UK engineers are women, with figures approaching 30% in some countries (Women's Engineering Society, 2018).

## Other single country studies

The impression that UK publics associate science and engineering with a variety of positive attributes is reproduced in research in some other countries. In Australia, scientists and engineers (more than 90%) were ranked the equal second most prestigious profession of 16 (top was doctors at almost 100%) (Lamberts, 2017). Also, in Australia, scientists and engineers were in the top five professions with respect to the contribution that they make to society. In China, scientists (41%) were ranked as the third most prestigious profession of the 11 that were measured; the top two were teachers (56%) and doctors (53%) (China Research Institute for Science Popularization (CRISP), 2015)

Engineers Canada (2017) suggests that in Canada engineers are most often seen as: modern (82%), open to new ideas (79%), interesting (78%), smarter than average (72%), technically proficient (87%), responsible (80%), and having high levels of expertise (86%) and professional standards (85%). This research also compares engineering with six other professions with respect to overall impression and respect. In the case of 'overall impression', engineers (64%) receive a less favourable rating than nurses (85%), doctors (81%) and electricians (71%), and a more favourable rating than architects (62%), accountants (61%) and lawyers (49%). In the case of respect, almost exactly the same picture emerges, but the scores are all a little higher.

[22] Medical doctor, Lawyer, Accountant, Artist (e.g. actor, musician), Teacher, Business leader, Nurse, Airplane Pilot, Firefighter, Police officer, Journalist

# Chapter 6 Value and importance

## Key findings

- The UK and international literatures suggest that science, technology and engineering are recognised by high proportions of the public as important both to society (for example in terms of supporting economic growth and making our lives easier) and, to a lesser extent, themselves (for example finding knowledge about science useful or relevant to their everyday life).
- When science and engineering are compared with other professions and domains in terms of their perceived importance to society, they tend to emerge favourably, though not at the top (again, health-related professions are often seen as more important to society).
- In the one UK study that examines this, it notable that science does not perform well with respect to importance at the local or community level. Although a single finding, this may offer strategic insight for public engagement.
- Recognition of the importance of science and technology is reflected in high levels of support in the UK and other technologically-advanced countries for public funding for science.

## UK and international studies

This section addresses UK studies and international studies that include the UK. The UK national PAS surveys suggest that UK publics feel that science and engineering are very important, both to society and – to a lesser extent, perhaps – themselves (Ipsos MORI, 2011; 2014). With respect to society, among the statements that tap into this broad sentiment, this is illustrated in consistently high levels of agreement with statements relating to, for example: ‘making people’s lives easier’ (81% in 2014; 79% in 2011), ‘supporting future economic growth’ (76%; 76%) and ‘prosperity’ (91%; 88%). The UK national PAS surveys also suggests high agreement with the statements that science is such a big part of our lives that we should all take an interest (84%; 82%). Broadly speaking, these levels of agreement are consistent across earlier UK national PAS studies. Reinforcing this UK picture, Wellcome Trust (2016) suggests that 94% feel that medical research will improve quality of life in the future and TNS-BMRB (2015) suggests that chemists are seen as making a valuable contribution (84%).

EC (2013) suggests that these high levels of importance are also perceived in other technologically-advanced countries, and that the UK is close to the average in this regard. For instance, EC (2013) indicates that 76% of the UK public think that the overall influence of science and technology on society is positive (EU28: and EU15: 77%), 78% that ‘thanks to science and technology, there will be more opportunities for future generations’ (EU28: 75%; EU15: 76%), and 71% that ‘science and technology make our lives easier, more comfortable and healthier’ (EU28: 65%; EU15: 66%).

QE Prize (2017) tells an almost identical story with respect to engineering. QE Prize (2017) indicates that UK and international publics think that engineering can make a difference in addressing the world’s challenges (84% in the UK; 84% across the ten countries), is valuable for the economy (88%; 88%), has driven progress in the past (85%; 85%) and has an impact on people in their daily lives (90%; 92%).

Some studies invite participants to compare the importance of science and engineering with that of other sectors. Both science and engineering largely emerge favourably from these comparisons. Neilson (2017a) suggests that 74% think that science is important to British society and culture; this is lower than for the NHS (86%), the law (82%) and the police (79%), but higher than nine other professions/domains[23].

QE Prize (2017) contains a number of questions that compares attitudes to engineering – and sometimes science – with attitudes to other professions. The relatively high levels of importance attached to scientific professions is reinforced here, as is the extent to which the UK is broadly average across technologically-advanced countries. For instance, QE Prize (2017) indicates that 86% in the UK (and 85% across the ten countries) feel that engineering makes the world a better place (this is a higher than for the other six professions[24] examined in this question). In other questions, QE Prize (2017) compares science and engineering with 11 other professions[25], asking respondents to select the three most important professions with respect to a variety of criteria. In the case of 'vital for economic growth', engineering (UK: 60%; 60%) and science (53%; 53%) are second and third after business leaders (67%). With respect to 'able to change the world for the better', science (70%; 64%) scores most highly, and engineering (38%; 38%) is ranked fourth.

Within the context of this largely positive scenario, at the same time, Neilson (2017a) provides two examples of areas where science does not compare favourably with other activities. While 35% agree that science plays an important role in 'bringing communities together' and 30% that 'local science events are important', corresponding figures for sports (62%; 43%), and arts and culture (54%; 47%) are conspicuously higher. Although this is a single finding, given that it is in contradiction to the others in this section, it is perhaps a useful prompt to policy and practice in public engagement to consider ways of emphasising the local and community-based potential for public engagement with science.

With respect to the importance of science to the individual, the 2104 UK national PAS survey suggests that 72% (up from 67% in 2011) agree that it is important to know about science in their daily lives (Ipsos MORI, 2011; 2014). A further flavour of this is offered by the fact that 52% (44% in 2011) thought the science they learnt at school has been useful in their everyday lives (though note that this is higher for maths). Similarly, Wellcome Trust (2016) found that 66% of the public think their understanding of science is useful in their everyday lives, and also that a higher proportion (87%) believe it is useful for others – people in general – to have an understanding of science in their everyday lives.

Given the trustworthiness, other attributes and importance that is accorded to science, it is perhaps not surprising that support for government funding for science is high in the UK. This was 79% in the UK in 2014, up from 76% in 2011, when this question was introduced (Ipsos MORI, 2011; 2014).

## Other single country studies

Looking at the national PAS surveys, this is reflected in agreement with the following perspectives: making lives easier (89%) (Australia: Lamberts, 2017), a better world (77%), making lives healthier, easier, and more comfortable (72%) (Canada: CCA, 2014), more opportunities for future generations (84%), making lives healthier, easier, and more comfortable (81%) (China: CRISP, 2015), improving human health (91%), addressing key challenges for society (82%) (New Zealand: Neilson, 2017b), making lives better (61%), should be publicly-funded (73%) (Switzerland: Schäfer et al., 2018), creating future opportunities (just over 90%) (US: National Science Board (NSB), 2018)[26]. Across ten countries, QE Prize (2017) notes that engineering is the most trusted (87%) of seven professions to make the world a better place. Turning to the

[23] Politics, Religion, Business leaders, The media, Civil Service, Financial services, The Arts, Charities, and Sports.
[24] Medicine, Law, Business, Education, Politics, Entertainment industry.
[25] Medical doctor, Lawyer, Accountant, Artist (e.g. actor, musician), Teacher, Business leader, Nurse, Airplane Pilot, Firefighter, Police officer and Journalist.
[26] NSB (2018) is itself a literature review, and draws on several US sources between 2016 and 2018.

individual level, in the most recent Swiss study (2018), 69% agreed that it is ‘important to be informed about science and research’ and 41% agreed that ‘science and research play an important role in my life’. Eurobarometer research suggests that at least half of people in EU expect that, 15 years from now, science and technological development will have a positive impact on health and medical care (65%), education and skills (60%), transport and transport infrastructure (59%), energy supply (58%), protection of the environment (57%), fight against climate change (54%) and quality of housing (50%) (European Commission, 2013).

It is interesting to note that agreement with the view that the benefits of science and technology outweigh the harms is between 9 and 25 percentage points lower in the UK than in some other country contexts. While this view has 55% (2014) and 54% (2011) agreement in the UK (Ipsos MORI, 2011; 2014), similar statements in other surveys receive higher agreement: around 80% (Australia: Lamberts, 2017), 64% (Germany: WD, 2017), 72% (US: NSB, 2018). However, in Switzerland (Schäfer et al., 2018), the corresponding figure is just 33%. Given the methodological challenges associated with cross-country comparisons in this domain, the extent to which this is a meaningful observation is not clear.

Several national PAS studies directly examine support for science in the form of the notion that scientific research should be funded by government, even if the benefits of this are not immediate. Recent measures in other national PAS studies are: China: 77% (CRISP, 2015), Canada: 76% (CCA, 2014), Finland: 76% (TT, 2017), New Zealand: 66% (Neilson, 2017b, 2017), Switzerland: 73% (Schäfer et al., 2018) and US: 84% (NSB, 2018).

# Chapter 7 Two challenges: pace of change and religion

## Key findings

- Within the context of typically very positive attitudes towards science and technology in technologically-developed countries, there are two areas in which substantial minorities – or even majorities – have concerns: the pace of change in science and technology, and the relationship between science and faith or religion.
- It appears that here is a substantial minority – and sometimes a majority – in technologically-advanced countries that considers that the pace or speed of developments in science and technology is in some way problematic.
- There is a moderately sized minority in many technologically-advanced counties that would prefer more reliance on faith as opposed to science.

## Pace of developments

Given the overwhelming levels of support that are attracted to science and technology overall, results in this context are perhaps particularly meaningful. In the UK PAS research, three aspects of this issue are examined (Ipsos MORI, 2014). As was discussed earlier, 41% agree that the pace of developments in science and technology means that they 'cannot be properly controlled by government' (this is consistent since 2000). Similarly, 43% agree that they 'cannot follow developments in science and technology' (also consistent since 2000). Meanwhile, just 34% (down from 59% in 2000) agree that 'Science makes our way of life change too fast'. However, EC (2013) tests this same statement, and suggests a much higher UK figure than the 2014 UK research (51%), and even higher levels of agreement for the EU28 (62%) and EU15 (60%). The differences in the UK figures are most likely explained through methodological differences.

There are similar results in other national PAS studies. In Australia (Lamberts, 2017) and Canada (CCA, 2014), nearly half feel that 'science has changed our way of life too fast'. In Germany and Switzerland, the corresponding figures are surprisingly low at 32% (WD, 2018) and 34% (Schäfer et al, 2018), respectively. In the last two US surveys, 51% agreed that 'science makes our way of life change too fast' (NSB, 2018).

## Faith and religion

As was mentioned earlier, faith or religion is often identified as a determinant of attitudes to science and technology, particularly developments in the life sciences. Reflecting this, five of the national PAS surveys and EC (2013) include one or more questions on this topic. All of the studies that address this issue contain a question that invites respondents to balance science and faith in terms of societal or personal reliance. Responses to the first of these suggests that there is a moderately sized minority in many technologically-advanced counties that would prefer greater reliance on faith as opposed to science. In the 2014 UK study, 30% agreed with the statement, 'we depend too much on science and not enough on faith' (Ipsos MORI, 2014). Although this is consistent with the 2011 study, it also represents a downward trajectory from 44% in 1996.

EC (2013) places UK agreement with the same statement at 36%, compared with 39% for the EU28 and 37% for the EU15. Broadly similar findings are apparent in other national PAS studies. In both Australia (Lamberts, 2017) and Canada (CCA, 2014), 25% agreed with the statement, 'we depend too much on science and not enough on faith' (in the Australian study this is expressed as a question about the past). In Germany, 40% agreed with the statement, 'people trust too much in science and not enough in their feelings and faith' (the addition of the word 'feelings' might explain the higher level of agreement here) (WD, 2018).

The UK and Finnish studies ask respondents to balance science and faith in terms of belief or worldview. It is striking that, in the UK in 2014, 62% agreed with the – perhaps, rather convoluted – statement (new that year), 'It is possible to believe in a god and still hold the view that life on earth, including human life, evolved over time as a result of natural selection' (Ipsos MORI, 2014). In Finland, a much lower proportion – 31% - agreed with the similar but broader statement, 'a world view based on science does not conflict with religion' (TT, 2016).

The UK studies investigate the evolution/creation issue in two further questions (Ipsos MORI, 2014). In one, respondents are asked to state whether they agree or disagree with the statement, 'God created the earth and all life in it'. Here, 41% agreed in 2014, which is consistent with 2011 (39%), the first time the question was asked. In another question, respondents are asked to identify which of three main options most closely matches their own view about creation and evolution. The responses to this question were: creation: 19%, evolution, guided by God: 26%; and natural selection: 41%[27]. It is striking that more people chose options that gave a role to God (45%) than to those that did not (41%). The figures for younger people lean more towards the natural selection option.

[27] The full responses were: Creation: Humans and other living things were created by God and have always existed in their current form; Evolution, guided by God: Humans and other living things evolved over time, in a process guided by God; Natural selection: Humans and other living things evolved over time by natural selection, in which God played no part.

# Chapter 8 Education and career aspirations among young people

## Key findings

- Young people in the UK appear to be broadly satisfied with their science education.
- Although the science career aspirations of young people in the UK appear to be lower than some other professions, there is also evidence that they compare favourably to other technologically-advanced countries.
- Satisfaction levels and career aspirations are greater among boys and young people from higher socio-economic backgrounds.

## Science and engineering education

The attitudes of young people towards science and engineering education and careers are important in terms of the so-called 'leaky pipeline' from science education into science and engineering careers. In addition, science education is understood as a route to higher levels of science capital and a supportive social context for science and technology. Research on public attitudes to science and engineering education focuses on the current experiences of young people and the recollections of adults. In their UK study with young people, aged 10-14, Archer et al. (2013) report that satisfaction with science teaching is high and that attitudes towards science and scientists are very positive. Wellcome Trust's (2017) study with young people (aged 14-18) indicates that 68% find school science lessons interesting. It is a conspicuous feature of most measures in both studies that more positive views are to be found among boys. Wellcome Trust (2017) typically also highlights more positive attitudes – to both science education and careers – among young people who score highly on their Family Science Connection Index (FSCI)28 and science knowledge quiz, and among young people from black and Asian backgrounds. On this basis, white girls appear to have the poorest science educational experiences and lowest science career aspirations.

Wellcome Trust (2017) further suggests that the two strongest classroom-based predictors of positive attitudes towards science teaching are experiences of good quality teaching and the opportunity to undertake practical work[29]. Exhortations for more practical work in science education (Ofsted, 2013) are mirrored by an appetite for more practical work among young people (Wellcome Trust, 2017).

These latter findings are especially important since, taking an international perspective, Martin et al.'s (2016) work suggests that science teaching satisfaction levels among UK science students could be improved. This ongoing study measures four aspects of attitudes to science teaching among students aged 13-14 across almost 30 countries (a mix of OECD and non-OECD), including England[30]. The most striking feature about these findings is that England appears to be – at best – just average across these measures. For instance, the study suggests that, in England, 80% of students (aged 13-14) feel that they are receiving engaging

[28] The FSCI combines the responses to three questions to measure the strength of young people's family science networks.
[29] Millar (2004) has suggested that this is because practical work offers opportunities for action, reflection and creating links between ideas and the real world.
[30] These are all countries in which science is taught as an integrated subject at this age.

teaching (compared to a cross-country average of 83%). Other findings confirm this pattern with respect to: liking learning about science (75% compared to 81%); feeling confident at science (62% compared to 61%); and valuing learning about science (82% compared to 81%). Also, internationally, OECD (2015) examines enjoyment of science among young people aged 15 across 72 countries. This study suggests that the UK is above the OECD average in this regard. For a broad discussion of the factors that support participation in science education, see Bennett et al. (2013).

Turning to engineering, Define Insight (2016) has examined engineering education (and careers) from the perspectives of young people (aged 14-21), parents, career influencers (such as teachers and employers) and engineering professionals. This qualitative study suggests that the challenge for engineering is very different due to its relative scarcity as a secondary school subject and a lack of awareness about the detail of what an engineering career entails. That said, the observation that engineering may not be a suitable career for girls was prominent in this research. In some cases, this was related to the observation that it is hard for females in a male dominated profession.

The UK national PAS research has a number of items in which adults are asked to or choose to reflect on their own science education. In 2014, 23% (25% in 2011) agreed with the statement, ‘school put me off science’. In response to the statement, ‘the science I learnt at school has been useful in my everyday life’, 52% agreed (up from 45% in 2011). The corresponding figures for maths were 76% (67%). Finally, in response to the open-ended question, When I talk about “science”, what comes to mind?, 12% (7%) mentioned school Ipsos MORI, 2011; 2014).

## The career aspirations of young people

In their UK research with young people, Archer et al. (2013) suggest that, compared to a range of other careers, aspirations to become a scientist are relatively low (15%), though engineering (26%) and medicine/doctor (33%) fare better (the highest scorers were business, almost 58%, and art and design, 41%)[31]. Wellcome Trust (2017) suggests that 43% of young people are ‘interested’ in a science career but does not offer other professions as comparators. From an international perspective, OECD (2018) examines science-related career expectations among young people aged 15 across 72 countries. This study suggests that the UK is well above average when compared with the OECD countries, and fourth highest overall: 29% of the UK students stated that a science-related career is an ‘expectation’ for them (compared to 25% across the OECD, and 34% in Canada, 31% in Slovenia and 29% in Australia).

It is perhaps not surprising that Archer et al. (2013) note that aspirations to become a scientist (they do not comment on engineering or medicine) are related to familial science capital[32,33]. Wellcome Trust (2017) confirms this using its narrower FSCI. More significant are Archer et al.’s (2013) findings that this association increases with age (10-14), and that – in an echo of the findings that were discussed in Chapter 3 – both science aspiration and capital are greater among boys[34] and young people from higher socio-economic

31 Many thanks to Jennifer DeWitt for providing the precise percentages.

32 Although this report (ASPIRES) does not address aspirations in the context of engineering and medicine, this is a feature of the forthcoming ASPIRES2 project report. The team reports that similar patterns of aspiration are observable for engineering and medicine.

33 As mentioned earlier, science capital focuses on eight dimensions: scientific literacy; science-related attitudes, values and dispositions; knowledge about the transferability of science; science media consumption; participation in out-of-school science learning contexts; family science skills, knowledge and qualifications; knowing people in science-related roles; and talking about science in everyday life (Archer et al., 2016).

34 This is despite the finding, in the 2014 UK national PAS survey, that agreement with the notion that science (3%) and engineering (6%) are *not* careers suitable for women is extremely low (Ipsos MORI, 2014).

groups. Welcome Trust (2017) reiterates greater aspirations to a science career among boys (boys 51%; girls 35%) but suggests that income is *not* a predictor of science aspirations. This study notes higher aspirations among young people from black and Asian backgrounds (both 61%) than among those from white backgrounds (39%). Internationally, the OECD (2018) research is interesting because, the aforementioned gender gap is more-or-less absent in the UK (and across the OECD countries): the figures are 29% (25%) for boys and 30% (24%) for girls. This is most likely because medicine and other health-related careers are included in the OECD definition.

Archer et al. (2013) also note that awareness of the value of a science education beyond specifically becoming a scientist is low. These findings lead Archer et al. (2013) to prioritise the following lessons for UK policy: building science capital from a young age, embedding discussion of careers within the core curriculum (with an emphasis on the broader value of a science education), and – echoing Flynn et al. (1994) – tackling inequality.

# Chapter 9 Familiarity and interest

## Key findings

- There is evidence that publics in the UK and other technologically-advanced countries tend to think of themselves as familiar with the role of science and scientists, but less so with the role of engineering and engineers;
- Within technologically-advanced countries, there is a moderate level of interest in science and technology (the UK faring better on this measure compared with the EU average). In general, across technologically-advanced countries, medical and health issues attract more interest than other scientific issues such as technology and the environment, and engineering attracts less interest.
- Some research suggests that interest in science-related topics is greater than in other topics (such as politics or sport), while other studies indicate contrary or mixed pictures;
- Contrary to the general trend, the evidence suggests that interest in medical and health science is greater among women than men.

## Familiarity with science and engineering

Although comparisons between studies are not straightforward, there are hints in the research that – as, perhaps, might be expected – publics are more familiar with the idea of 'the scientist' than they are with the idea of 'the engineer'. The 2014 UK PAS survey suggest that two thirds (68%) *disagree* with the statement, 'I don't really know what a scientist does' implying that two thirds are familiar with what a scientist does Ipsos MORI, 2014).

However, recent work in Canada suggests that just 45% are familiar (i.e. have first- or second-hand experience) with engineers (Engineers Canada, 2017). This latter work is useful because it suggests that people in Canada, at least, are less familiar with engineers than they are with nurses (77%), doctors (76%), electricians (61%), lawyers (61%) and accountants (56%), but more familiar than with architects (35%). This research is also instructive because, across the professions tested, it suggests that – broadly speaking – there is a positive relationship between familiarity, and a favourable overall impression and levels of respect (see Chapter 4), and levels of trust (see Chapter 3). For engineering itself, this study also suggests a broadly positive relationship between familiarity and the attribution to engineers of a set of favourable professional attributes (see Chapter 4).

QE Prize (2017) examines public familiarity with a set of sub-disciplines within engineering in the UK (and across the ten countries). This research suggests that publics are most familiar with computer engineering: 45% (48%), and then with: mechanical engineering: 42% (38%); electronic & electrical engineering: 42% (41%); IT engineering: 41% (41%); software engineering: 40% (41%); civil engineering: 36% (35%); aerospace engineering: 32% (34%); robotics engineering: 28% (28%); chemical engineering: 25% (27%); and biomedical engineering: 22% (23%). On the basis of these responses, QE Prize (2017) suggests that 65% (66%) are familiar with engineering in some form. Comparing this with the lower figure in Engineers Canada (2017), this perhaps indicates that stated familiarity increases when more opportunities for an affirmative answer are provided.

## Interest: UK and international research

EC (2013) suggests that 64% of people in the UK are interested in science and technology; this compares favourably with the findings for the EU28 (53%) and EU15 (57%). Although the UK national PAS research does not specifically ask about interest in science and engineering, the moderate strength of interest in science is implied in the responses to two questions. For instance, the 2014 UK PAS research suggests that 51% feel that they hear and see too little information about science, while just 6% hold the opposite view (there is little change from the 2011 research) (Ipsos MORI, 2011; 2014). This suggests both an interest in science and an appetite for more information, and the desire for more information has increased since 2000. Meanwhile, the study suggests that 67% have engaged in a science-related activity in last twelve months. While we might assume that this level of engagement reflects widespread but perhaps not overwhelming interest, the finding that 26% have not engaged in such activities is not positive. Wellcome Trust (2016) suggests that interest in medical research is strong and stable (though down from 2009) at 77%, with greater levels of interest in new treatments and less in how the body or mind works. Although, as discussed in Chapter 3, men very often express greater interest in science and technology than women, this is reversed with respect to medical research.

QE Prize (2017) compares interest in science, technology and engineering (as separate items and, with the addition of maths, as a single STEM item) with a range of other topics, activities and pursuits[35]. The study suggests that, in the UK, interest in STEM (89%), technology (78%), politics and current affairs (73%) and science (70%) is relatively high compared with the five other pursuits. Notably, engineering (44%) scores the lowest of the eight topics tested. Recalling that QE Prize (2017) is an international study, it is interesting that, although the scores across all of the eight topics are higher for the ten countries as a group than for the UK, they conform to a similar pattern to the UK.

## Other single country studies

National PAS research in other countries tells a mixed story. In some studies, science-related issues attract high levels of interest relative to other topics. Across the research, it is noticeable that, when health-related and medical sciences are tested, these tend to register relatively high levels of interest. The Australian PAS research (Lamberts, 2017) suggests relatively high levels of interest in science-related topics. In this research, the percentages who say they are 'very interested' in science-related topics range from 51% to 67%: health (67%), new medical discoveries (64%), new scientific discoveries (61%), new inventions and technologies (57%) and environmental issues (51%). Meanwhile, the corresponding 'very interested' figures for other topics or issues (film, music, crime and politics) range from 15% to 40%[36]. Similarly, the PAS research in Sweden (VA, 2017) places interest in research at 44%, higher than the four other topics tested: culture (40%), economics and politics (both 38%), and sport (36%). In the US national PAS survey work, science- and technology-related themes are among those garnering most interest (NSB, 2018). More specifically, respondents were most interested in new medical discoveries (95%), and both new technologies (88%) and new scientific discoveries (84%) scored highly. Local school issues, environmental pollution and military and defence policy also scored above 80%, while several other issues hold lower levels of interest.

China offers a contrary example. Although the Chinese PAS survey (CRISP, 2015) reports very high levels of interest in living and health (93%), this is not understood as a science-related topic in the Chinese study. More broadly, this study reports levels of interest in new discoveries in science (77%), new inventions and technologies (75%) and progress in medical science (70%) that – while seemingly high – are *lower* than

[35] The full list: Science, Technology, Engineering, Maths, Fashion, Politics and current affairs, Arts and Sports.
[36] The precise percentages are not given in the report.

interest in education, economic development, sports and agricultural development (all between 78% and 87%). In Finland, the 2016 national PAS study suggests that 68% are interested in the sciences, research and technology in the media. This is lower than nature and environment (81%), and social issues in general (74%), but higher than five other topics (sport, entertainment, politics, culture and art, and economy and finance) (TT, 2016).

In Switzerland (Schäfer et al., 2018) and New Zealand (Neilson, 2017b), no topics are tested for comparison, but 50% and 83%, respectively, express interest in science and research.

# Chapter 10 Information and activities

## Key findings

- In the UK and some other technologically-advanced countries, although the internet is an increasingly important source of information about science and technology, TV and newspaper still appear to be more important. In the US, the internet is the most important source;
- In the UK, around half of the public feel informed about science and technology (this is replicated in some other technologically-advanced countries) and around half do not feel capable of understanding science and technology;
- In the UK, many people express difficulties about establishing 'the facts' about science and technology, in part due to media-related challenges, such as conflicting news reports and lack of trust in journalists;
- Participation in science-related activities outside of school/college and work (for example science museums, science festivals) appears to be broadly stable over the past decade.

## Sources of information

Sources of information about science and technology have been examined in the UK (in the 2014 national PAS research, for the first time, and the Wellcome Trust (2016) study of public attitudes to medical research) and in a few national studies in other countries. Across this research, two points are most notable:

- Almost all people obtain information about science and technology via various forms of media, and not via direct engagement with scientists, scientific papers or public engagement with science activities;
- In common with most areas of contemporary life, the most commonly used media sources are increasingly online and decreasingly traditional (ie TV and newspapers), though different countries are at different stages on this transition.

Ipsos MORI (2014) reports that, although UK internet and social media use has been increasing rapidly in broad terms, traditional media (TV and newspapers) were the most commonly cited sources of information about science and technology: 59% cited TV as one of their two most regular sources, while 23% cited newspapers, and on-line newspapers and news sites and other online sources were mentioned by 15% and 9%, respectively. In the qualitative research in this study, an interesting distinction is noted between information that is obtained incidentally (where TV remains dominant) and specific information that is actively sought (where the internet becomes much more relevant) (Ipsos MORI, 2014; Takahashi and Tandoc, 2016). This distinction is strongly reflected in Wellcome Trust (2016), which notes that information about medical research was actively sought in the previous year by 42% of the public, typically within the context of seeking information about a specific medical condition or treatment that is relevant to them. This study suggests that the internet is overwhelmingly used for this purpose (by 90%), compared with 40% who talk to others and 31% who sought professional medical advice.

Somewhat similarly to Ipsos MORI (2014), EC (2013) suggests that people in the UK get information about science and technology from TV (66%), newspapers (36%) and websites (39%). Here, the UK is very similar to the EU28/EU15 averages, the corresponding figures being: TV (65%/65%), newspapers (33%/36%) and websites (32%/34%) (EC, 2013). The most recent Finnish national PAS survey suggests a similar picture: here, 81% say that TV and radio are important sources, while the corresponding figures are 71% and 70%

for newspapers and all internet sources, respectively (TT, 2016). Based on previous surveys, TT (2016) comments that the figures for traditional media are declining, while the internet is increasing. By contrast, New Zealand would appear to be a little further, and the US a lot further, along this transition. In the most recent national PAS research in New Zealand, 69% identified TV as a source of information about science and technology that they had used in the past year, alongside the following main sources: online videos (e.g. YouTube): 45%; newspapers and magazines: 45%; online news sites: 45%; and, internet research: 42% (Neilson, 2017b). Meanwhile, in the US, 55% identified the internet as their primary source of information about science and technology (this figure has been rising gradually since 2001), while 24% and 4% cited TV and newspapers, respectively (both of these figures are declining) (NSB, 2018)[37].

## The challenges to being informed

National PAS surveys offer a mixed picture about the extent to which people feel informed about science and technology, but also give voice to a range of concerns about the challenges of establishing 'the facts' or being informed about science and technology. While this latter phenomenon might contemporarily be framed in terms of recent 'post truth' debates, it is important to note that these appear to be also related to much longer standing challenges relating to the ways in which science and the media work, both independently and in their interactions (Gregory and Miller, 2000).

Starting with the extent to which people feel informed about science and technology, the 2014 UK PAS study suggests that more people in the UK *do not* feel informed (55%) than feel informed (45%) about 'science, and scientific research and developments'; this has typically been the case since 2005 according to this series of studies. EC (2013) asks a different question on this theme; it mentions 'technology' and does not mention 'research'. This study suggests that 56% in the UK feel informed 'about developments in science and technology' and 43% do not; self-perceptions of being informed are significantly lower in the EU28 (40%) and EU15 (43%) than in the UK, according to this study. Meanwhile, in New Zealand, more people – 60% – say that they feel '*well* informed', while 37% say that they do not (Neilson, 2017b).

Research in the UK and New Zealand suggests that there is an appetite for more information about science and technology. As was mentioned in the previous section, the 2014 UK PAS research suggests that 51% feel that they hear and see 'too little' information about science, while just 6% hold the opposite view (there is little change from the 2011 research) (Ipsos MORI, 2011; 2014). In New Zealand, more people indicate that they hear and see about the right amount of information, but still 43% say 'too little' and just 6% say 'too much' (Neilson, 2017b).

At the same time, research also highlights a number of long-standing challenges that people might experience when trying to establish 'the facts' or to become informed about science and technology issues. The first of these is the extent to which people feel *or do not feel* capable of understanding – or becoming informed about – science and technology, Ipsos MORI (2014) suggests that there is a significant minority who themselves feel that this is a challenge. For instance, although 54% *disagree* that, 'I don't think I'm clever enough to understand science and technology, and although this represents an ongoing increase since 2000, still 30% agree with this statement. This question was also posed with respect to engineering for the first time in 2014, yielding almost exactly the same results. Further, 43% agree that, 'I cannot follow developments in science and technology because the speed of development is too fast' (this is broadly consistent since 2000), and 55% agree that, 'science and technology are too specialised for most people to understand them'; there is broadly a downward trajectory here since 2000.

[37] Although this is by no means clear, it may be significant that Ipsos MORI (2014) refers to on-line, EC (2013) to websites (in the English version) and NSB (2018) to the internet.

In addition, many people appear to find it challenging to establish ‘the facts’ from among the information that is available. For instance, the 2014 UK national PAS survey suggests that 71% agree that, ‘there is so much conflicting information about science it is difficult to know what to believe’. This is consistent with the 2011 survey (the first time the question was asked). While it is also significant that only 52% agree with the statement, ‘the information I hear about science is generally true’ (up from 46% in 2011), it is perhaps more meaningful that a higher percentage than is typical – 40% – responded that they ‘neither agree nor disagree’ or ‘don’t know’.

One of the key reasons for this second challenge is related to public attitudes to the media. In keeping with broader research on public attitudes to the media, research into public attitudes to science in the media suggests that the public is not trusting of journalists or the media. For instance, in the studies that include journalists in the set of professions that is tested, journalists score very poorly in terms of public trust (Ipsos MORI, 2011; 2014; Wellcome Trust, 2016; Ipsos MORI, 2017). In addition, the 2014 UK PAS survey suggests that agreement is high with respect to both, ‘the media sensationalises science’ (71%, broadly consistent since 2005)) and ‘politicians are too easily swayed by the media’s reaction to scientific issues’ (also 70%, representing increases of 4% on 2008 and again on 2011). Although the media is not examined in most national PAS research, in Germany 34% have said that they are satisfied with media coverage of science and research, while 22% responded that they are unsatisfied (WD, 2016)

It has long been acknowledged that – for a range of reasons – the relationships between science, the media and the public are challenging (Gregory and Miller, 2000). At the same time, it seems plausible that these challenges are deepened in the internet and social media age (Groshek and Bronda, 2016).

## Science-related activities

The 2014 UK PAS research (Ipsos MORI, 2014) suggests that 67% of the UK adult population had undertaken at least one science-related activity outside of school/college or work in the past year, and that 38% had undertaken two activities. Based on a differently worded question, Wellcome Trust (2017) places the former figure at 51%. In both studies, the most undertaken activities were visits to: nature reserves (Ipsos MORI, 2014: 40%; Wellcome Trust: 41%), zoos or aquariums (39%; 36%) and science museums (23%; 20%[38]). Thereafter, the figures are: science and discovery centres (13%; n/a), laboratory visits (7%; 6%), planetariums (6%; 6%) and science festivals (3%; 2%). Although ComRES (2017) groups activities differently, broadly similar patterns are observable here too: museum/planetarium (54%), zoo/aquarium/nature reserve (54%) and laboratory visits (8%).

The 2014 UK national research (Ipsos MORI, 2014) makes a number of observations on this topic:

- Although the precise list of activities tested changed slightly from 2011, the study reports broad stability in this regard;
- Although there is a concentration of science-related activities on offer in London, people in London undertake fewer activities than the UK average. The authors speculate that this is likely to be explained by London’s more socially and ethnically diverse population – as aforementioned, ethnic minorities and the less affluent are less likely to visit these sorts of places;
- The study indicates that there is a single group of people who typically go to all sorts of cultural activities, whether science or arts-related, rather than two different groups of ‘arts’ and ‘science’ people.
- White people are more likely than those from ethnic minorities to have done a science-related activity (69% versus 51%).

[38] Wellcome Trust (2017) also includes science centres in this category.

Although the data from other countries is not as detailed as the UK data, it does appear to show broadly similar patterns of participation:

- Canada: zoo and aquarium: 43%; science museum: 32% (CCC, 2014).
- New Zealand: zoo, aquarium, museum, science centre and planetarium: 50%; and natural environment: 26% (Neilson, 2017b).
- US: zoo, aquarium: 48%; natural history museum: 30%; science and technology museum: 26% (NSB, 2018).

# Chapter 11 Conclusions

## Introduction

The objective in this final Chapter is to summarise the key findings of the report and to discuss some of them within the broader contexts of policy and action within UK science and in UK public engagement with research (PER). While some aspects of these discussions are positive in that they offer scope for the development of PER policy, others are more challenging as they reveal tensions between public attitudes, the ways in which UK science and technology projects are managed and governed by UK 'expert systems' and PER policy.

## Background to the literature review

This literature review has been produced as part of the 2018 UK Public Attitudes to Science (PAS) study, funded by the UK Department for Business, Energy, and Industrial Strategy (BEIS). Responding to ongoing concerns about public support for science and technology in the UK and other technologically-advanced countries, this round of the UK research follows earlier studies in 2000, 2005, 2008, 2011 and 2014, and is part of a growing international body of national PAS studies and academic work. The objective of this literature review is to identify and present broad-based narratives from the public attitudes to science, technology and engineering literature. The review focuses on the UK, within the context of other technologically-advanced countries. The review particularly emphasises studies that were conducted since 2010. The review methodology drew on the principles of Rapid Evidence Assessments.

## 'Contingent progress'

In an effort to encapsulate the overall findings of this literature review, we wish to employ and further elaborate on Smallman's (2018) term, 'contingent progress'. As was discussed in Chapter 3, on the basis of her analysis of materials from Sciencewise projects, Smallman uses this term to describes public attitudes to science and technology. Smallman describes the attitude of 'contingent progress' thus: 'science and technology are seen not only as producing goods and solutions but also as producing (unforeseen) problems, problems which are as inherent to the technologies as the benefits they bring, where industry is a necessary but distorting influence that needs to be managed by the state' (p670).

This review – based on a broader set of materials – reaches very similar conclusions. For instance, in the context of 'progress', the review suggests that publics typically appreciate the importance of science, technology and engineering to society. In addition, it shows that science and engineering are among the most trusted and respected professions, but that – emphasising contingency – private or commercial science are not as well trusted. Further emphasising contingency, the review shows that the 'expert systems' that direct and manage national programmes and projects in science and technology are not trusted to reflect public interests and values (as opposed to those of government and industry). We discuss 'expert systems' further in section 11.7.

At the same time, further emphasising contingency, the review shows that sizeable minorities (in the UK and elsewhere) feel that the pace of change in science and technology is too fast, and that more reliance on faith (as opposed to science and technology) would be appropriate. With respect to pace of change, this is sometimes a small majority.

## Methodological challenges: from the general and the specific

In section 2.3 we discussed a range of methodological challenges that characterise the large-scale national PAS surveys upon which the institutions of science – and, indeed, this review – overwhelmingly rely. At this stage, we would like to reiterate Wynne's (1991) warning against the 'simplistic over-interpretation of large-scale surveys', especially those that relate to the unitary object, *"science" in general* and very often focus largely on quantitative measures. In addition, as we have discussed, quantitative surveys – while valuable in many ways – are not good at capturing context and contingency. However, as Wynne implies, attitudes to science – though relatively stable in some ways – are exactly that, context-dependent and contingent, and they are formed through everyday experiences. The two examples discussed in section 11.7 might be good illustrations of the negative ways in which the public sometimes experiences science and technology in context.

For policy-makers, perhaps, Wynne's challenge – then as now – is to focus **more on understanding and acting on the dimensions of these contingencies as they apply to people's everyday encounters with specific applications of science and technology**. A further challenge, required by this move, would be to **focus much more on qualitative and even ethnographic approaches** to data collection and analysis.

## Positive findings

From the perspective of the institutions that govern UK science, there is no doubt that the overall picture presented by quantitative data in this review has a number of positive aspects to it. There is evidence that public trust in science and scientists, and engineering and engineers, increased slightly between 2011 and 2014. In addition, these two professions are typically more trusted than most professions. As was mentioned earlier, this *might* imply that the public sees these individuals and professions as a beacon of trustworthiness or 'truth' within the context of a broader 'post truth' world. UK publics clearly also attribute a range of other positive attributes to these professions. In addition, the UK public typically acknowledges the importance of science to society (with the possible exception of the local and community level, and this is discussed below) and is interested in science, particularly health-related and medical science and technology.

## Trends over time and international contexts

Generally-speaking, following shifts towards more positive UK attitudes to science, technology and engineering between 2000 and 2011, attitudes appear to be more stable between 2011 and 2014. This is perhaps to be expected as the improvements in the early part of the twenty first century are often associated with a sense of 'recovery' following a number of challenges around the turn of the century (such as GM, BSE/CJD, and foot and mouth). In addition, while it is not possible to establish cause and effect in this regard, it seems plausible to suggest that the ongoing UK commitment to public engagement with research is one of the factors that has contributed to these positive findings.

As has been discussed international comparisons based on single country studies are not straightforward for a number of reasons. Indeed, even those international studies that are available do not allow full comparison of the UK with other technologically-advanced countries. That said, on the basis of the limited number of international studies that have been included in this review (e.g. EC, 2013; QE Prize, 2014), we can conclude that – broadly speaking – the UK is more-or-less average with regards to public attitudes to science, technology and engineering. Indeed, the extent to which the UK public is typical of publics in technologically-advanced countries in these regards is striking. Of course, this means that on most measures there are countries with more positive public attitudes to which the UK might aspire (as well as countries with less positive attitudes). These are not straightforward to implement, but further international research to more adequately understand public attitudes across technologically-advanced and to investigate the dimensions of the differences between countries would be of great value. As was mentioned earlier, the Wellcome Global Monitor[39], the first of which is due for publication in 2019, will be valuable in this regard.

## Trust in ‘expert systems’

As was discussed in Chapter 3, the term ‘expert systems’ (Giddens, 1990) has been used in this report to encapsulate the networks of expertise, institutions and regulatory processes (of markets, technologies and practices) that people rely on to manage science and technology. A key finding of this review is that the high level of public trust that is expressed for science and scientists (and engineering and engineers) is not reproduced with respect to ‘expert systems’. Here, on the basis of quantitative studies, terms such as ‘resigned trust’ (Ipsos MORI, 2014) and ‘tolerance of technocracy’ (Bauer et al., 2016) have been used. In addition, qualitative research, and qualitative analysis of a range of deliberative projects, has suggested that the public believes that ‘expert systems’ often do not act in ways that the public understands to be trustworthy. For instance, research suggests that the public is often sceptical of the willingness of ‘expert systems’ to: foreground public interests and values (over those of commercial interests); attend to any unequal distribution of the benefits and risks that accrue from science and technology; and, to implement robust systems to ensure responsibility and accountability when things go wrong (Macnaghten and Chilvers, 2014). In addition, Smallman’s (2018) work – and this literature review – highlight the disjuncture between the ‘contingent progress’ attitude of the public and the ‘science to the rescue’ discourse that is consistently presented in expert and governmental materials. To recap, Smallman (2018) describes ‘science to the rescue’. Here, ‘science is a driver of our economy and competitiveness and can solve our problems and deliver social goods; social and ethical issues are public matters relating to risk and understanding that stand aside from the technologies themselves and can be quantified and resolved my more research or information’ (pp669-70). It seems highly plausible that this disjuncture is itself a source of public concerns about science and technology.

This example, which was prominent in the news during the preparation of this report, might illustrate the challenge here. In September 2018, the Infected Blood Inquiry[40] began, some forty years after concerns were first raised. While a self-evidently positive step, this case illustrates the common sense of public concerns about the ability of ‘expert systems’ to implement meaningful systems of responsibility and accountability when things go wrong.

These examples serve as an important reminder that **it is important for ‘expert systems’ to reflect more fully on the ways in which they themselves contribute to public disquiet or lack of trust, rather than diagnosing this as a public problem to be addressed through public engagement** (Wynne, 2006). This, in turn, brings back to mind the very interesting recommendation in BBSRC-EPSRC (2011) regarding the importance of appropriate future leadership within ‘expert systems’. Policy-makers may wish to consider and investigate what forms of future leadership these findings demand.

## The importance of science and technology at local and community scales

In Chapter 6, we discussed the finding that – in a UK study – science does not compare favourably with two other activities with respect to two measures: ‘bringing communities together’ and ‘local science events are important’ (Neilson, 2017a). To recap, while the levels of agreement for science are 35% and 30%, the

[39] https://wellcome.ac.uk/what-we-do/our-work/public-views-science-and-health#wellcome-global-monitor.
[40] https://www.infectedbloodinquiry.org.uk/.

corresponding figures for sports are 62% and 43%, and for arts and culture, 54% and 47%. It is important to note that this is a single finding and further investigation of this issue – perhaps qualitative, as well as quantitative – would be of value. Nonetheless, this finding is striking, not only because science does not score as well as the other two activities, but also because the scores for science are much lower in these specific contexts than they are at a more general, abstract or national level.

When we think about participation in Saturday and Sunday football, or – at a lesser scale, perhaps – amateur dramatics, it is easy to see why sports, and art and culture might score more highly than science in these regards. Importantly, though, the question is: how might science become more like Saturday football or amateur dramatics? Of course, local and community-based science projects are a feature of the UK public engagement landscape, often as part of the citizen science agenda. The term citizen science is typically used to encompass a wide variety of formats and activities (some more and some less participatory) in which scientific work is undertaken by members of the general public (some more and some less scientifically-literate), sometimes in collaboration with professional scientists and scientific institutions (see Hecker et al., 2018 for a range of recent perspectives). Should this finding be taken seriously, the institutions that fund UK public engagement might wish to place greater emphasis on:

- **Citizen science projects in general**;
- The **local, bottom-up, grassroots, community-based and -led, and participatory elements of such projects (for instance, through processes such as co-creation and co-design, and by offering more opportunities for community led projects).** This might imply more direct funding to local, non-professional organisations and perhaps less emphasis on the professional and institutional aspects of citizen science projects.

It may be that the public engagement community can learn – in context appropriate ways – from the practices and processes that are employed by the arts and by sports at the local and grass roots level.

## Inequality

As was discussed in Chapter 3, one of the most consistent findings in PAS studies, across a range of country contexts, is that people from lower socio-economic groups (variously measured) tend to have less positive attitudes, to be less interested, to feel less informed and to participate in fewer science and technology-related activities. Importantly, this finding is also reproduced among young people in terms of their science career aspirations.

Within the public engagement agenda, a key response to such findings has been to endeavour to go beyond the white, middle class 'usual suspects' and to purposefully target people in lower socio-economic groups. Of course, this is highly laudable. However, such research findings have also prompted Archer et al. (2013) to propose that tackling inequality should be part of a package of measures designed to increase 'science capital' in the UK. **From the perspective of a broad-based literature review, the consistency with which these findings appear suggests that Archer et al. (2013) are correct to emphasise this broad social response** alongside measures that specifically focus on public engagement.

## Engineering

In some respects, the findings of this literature review with respect to engineering are similar to those with respect to science and technology. Levels of trust in engineers are relatively high, and engineering is associated with a range of other positive attributes in the minds of publics in many countries. Engineering is also recognised by the public as important to society.

At the same time, the review highlights a distinctive challenge for engineering. In particular, the review shows that publics tend to be less familiar with and less interested in engineering than with respect to science and technology. These will be familiar findings to those working in engineering institutions and work will no doubt continue on addressing these issues.

## Media and information

In the UK and some other technologically-advanced countries, although the internet is an increasingly important source of information about science and technology, TV and newspaper still appear to be more important (although the internet is already more important when people are seeking specific information). In the US, the internet is the most important source. In the UK, reflecting long-standing concerns as well as more contemporary post-truth concerns, levels of public concern about media reporting of science issues are high and many people express difficulties about establishing ‘the facts’ about science and technology. In the UK, around half of the public feel informed about science and technology (this is replicated in some other technologically-advanced countries) and around half do not feel capable of understanding science and technology. These concerns might be a prompt for PER policy to emphasise this issue more fully, in terms of helping people to identify reliable sources of information about science and technology.

## Gender

The literature review suggests that the long-standing ‘gender divide’ (Ipsos MORI, 2014) across attitudes to science – trust, support, interest, feeling informed etc – shows no sign of narrowing. Indeed, the only measure on which women typically score more highly than men is interest in health-related science (as well as concerns about science, of course). Alongside gender differences in aspirations to, the uptake of and progression in science and engineering careers, these challenges are well-known to policy-makers, and action on these issues should continue.

## Education and career aspirations

Young people in the UK appear to be broadly satisfied with their science education. Although the science career aspirations of young people in the UK appear to be lower than some other professions, there is also evidence that they compare favourably to other technologically-advanced countries.

## Interest and activities

Within technologically-advanced countries, there is a moderate level of interest in science and technology (the UK faring better on this measure compared with the EU average). In general, across technologically-advanced countries, medical and health issues attract more interest than other scientific issues such as technology and the environment, and engineering attracts less interest. Some research suggests that interest in science-related topics is greater than in other topics (such as politics or sport), while other studies indicate contrary or mixed pictures. Contrary to the general trend, the evidence suggests that interest in medical and health science is greater among women than men. More than half of people in the UK have participated in a science-related activity (outside of school/college or work) in the past year (2014 and 2011). Participation levels are similar in a number of other technologically-advanced countries for which data are available.

# Final comments

Perhaps the key finding of this review is the distinction between two sets of findings. The first is the more positive findings relating to *science (and scientists), in general*, for instance relating to trust, other positive attributes, interest, support and so on. No doubt, ongoing attention to PER and broader science communication activities will continue to contribute to such positive attitudes. The second is the much more mixed findings – for instance, the relative lack of trust – related to particular technologies or application and, in particular, the ways in which they are determined and managed by 'expert systems'. These findings are not new, they have been discussed in a variety of ways for more than thirty years. However, if it is the case that public trust in science should also mean public trust in 'expert systems', it is to be hoped that the people working within such systems – particularly in positions of seniority and leadership – will be able to turn the science and society lens onto their own actions.

# Chapter 12 Bibliography


Adams, J. (1995), *Risk*, UCL Press, London.

Allum, N., E. Sibley, P. Sturgis and P. Stoneman (2014) Religious beliefs, knowledge about science and attitudes towards medical genetics, *Public Understanding of Science*, 23(7): 833–849

Archer, L., J. DeWitt, J. Osborne, J. Dillon, B. Wong, and B. Willis (2013) *ASPIRES Report: Young people's science and career aspirations, age 10 –14*, https://www.kcl.ac.uk/sspp/departments/education/research/aspires/ASPIRES-final-report-December-2013.pdf.

Archer, L., E. Dawson, J. DeWitt, A. Seakins and B. Wong (2015) ''Science Capital'': A Conceptual, Methodological, and Empirical Argument for Extending Bourdieusian Notions of Capital Beyond the Arts, *Journal of Research in Science Teaching*, 52(7): 922–948.

Archer, L. and six others (2016) *Science capital made clear*, https://kclpure.kcl.ac.uk/portal/en/publications/science-capital-made-clear(8e5b1267-87f0-4792-94b8-d0f4a784db75).html.

Bauer, M (ed.) (2015) Special issue: Public engagement in science, *Public Understanding of Science*, 23(1): 3-120.

Bauer, M. (2017) No time for experts? Trust in science after the BREXIT vote of 23 June 2016, in Schiele, B. and LeMarec, J., (eds.) Cultures de Science. Montreal, Canada : Acfas, 2017, pp. 91-99, http://eprints.lse.ac.uk/78047/.

Bauer, M., M. Hall, S. Howard and B. Franks (2016) Do we like TINA: a growing tolerance of technocracy in Britain?, *Science and Democracy Network 15th Annual Meeting*, June 23-25, 2016, London.

Barben, D (2010) Analyzing acceptance politics: Towards an epistemological shift in the public understanding of science and technology, Public Understanding of Science, 19(3): 274–292.

BBSRC-EPSRC (2011) Synthetic Biology Dialogue, https://bbsrc.ukri.org/documents/1006-synthetic-biology-dialogue-pdf/.

BEIS (2018 *pers. comm.*) Discussion with Anthony Whitney, BEIS

Bennett, J., M. Braund and R. Sharpe (2013) Student attitudes, engagement and participation in STEM subjects (for Royal Society's Vision Project), https://pure.york.ac.uk/portal/en/publications/student-attitudes-engagement-and-participation-in-stem-subjects(0034c02e-86e6-4fc6-9eed-d7d24c7a0e79).html.

Besley, J. (2013) The State of Public Opinion Research on Attitudes and Understanding of Science and Technology, Bulletin of Science, Technology & Society, 33(1-2): 12-20.

Bodmer, W. (1985) Public Understanding of Science, The Royal Society, London. https://royalsociety.org/~/media/royal_society_content/policy/publications/1985/10700.pdf.

Buys, L., R. Aird, K. van Megen, E. Miller and J. Sommerfeld (2014) Perceptions of climate change and trust in information providers in rural Australia, *Public Understanding of Science*, 23(2): 170–188.

China Research Institute for Science Popularization (CRISP) (2015) Main findings from survey of public understandings of science (not available online).

ComRES (2017) Research Councils UK – Public insight research, https://webarchive.nationalarchives.gov.uk/20180322125503/http:/www.rcuk.ac.uk/documents/publications/rcukpublicinsightproject-pdf/.

Council of Canadian Academies (2014) *Science Culture: Where Canada Stands.* Canada's Science Culture, http://www.scienceadvice.ca/en/assessments/completed/science-culture.aspx

Dake, K. (1992) Myths of nature: culture and the social construction of risk, *Journal of Social Issues*, 48(4), pp:21-37.

Davidson, D. and W. Freudenburg (1996) Gender and environmental risk concerns: a review and analysis of available research, *Environment and Behavior*, 28(3): 302-339.

Dawson, E. (2018) Reimagining publics and (non) participation: Exploring exclusion from science communication through the experiences of low-income, minority ethnic groups, *Public Understanding of Science*, 27(7): 772–786.

Define Research and Insight/RAEng (2016) Engineering Talent Project Research.

Engdahl, E. and R. Lidskog (2014) Risk, communication and trust: Towards an emotional understanding of trust, *Public Understanding of Science*, 23(6): 703–717.

Engineering UK (2018) The state of engineering: Synopsis and recommendations, https://www.engineeringuk.com/media/1576/7444_enguk18_synopsis_standalone_aw.pdf.

Engineers Canada (2017) *Public Perceptions of Engineering and Engineers* https://engineerscanada.ca/reports/public-perceptions.

European Commission (2013) *Eurobarometer 401: Responsible Research and Innovation (RRI), Science and Technology*, https://www.europeandataportal.eu/data/en/dataset/http-ec-europa-eu-public_opinion-archives-eb_special_419_400_en-htm401.

European Commission (2014) *Eurobarometer 419: Public Perceptions of Science, Research and Innovation.* European Commission, http://ec.europa.eu/commfrontoffice/publicopinion/archives/ebs/ebs_419_en.pdf

European Commission (2015) *Public Opinion on Future Innovations, Science and Technology.* Eurobarometer Qualitative Study, http://ec.europa.eu/commfrontoffice/publicopinion/archives/quali/ql_futureofscience_en.pdf.

Flynn, J., Slovic, P. and C. Mertz (1994) Gender, Race, and Perception of Environmental Health Risks, *Risk Analysis*, 14(6): 1101-1108.

Giddens, A. (1990) *The consequences of modernity*, Polity Press, http://voidnetwork.gr/wp-content/uploads/2016/10/The-Consequences-of-Modernity-by-Anthony-Giddens.pdf.

Gregory, J. and S. Miller (2000) *Science in public: communication, culture, and credibility*, Perseus Pub, Cambridge, Mass.

Groshek, J. and S. Bronda (2016) How social media can distort and misinform when communicating science, The Conversation, http://theconversation.com/how-social-media-can-distort-and-misinform-when-communicating-science-59044.

The Guardian (2010) Q&A: 'Climategate', https://www.theguardian.com/environment/2010/jul/07/climate-emails-question-answer.

The Guardian (2016) Trust in charities at record low after scandals, https://www.theguardian.com/society/2016/jun/28/trust-in-charities-at-record-low-after-scandals.

Hecker, Susanne, Muki Haklay, Anne Bowser, Zen Makuch, Johannes Vogel and Aletta Bonn (eds.) (2018) *Citizen Science: innovation in open science, society and policy*, UCL Press, https://www.ucl.ac.uk/ucl-press/browse-books/citizen-science.

Hopkins Van Mil (2017) Potential uses for genetic technologies: dialogue and engagement research conducted on behalf of the Royal Society, https://royalsociety.org/~/media/policy/projects/gene-tech/genetic-technologies-public-dialogue-hvm-full-report.pdf.

House of Lords, Science and Technology Committee (2000) Science and Society, https://publications.parliament.uk/pa/ld199900/ldselect/ldsctech/38/3801.htm.

Ipsos MORI (2011) *Public Attitudes to Science,* Department for Business Innovation and Skills, https://www.ipsos.com/ipsos-mori/en-uk/public-attitudes-science-2011

Ipsos MORI (2014) *Public Attitudes to Science, 2014.* Ipsos MORI, https://www.ipsos.com/ipsos-mori/en-uk/public-attitudes-science-2014.

Ipsos MORI (2014) Public Attitudes to Science, 2014. Ipsos MORI, https://www.ipsos.com/ipsos-mori/en-uk/public-attitudes-science-2014.

Ipsos MORI (2017) *Veracity Index*, 2017, https://www.ipsos.com/ipsos-mori/en-uk/politicians-remain-least-trusted-profession-britain.

Irwin, A. (2006) The Politics of Talk: Coming to Terms with the 'New' Scientific Governance, Social Studies of Science, 36(2): 299–320.

Kahan, D, A. Landrum, K. Carpenter, L. Helft and K. Hall Jamieson (2017) Science Curiosity and Political Information Processing, *Advances in Political Psychology,* 38(1): 179-199.

Kakutani, M. (2018) The Death of Truth, HarperCollins.

Lamberts, R. (2017) The Australian Beliefs and Attitudes Towards Science Survey, The Australian National University, https://www.industry.gov.au/data-and-publications/the-australian-beliefs-and-attitudes-towards-science-survey-2017.

Macnaghten, P. and J. Chilvers (2014) The future of science governance: publics, policies, practices, *Environment and Planning* C: Government and Policy, 32: 530 – 548.

Marques, M., C. Critchley and J. Walshe (2015) Attitudes to genetically modified food over time: How trust in organizations and the media cycle predict support, *Public Understanding of Science,* 24(5): 601–618.

Martin, M., I. Mullis, P. Foy & M. Hooper, M. (2016) Student Engagement and Attitudes section, in TIMSS 2015 International Results in Science, http://timssandpirls.bc.edu/timss2015/international-results/timss-2015/science/student-engagement-and-attitudes/.

Millar, R. (2004) The role of practical work in the teaching and learning of science, Paper prepared for the Committee: High School Science Laboratories: Role and Vision, National Academy of Sciences, Washington, DC, http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_073330.pdf.

National Science Board (2018) *Science and Technology: Public Attitudes and Understanding.* Science and Engineering Indicators, Chapter 7 in Science & Engineering Indicators 2018, https://www.nsf.gov/statistics/2018/nsb20181/report.

Neilson (and KCL) (2017a) Culture and major events tracking study, https://www.kcl.ac.uk/cultural/partnerships-and-enquiry/cultural-data-tracker/cultural-data-tracker.aspx.

Neilsen (2017b) *Report on Public Engagement with Science & Technology.* Ministry of Business, Innovation & Employment, https://www.curiousminds.nz/actions/community/nielsen-survey/

OECD (2015) Programme for International Student Assessment (PISA): Results in focus, http://www.oecd.org/pisa/.

Ofsted (2013) Science education in schools: maintaining curiosity, https://www.gov.uk/government/publications/maintaining-curiosity-a-survey-into-science-education-in-schools.

Osborne, J., S. Simon and S. Collins (2003) Attitudes towards science: A review of the literature and its implications, *International Journal of Science Education*, 25(9): 1049-1079.

OPM (205) Understanding public perceptions of specific applications of nanotechnologies: A public dialogue (Report to the Department for Environment, Food and Rural Affairs), https://sciencewise.org.uk/wp-content/uploads/2018/11/Nanotech-case-study_20180926.pdf.

Pardo, R. and F. Calvo (2002) Attitudes toward science among the European public: a methodological analysis, *Public Understanding of Science*, 11: 155–195

Queen Elizabeth Prize for Engineering (2017) *Create the Future*, http://qeprize.org/research/.

Sanz-Menéndez, L. and G. Van Ryzin (2015) Economic crisis and public attitudes toward science: A study of regional differences in Spain, *Public Understanding of Science*, 24(2): 167–182.

Schäfer, M., T. Füchslin, J. Metag, S. Kristiansen and A. Rauchfleisch (2018) The different audiences of science communication: A segmentation analysis of the Swiss population's perceptions of science and their information and media use patterns, *Public Understanding of Science*, 27(7): 836-856.

Shuckburgh, E., R.Robison and N.Pidgeon (2013) Climate Science, the Public and the News Media: Summary Findings of a Survey and Focus Groups Conducted in the UK in March 2011, http://nora.nerc.ac.uk/id/eprint/500544/1/lwec-climate-science.pdf.

Simon, R. (2010) Gender differences in knowledge and attitude towards biotechnology, *Public Understanding of Science*, 19(6): 642–653.

Slovic, P. (1992) Perceptions of Risk: Reflections on the Psychometric Paradigm, in Krimsky, S. and Golding, D. (eds.), *Social theories of risk*, chapter 5, pp. 117-152, Praeger Publications, Westport.

Slovic, P. (1997) Trust, emotion, sex, politics, and science: Surveying the risk-assessment battlefield, *Risk Analysis*, 19(4): 689-701.

Smallman, M. (2018) Science to the rescue or contingent progress? Comparing 10 years of public, expert and policy discourses on new and emerging science and technology in the United Kingdom, *Public Understanding of Science*, 27(6): 655–673.

Smith, B. and E. Jensen (2016) Critical review of the United Kingdom's "golden standard" survey of public attitudes to science, *Public Understanding of Science*, 25(2): 1-17.

Sturgis, P, I. Brunton-Smith and C. Fife-Schaw (2010) Public attitudes to genomic science: an experiment in information provision, *Public Understanding of Science*, 19(2): 166–180.

Takahashi, B. E. Tandoc (2016) Media sources, credibility, and perceptions of science: Learning about how people learn about science, Public Understanding of Science, 25(6): 674–690.

Thorpe, C. and J. Gregory (2010) Producing the Post-Fordist Public: The Political Economy of Public Engagement with Science, *Science as Culture*, 19(3): 273-301.

Tieteen Tiedotus (TT) (2016) Summary of the Finnish Science Barometer: A STUDY OF THE FINNS' ATTITUDES TOWARDS SCIENCE AND THEIR OPINIONS ON SCIENTIFIC AND TECHNOLOGICAL PROGRESS, http://www.tieteentiedotus.fi/tiedebarometri.html.

TNS BMRB (2015) *Public attitudes to chemistry.* Royal Society of Chemistry, http://www.rsc.org/campaigning-outreach/campaigning/public-attitudes-chemistry/.

Unsworth, K. and K. Fielding (2014) It's political: How the salience of one's political identity changes climate change beliefs and policy support, *Global Environmental Change*, 27: 131-137.

Vetenskap & Allmänhet (VA) (2017) VA Barometer, 2017/8, https://v-a.se/2018/03/va-barometer-2017-2018-english/.

Wellcome Trust (2016) Wellcome Trust Monitor Report Wave 3: Tracking public views on science and biomedical research, https://wellcome.ac.uk/what-we-do/our-work/public-views-science-and-health#wellcome-uk-monitor.

Wellcome Trust (2017) Young people's views on science education, https://wellcome.ac.uk/what-we-do/our-work/young-peoples-views-science-education.

Williams, L., P. Macnaghten, R. Davies and S. Curtis (2017) Framing 'fracking': Exploring public perceptions of hydraulic fracturing in the United Kingdom, *Public Understanding of Science*, 26(1): 89–104.

Wissesnschaft im Dialog (2017) *Science Barometer 2017*, https://www.wissenschaft-im-dialog.de/en/our-projects/science-barometer/science-barometer-2017/.

Women's Engineering Society (2018) Statistics on Women in Engineering, https://www.wes.org.uk/sites/default/files/2018-01/Women%20in%20Engineering%20Statistics%20-%20January%202018%20-%20created%20by%20Sarah%20Peers_0.pdf.

Wynne, B. (1991) Knowledges in Context, *Science, Technology and Human Values*, 16(1): 111-121.

Wynne, B. (1992) Public understanding of science research: new horizons or hall of mirrors?, *Public Understanding of Science*, 1(1): 37–43.

Wynne, B. (2006) Public Engagement as a Means of Restoring Public Trust in Science – Hitting the Notes, but Missing the Music?, Community Genetics, 9: 211–220.

Ziegler, A. (2017) Political orientation, environmental values, and climate change beliefs and attitudes: An empirical cross country analysis, *Energy Economics*, 63(C): 144-153.

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