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Science in society: re-evaluating the deficit model of public attitudes[1]

Patrick Sturgis and Nick Allum

The "deficit model" of public attitudes towards science has led to controversy over the role of scientific knowledge in explaining lay people's attitudes towards science. In this paper we challenge the de facto orthodoxy that has connected the deficit model and contextualist perspectives with quantitative and qualitative research methods respectively. We simultaneously test hypotheses from both theoretical approaches using quantitative methodology. The results point to the clear importance of knowledge as a determinant of attitudes toward science. However, in contrast to the rather simplistic deficit model that has traditionally characterized discussions of this relationship, this analysis highlights the complex and interacting nature of the knowledge—attitude interface.

1. The deficit model and its critics

The field of study known as "public understanding of science" stands today at something of a crossroads.[2] In the 15 years or so since the publication of the Bodmer report by the Royal Society, the loose assemblage of interdisciplinary approaches that have been applied to the field has produced much in the way of practical educational initiatives such as "Science, Technology and Engineering Week" in the UK and "Project 2061" in the USA.[3] Many other science popularization initiatives in the UK were funded through the now defunct Committee for Public Understanding of Science (COPUS). Scholarship has also flourished, with much funding directed at academic research into science communication and public attitudes towards science and technology.

A major aim of COPUS was not only to popularize science, but also to enhance the "scientific literacy" of the British public. The Bodmer report was commissioned in the belief that the public's interest in and support for science and scientists was waning. At the same time, scientists themselves had retreated from public debate to an alarming degree. The report suggested not only that scientists now had a duty to go out and communicate the benefits of science to a wider public, but also that a more "scientifically literate" public would be more supportive of scientific research programs and more enthusiastic about technological innovations. This would, of course, be a rather happy outcome for the scientific research community.

A scientifically literate citizenry is also one that can effectively participate in public debates about science and hold government to account over the speed and direction of science policy. From this normative perspective, in modern democratic societies, citizens need to have sufficient levels of accurate information on which to base their assessments of

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policy alternatives in order that their policy preferences best reflect their own self or group interests.[4] As scientific and technological innovations become increasingly central to the functioning of modern societies and to the daily lives of individual citizens, the argument goes, so the importance of technical and scientific knowledge within the mass public is concomitantly augmented.

There is little doubt, however, that one of the primary motives underlying recent government and business initiatives to increase public "understanding" of science is what Nelkin calls "selling science".[5] Implicit in this programmatic agenda is the claim that "to know science is to love it'. That is to say, the more one knows about science, the more favorable one's attitude towards it will be. Regrettably, from this point of view at least, publics both in Europe and in the USA appear to possess depressingly low levels of scientific knowledge. Jon Miller conceptualizes "civic scientific literacy" as comprising three related dimensions: "a vocabulary of basic scientific constructs sufficient to read competing views in a newspaper or magazine . . . an understanding of the process or nature of scientific inquiry . . . some level of understanding of the impact of science and technology on individuals and on society."[6] While Miller's concept is by no means an uncontested one, by his definition not more than one-quarter of the European and US publics qualify as scientifically literate. Moreover, this situation has hardly changed since systematic measurements first began in the late 1950s, despite the best efforts of governments and educators alike to popularize science and make it more accessible to ordinary citizens during the intervening years. Withey found that in 1957 only about 10% of US citizens correctly defined science as having to do with the concepts of controlled experimentation, theory, and systematic variation.[7] Fifteen years later, when the US National Science Foundation (NSF) initiated its Science Indicators survey series, the proportion was unchanged.[8] In 1988, Durant, Evans, and Thomas reported that only 17% of the British public spontaneously referred to experimentation and/or theory testing when asked the question: "what does it mean to study something scientifically?"[9] When the same question was asked nearly 10 years later, in the 1996 British Social Attitudes survey, the proportion remained statistically unchanged at 18%. The picture for what might be considered "factual" or "textbook" scientific knowledge is similar.[10] For instance, Durant, Evans, and Thomas report that in 1988 only 34% of the British public knew that the earth goes around the sun once per year, and only 28% knew that antibiotics kill bacteria but not viruses (see appendix for more factual knowledge questions from this survey).[11] In the USA, respondents faced with the same questions fared similarly to their British counterparts, with 46 and 25% providing the correct answer respectively.

Against this backdrop of widespread scientific "ignorance" amongst lay publics, there has been, over the past few decades, rising public skepticism about the benefits of scientific and technological innovation and a diminishing conviction that scientific progress is coterminous with social progress.[12] In Britain, this view motivated a major public inquiry into the relationship between science and society by the House of Lords Select Committee on Science and Technology, which suggested that "society's relationship with science is in a critical phase" characterized by "public unease, mistrust and occasional outright hostility."[13] Unease of this kind has been evident for a number of years in public controversies, concerning, for example, the real and potential dangers of dichlorodiphenyltrichloroethane (DDT) in the early 1960s, nuclear power in the 1970s and 1980s and, more recently, crises in public confidence in farming and food technologies following the bovine spongiform encephalopathy (BSE) scandal in Britain in the 1990s. Typifying this state of affairs at present is gene technology. While held out by some as promising almost limitless future benefits for society, optimism about these prospects in Europe has steadily declined since the beginning of the 1990s.[14] The scientific community, along with governments and industry, now all recognize that a sufficiently hostile public and media can seriously constrain or even veto a contentious research program.[15]

The assumption that it is a lack of public understanding or knowledge that has led to the present climate of skepticism toward science underpins what has come to be known as the "deficit model."[16] In this formulation, it is the public that are assumed to be "deficient", while science is "sufficient".[17] The public's doubts about the value of scientific progress or fears about new or unfamiliar innovations, such as genetically modified organisms or microwave ovens, are due to ignorance of the science behind them. Lacking a proper understanding of the relevant facts, people fall back on mystical beliefs and irrational fears of the unknown. If one accepts this hypothesis, the obvious implication for science policy is that public information campaigns should be instigated to remedy the public's disenchantment with science. Whilst the deficit model, as we shall refer to it here, is to some extent a simplification, or even something of a "straw man," it quite evidently underlies many programmatic statements from the scientific community when the misplaced fears of a scientifically illiterate public and mass media are bemoaned.[18] And the simple logic of the deficit model is supported by a good deal of cross-national empirical evidence for a robust but not especially strong positive correlation between "textbook" scientific knowledge and favorability of attitude toward science.[19]

Unsurprisingly, given its normative and epistemological implications, the deficit model has come in for sustained criticism on a number of grounds. First, the assumption that so-called "irrational" fears of lay publics are based on lack of scientific understanding has been strongly challenged by a number of commentators. Douglas and Wildavsky, for example, have argued that fears about new technologies are functional in that they provide a basis for maintaining cultural associations.[20] In other words, people select risks to worry about according to the norms of their social milieu rather than responding to supposedly more "objective" hazards. Others have shown that perceptions of technological risks are related to certain types of worldviews or the holding of certain core beliefs and values such as environmentalism. In none of these conceptions is the perception of risk dependent primarily on one's level of scientific understanding.[21]

Another criticism of the deficit model and the way in which it has been approached via quantitative survey research focuses on the selection of appropriate measures of scientific understanding.[22] This argument posits that proponents and opponents in scientific controversies are likely to select different domains of knowledge as being relevant or important.[23] The normative assumptions behind the selection and development of knowledge measures such as those of Withey, Miller and Evans, and Durant may not necessarily correspond with those of all protagonists in any given scientific controversy. Peters, for example, criticizes some of the knowledge measures used in the 1992 Eurobarometer survey as being based on a "culturally determined idealisation" of what should constitute scientific knowledge.[24] As a result, he argues, the measures present a biased indication of the relative levels of relevant scientific understanding that is dependent on respondents' national and cultural locations. Another recent current of criticism of the deficit model suggests that the effect of scientific knowledge is far outweighed by the influence of social trust on perceptions of new and potentially risky technologies.[25]

While these criticisms are undoubtedly in many ways valid, they do not, in our view, sufficiently problematize the deficit model to justify scrapping it entirely. Indeed, we find it puzzling that many scholars utilizing survey research methods that consistently uncover associations between knowledge of and attitudes towards science, despite controlling for a range of other important characteristics such as age, education, and social class, often choose to ignore this finding and instead emphasize the other factors that are also influential in the formation of attitudes.[26] It is quite clear that culture, economic factors, social and political values, trust, risk perception, and worldviews are all important in influencing the public's attitude towards science. There is, however, no reason to assume in consequence that scientific knowledge does not have an additional and independent effect, for reasons that are thus far not clearly understood. In fact there is ample reason to consider it quite implausible that the well-informed and poorly informed citizen go about the business of making up their minds in the same way.[27]

2. The contextualist perspective

A more trenchant critique is one that suggests the existence of other knowledge domains that influence attitudes towards science and technology in opposite or conflicting ways to factual scientific knowledge. Jasanoff, for example, suggests that what is important for people's understanding of science is not so much the ability to recall large numbers of miscellaneous facts but rather "a keen appreciation of the places where science and technology articulate smoothly with one's experience of life... and of the trustworthiness of expert claims and institutions."[28] Brian Wynne, an incisive critic of the deficit model of the public understanding of science (PUS), delineates this position further. Criticizing survey-based PUS research's over-reliance on simple "textbook" knowledge scales, he suggests that in order to properly capture the range of knowledge domains relevant to lay attitudes towards scientific research programs "three elements of public understanding have to be expressly related: the formal contents of scientific knowledge; the methods and processes of science; and its forms of institutional embedding, patronage, organization, and control."[29]

Clearly the implication of what we shall here refer to as the "contextualist"[30] position is that the deficit model considers only the first two of these elements and that in neglecting the different forms of engagement that individuals and groups might have with science in a variety of contexts, PUS research has overstated the importance of the simple linear deficit model. Other knowledges—be it intimate knowledge of working procedures at a nuclear power plant or awareness of the practical political interdependencies between government, industry and scientific institutions—will always be moderating factors. The ways in which people utilize their factual scientific knowledge is contextualized by the circumstances under consideration. As a corollary to this line of argument we can assume that the third element in this formulation will influence public attitudes in ways opposite to or conflicting with the first two elements. If not, then it would appear to be nothing other than a somewhat more elaborated restatement of the deficit model.

In this vein, Steven Yearley highlights public trust in scientific expertise as a key factor in the contextualization of knowledge of science.[31] Trust in expert claims, he argues, is always mediated by knowledge of the institutional arrangements under which expertise is authorized. Claims to expert knowledge are always contestable, depending on what one knows of the relevant institutions. For instance, claims made by government experts may be evaluated differently to those made by scientists employed by non-governmental organizations. At this point, trust becomes the issue. Of course, in making these evaluations, other psychological and social factors come into play: political ideology, personal interests, and preferences. Nevertheless, all things being equal, some form of "institutional knowledge" will serve in this example to contextualize "factual" scientific knowledge and knowledge of scientific methods when people evaluate the science under consideration.

Wynne and others who have been instrumental in the articulation of the contextualist perspective have argued that a survey-based, quantitative approach cannot shed any useful light on this or other contextualizing forms of knowledge. In fact, it would not be an exaggeration to say that one of the central axioms of this perspective seems to be that survey-based methods are at best procrustean and at worst fundamentally misleading for understanding the lay public's knowledge of and interactions with science.[32] The principal contention is that "surveys take the respondent out of [their] social context and are intrinsically unable to examine or control analytically for the potentially variable, socially rooted meanings that key terms have for social actors".[33] Methodologically, the contextualist perspective has relied instead on qualitative case studies for empirical support.[34] A contextualist theoretical outlook and a quantitative methodological approach are, apparently, incommensurable from this perspective.

This conflation of theory and method—with contextualist perspectives requiring an ideographic/qualitative approach and quantitative/survey based research seen as good only for propounding the deficit model—is, we believe, both an unnecessary and an unhelpful state of affairs. As Einsiedel astutely remarks: "Contrasting [the deficit model] with the interactive science model[35] may have analytical value, but one thereby tends to emphasize the stark differences between the two and to overlook the possibility that these frameworks may be complementary rather than mutually exclusive".[36] Furthermore, the idea that survey-based analyses are not capable of or suitable for demonstrating a contingent or mediated relationship between knowledge and attitude does not bear close scrutiny. Evans and Durant, for example, show that while the simple deficit model holds for attitudes to science in general, better informed respondents tend to be among the most skeptical when it comes to "morally contentious" and "non-useful" sciences.[37] Similarly, Bauer, Evans and Durant show that the strength of the knowledge–attitude relationship varies across Europe according to national levels of economic advancement.[38] However, while these studies demonstrate, through quantitative analysis, the contingent nature of the knowledge–attitude nexus, they do not focus specifically on the mediational or contextualizing form of knowledge as set out, however imprecisely, by those propounding this theoretical model.

The present research is motivated by a concern to address this gap in the empirical literature; we believe that potentially valuable theoretical insights and developments in the field of PUS are being stymied by the paradigmatic formalisms and methodological orthodoxies of divergent research traditions. Rather than seeing the contextualist perspective as a potentially decisive critique of the deficit model, we hope in this paper to show how these two theoretical perspectives might be integrated in a more complex and complete account of how what people know about science and the context in which it is practiced affects their general favorability toward science and the scientific community. In using a quantitative, survey-based approach as the vehicle in this regard, we do not aim to pick it out as the methodological "royal road," but, rather, aim to illustrate how both the deficit and contextualist models might be investigated from this particular perspective.

3. Measuring contextual knowledge

The key problem, of course, in integrating the contextualist perspective within a survey-based quantitative analysis is obtaining satisfactory operationalizations of the relevant knowledge domains. Finding adequate indicators of hypothetical and unobservable concepts is difficult at the best of times.[39] The process is at its most treacherous when, as in the current instance, the concepts in question are "fuzzy", multi-dimensional, and, to a large degree, contested. However, the potentiality of biased or unreliable measurement should not, we would argue, lead us to abandon the idea that there might be something of interest to be measured. Rather, the question that needs to be addressed is: how can we obtain the best measurements?

The notion of contextualizing knowledge is not, to be sure, a domain of specified and particular content in and of itself. Rather, it expresses the idea of an interacting causal mechanism between two or more independent variables and an unspecified dependent variable. Earlier we briefly reviewed some of the definitions and examples that proponents of the contextualist perspective have suggested might constitute knowledge domains that act in such a way in combination with factual scientific knowledge and attitudes toward science. We would summarize these as falling into either of two main categories: "institutional knowledge of science," denoting an understanding of the ways in which science is embedded within wider political, economic, and regulatory settings, and "local knowledge," which we take to mean knowledge of the ways in which specific applications of science or technology connect with everyday practices in particular contexts. As we are here focusing on the national picture, using data that is representative of the British population rather than any specific localities, we focus our attention on the former of these. There is, however, no reason why the analytical approach we adopt here could not equally well be applied to small area data if an appropriate measure of the relevant "local knowledge" in question were available.

So how does one go about measuring the average citizen's knowledge of the political and institutional relationships in which science and the development of science policy and regulation is embedded? Well, here we propose that the answer truly is in the question. For what we are surely dealing with here is a kind of "political sophistication"—a concept which has undergone a great deal of theoretical and empirical scrutiny in the field of political science over the last 30 or so years.[40] This program of research has repeatedly demonstrated that, first, individual citizens vary enormously in the amount they know about politics and that, second, one's level of political knowledge has a significant impact on one's political preferences, likelihood of voting, and a whole host of other important behaviors, attitudes, and beliefs.[41] What it has also shown is that, as with most areas of knowledge or intelligence, in politics people tend to be "generalists", such that their level of knowledge in any one particular domain will be highly predictive of their level of knowledge in another.[43] So people who know the names and faces of political "actors" also tend to know about the institutions of government and where parties and candidates stand on the major issues of the day. For example, Delli-Carpini and Keeter have shown that, in two recent US surveys, the average correlation between scales measuring knowledge about political "players" and the policy stances of political parties is approximately 0.80. They also find that, in a range of US surveys, the lowest correlation between sub-domains of political knowledge (drawn from a pool of ten different domains) is as high as 0.52, while the greatest is 0.97.

Based on results like these, we would argue that if we can distinguish between individuals in terms of their level of political knowledge, such a measure is also likely to be discriminative of the extent to which people are aware of the political and institutional relationships within which the practice and regulation of science and technology is located. Let us not forget, after all, that the ways in which science is practiced, regulated, and deployed in society is still essentially a "political" matter.

So while political knowledge batteries—as routinely implemented in surveys of political attitudes and behavior—are clearly not direct measures of the "institutional knowledge of science" construct as set out earlier, we believe that they will likely act as reasonably good proxies: people who are knowledgeable about political parties and the issue positions they endorse, are also more likely to be familiar with existing forms of scientific regulation, government committee structures, and the nature of links between science, industry, and government and so forth.

An additional reason for preferring this particular operationalization in the analysis is the difficulty of obtaining purely factual "answers" to any questions that might otherwise be used as indicators. Bauer and colleagues have developed a set of items designed to measure what they also term "institutional knowledge of science". They found that "institutional knowledge" comprises two sub-domains of belief about: (1) the autonomy of scientists; and (2) the ways in which institutions function.[43] However, they themselves acknowledge the potential pitfalls of trying to directly assess this type of knowledge by pointing to what they the see as the inherently contested nature of "facts" about institutions. As a result, the problem with Bauer and colleagues's scale is that too many of the items, in the absence of any objective means of determining the "correct" response, stray from the knowledge into the attitudinal domain.[44] As we are here primarily interested in how different domains of *knowledge* impact on attitude toward science, we feel that it is of paramount importance to employ measures of knowledge that have, without descending into solipsism, easily verifiable right or wrong answers. It is therefore, we believe, preferable to use a less direct but verifiably a knowledge-based measure of our key theoretical construct than a more direct but also a more ambiguous and contestable one.[45]

4. Analysis

From the discussion earlier it is possible to deduce a number of empirical hypotheses concerning the relationship between the favorability of people's attitudes toward science and their level of political and scientific sophistication. These are tested on data from a survey of a representative sample of the British population. First, then, the deficit model holds that a generally negative attitude toward science is underpinned by, inter alia, a lack of "textbook" scientific knowledge. Our first hypothesis therefore becomes:

H1 The main effect of scientific knowledge on general attitude toward science—controlling for a range of important demographic characteristics—will be significant and positive.

The contextualist account, on the other hand, contends that understanding of the relationships between political and financial institutions and the scientific community is at least as important as scientific knowledge and will, in the aggregate, serve to diminish, or even counteract any simple positive linear relationship between textbook scientific knowledge and attitude toward science. Our second hypothesis is therefore:

H2 The main effect of political knowledge on general attitude toward science—controlling for a range of important demographic characteristics and scientific knowledge—will be significant and negative.

If the contextualist account is correct, we would also expect that political knowledge will act to moderate the effect of scientific knowledge in the formation of attitudes. In other words, for people with a lot of knowledge about politics and institutional decision-making, scientific knowledge will not be related to attitudes in the same way as it is for those without much political awareness. Accordingly, our third hypothesis is:

H3 The effect of scientific knowledge on attitude toward science will vary as a function of level of political knowledge.

Finally, the contextualist account sees contextual knowledge as a kind of "protective filter," endowing us with an important skepticism concerning the aims, objectivity, and independence of the scientific community. Thus, while we might expect to see a strong correlation between textbook scientific knowledge and acceptance of science for those less knowledgeable in this domain, any such relationship should also steadily diminish as the stock of political knowledge increases. Our fourth hypothesis (conditional on non-rejection of H3) therefore becomes:

H3b the positive effect of scientific knowledge on attitude toward science will be greatest at low levels of political knowledge and will with increasing levels of political knowledge diminish.

These hypotheses are tested using ordinary least squares (OLS) regression on a scale measuring favorability of attitude toward science and applications of scientific knowledge. Data are from the 1996 British Social Attitudes Survey, which contains the necessary measures of all key variables.[46] The dependent variable is an additive scale comprising four five-point Likert items (Cronbach's α .53)[47] that measure a general attitude toward science and the benefits of technological innovation. These questions have been included in a number of previous surveys and have been used to create a measure of general attitude toward science in a number of studies.[49] Exact wordings for these items are provided in the appendix. Raw scores on the summed scale have a possible range of 0–16 as the individual items were all coded 0 (least favorable) to 4 (most favorable). To facilitate interpretation and comparability with the other key variables in the analysis, the raw scores were converted into percentiles, representing the percentage of respondents at each value of the raw scale (Gilens, 2001).[49] Respondents at a particular level of the scale were assigned the mid-point of the set of percentiles covered by that particular value. Thus, for example, 0.2% of respondents had the lowest score on the raw summed scale. These respondents were assigned a percentile score of 0.001, representing the mid-point of this set of percentiles on a 0 to 1 scale.[50] Higher scores on this scale therefore indicate a more favorable attitude toward science. A histogram of the raw scale score is presented in the appendix (Figure 1A).

As a measure of scientific knowledge, we use a ten-item subset of the scale originally developed by Durant, Evans, and Thomas that subsequently became known as the "Oxford" scale of scientific knowledge.[51] The subscale used here (range 0–10) taps a range of areas of scientific knowledge (Cronbach's α .68, mean value 6.3; skewness –.53; kurtosis –.18). These include: understanding of probability theory; understanding of the nature of scientific enquiry; understanding of experimental design and control groups; and a number of areas of "textbook" scientific knowledge. Following Durant and colleagues, we combine these items to form a single scale. This decision is supported by the one factor solution produced in a factor analysis of these items. Raw scale scores were also converted to a percentile measure as outlined earlier. Exact wordings for these items and details of codings of correct/incorrect responses are provided in the appendix.

For our measure of political knowledge, we use a six-item scale tapping respondent knowledge of the policy stances of the main political parties in Great Britain (Cronbach's α .66, mean value 3.4, skewness –.29, kurtosis –.92). Raw scores ranged from 0 to 6 and were also converted to a percentile measure to ease interpretation and comparability. The bivariate Pearson's correlation between the scientific and political knowledge variables was .46 ($p < 0.001$). Exact wordings and coding schemes are provided in the appendix.

5. Results

Table 1 shows the results of three OLS regression models predicting general attitude toward science. Predictors in the models are: political affiliation; age; gender; religiosity; social class; scientific qualifications; general educational attainment; marital status; and employment status.[52] Political knowledge, scientific knowledge, and their interaction are incorporated in the models in iterative steps. Model diagnostics indicate no causes for concern regarding multicollinearity (lowest tolerance value .64 for scientific knowledge). The results of model 1 clearly support H1, with a positive and highly significant coefficient of .286 ($p < 0.001$) for scientific knowledge, even in the presence of other important determinants of general attitude toward science. Note also that the majority of other independent variables in the model are significant at the $p < 0.05$ level or lower and in the expected direction—being male, younger, non-religious, right wing, having scientific qualifications, and being in a non-manual social-class are all positively associated with a more favorable attitude toward science.

Model 2 incorporates all the independent variables in model 1, but adds political knowledge as a predictor in the model. The significant and positive main effect of political knowledge does not support H2 but in fact shows that the opposite of H2 pertains—greater levels of political knowledge also lead to a *more* favorable attitude toward science. This finding would appear to be at odds with the contextualist perspective. For the contextualist critique of the deficit model argues that it provides an overly simple, holistic account of the knowledge—attitude relationship and that considering other domains of knowledge such as “institutional knowledge of science” as determinants of attitude would show a reversal of the positive association commonly found between “textbook” scientific knowledge and attitude toward science.

Our interpretation here depends crucially, of course, on acceptance of the political knowledge measure acting as a reasonable proxy for the “institutional knowledge of science” domain described by contextualist accounts—a point that we consider at greater length later. Note also that R^2 increases significantly and that the coefficients for the other independent variables are not much affected as a result of the inclusion of political knowledge in the model. The biggest change is in the negative coefficient for gender (female), indicating that at least some of the more negative attitude toward science amongst women may be due to the difference in levels of political knowledge between the sexes.

Model 3 further elaborates on models 1 and 2 by including the interaction of political and scientific knowledge as an additional predictor of attitude toward science. The significant interaction parameter in model 3 shows that there is indeed a contextualizing or moderating effect of political knowledge on the relationship between textbook scientific knowledge and attitude toward science, supporting hypothesis H3. Someone with the lowest level of political knowledge (0) and the lowest level of scientific knowledge (0) would have a predicted score of 0.49 (the intercept) on the attitude toward science variable (that is to say they would be on the 49th percentile of the attitude variable). If someone has the lowest score on the political knowledge measure, a 1 unit increase in scientific knowledge would lead to a 0.18 *increase* in attitude toward science. If someone has the lowest score on the scientific knowledge score, however, a 1 unit increase in political knowledge would lead to only a 0.008 increase in attitude toward science. The positive coefficient for the interaction of political and scientific knowledge indicates that, for every one unit increase in political knowledge, the slope of attitude toward science on scientific knowledge increases by 0.16 or, equivalently, for every 1 unit increase in scientific knowledge, the slope of attitude toward science on political knowledge increases by 0.16. Thus, at all levels of scientific

Table 1. Ordinary least squares regression models predicting general attitude toward science

Variables in model	Model 1	Model 2	Model 3
Constant	.468*** (.028)	.453*** (.028)	.488*** (.032)
Scientific knowledge	.286*** (.023)	.254*** (.024)	.176*** (.043)
Favours Labour Party	–.012* (.005)	–.010† (.005)	–.009† (.005)
Age	–.001*** (.000)	–.002*** (.000)	–.002*** (.000)
Female	–.066*** (.011)	–.053*** (.012)	–.052*** (.012)
Attends church	–.058*** (.014)	–.062*** (.014)	–.063*** (.014)
Non-manual class	.053*** (.012)	.048*** (.012)	.047*** (.012)
Science qualification	.056*** (.014)	.050*** (.014)	.048*** (.014)
Higher degree	.013 (.014)	.007 (.014)	.005 (.014)
Marital status	–.020† (.012)	–.022† (.012)	–.021† (.012)
Employment status	.007 (.012)	.005 (.012)	.005 (.012)
Political knowledge		.087*** (.024)	.008 (.043)
Political × scientific knowledge			.158*** (.072)
R^2	.211	.215	.217
Standard error of the regression	.256	.255	.255
Statistical significance of change in R^2	–	.005	.002
F	61.906***	57.792***	53.473***

† $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.
Notes: Standard errors in parentheses. Number of cases 2328.
Source: British Social Attitudes Survey, 1996.

knowledge, the effect of growth in political knowledge is to further enhance the already favorable attitude. This is counter to what the contextualist model would predict as specified in hypothesis H3b. The same "amplification" effect applies equally to scientific knowledge, which maintains a positive slope on attitude toward science at all levels of political knowledge—with the largest coefficients appearing at higher levels of political knowledge.

The nature of this interacting effect between political and scientific knowledge on attitude toward science can be represented in three-dimensional space by taking the predicted score on the attitude dependent variable from model 3 at each combination of levels of the other two variables as shown in Figure 1.[53] Figure 1 clearly illustrates the curvilinear relationship between each knowledge domain and attitude toward science. Note how the regression plane always moves in an upward direction on the *z*-axis with increases in scientific or political knowledge. The group most favorable toward science are those at

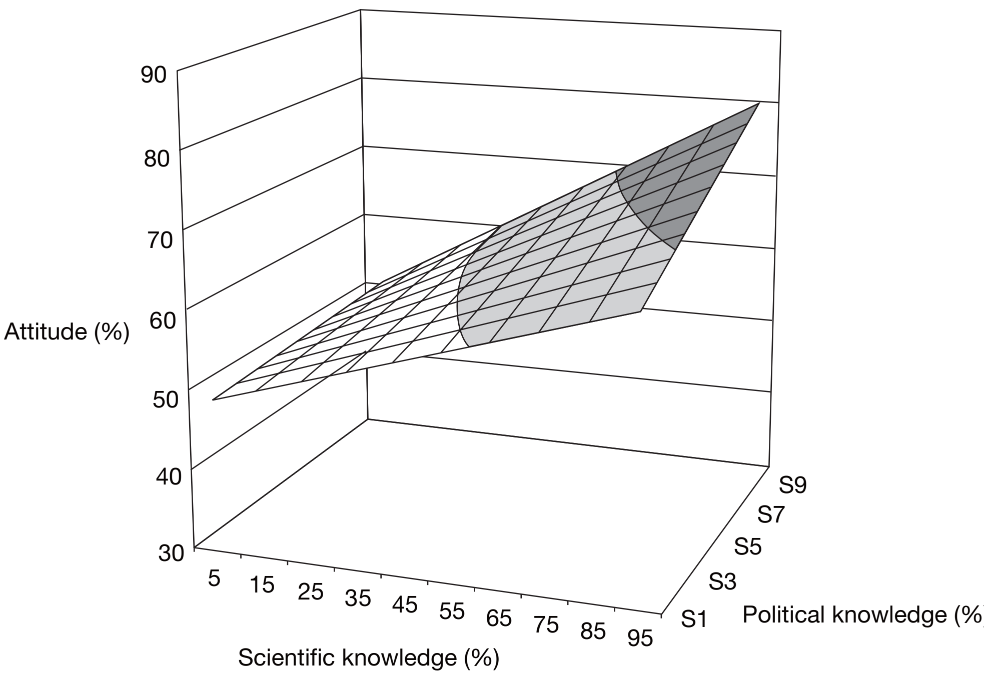

Figure 1. Joint effect of scientific/political knowledge on attitude toward science.

the top percentile of both knowledge dimensions, while the least favorable are those with the lowest score on political knowledge *and* the minimum on the scientific knowledge scales. For those at the highest level of political knowledge, moving from the bottom to the top of the scientific knowledge scale alone results in a increase in favorability of attitude toward science of almost 30 percentiles. This compares with a more modest jump of about 17 percentiles for the same increase in scientific knowledge amongst those at the lowest level of political knowledge

This then appears to be the reverse of what the contextualist account would lead us to expect—rather than political knowledge acting to attenuate the positive effect of "textbook" scientific knowledge on attitude toward science, it actually appears to *amplify* the existing positive association. Furthermore, of the two domains, scientific knowledge appears to be far the stronger determinant of attitude toward science. The largest increase in favorability of attitude caused by increasing political knowledge is 14%, while the equivalent figure for scientific knowledge is more than double that amount. This can be seen from the fact that the angle of elevation of the regression plane in Figure 1 is more oblique from left to right than it is from front to back.

6. Discussion

We have tried in this paper to show how the contextualist and deficit perspectives in PUS might be integrated within a survey-based quantitative analysis. In doing so we hope to open up a more open and fruitful dialogue between researchers in the field who come, perhaps, from different methodological and epistemological research traditions. Too often methodological formalism and theoretical orthodoxy seems to prevent the useful cross-fertilization of ideas and stifles the progression and refinement of theory. To be sure, we recognize that there are a number of problems and limitations in our approach and do not claim that the conclusions we draw concerning the complex relationship between different domains of knowledge and attitude toward science are definitive. Nonetheless, many of the caveats we ourselves would place on these results derive from circumstances beyond our control; we have had, for example, to rely on analysis of secondary data and, to that extent, have not been able to develop our own operationalizations of key constructs in our theoretical models. For this reason we hope that readers will see this analysis as a position piece to be elaborated and improved upon in the future.

We anticipate two primary lines of objection to our analysis and the conclusions we have drawn from it. To those who contend that these sorts of questions are simply not amenable to a quantitative, survey-based approach, we have little to say in reply.[54] It is not the aim of this paper to counter a generalized skepticism of the survey method (indeed any such skeptics reading this paper are perhaps more likely to have had their prejudices confirmed), but to show how these two important theoretical perspectives might be integrated within a single methodological study. More forceful criticism will concern the operationalizations of our key theoretical constructs: "general attitude toward science", "textbook knowledge of science," and "institutional knowledge of science", to which we turn later.

We are aware that the use of such a generalized measure of attitude toward science raises issues of the exact meaning of such an abstract construct and whether our results can, in any way, be expected to apply to more concrete and localized contexts. One does, of course, need to be extremely careful when interpreting general attitudes and their relationship to more specific opinions and behaviors.[55] Nevertheless, we believe that an overall evaluation of science as measured here is diagnostic of a wider set of attitudes, values, and beliefs reflecting a person's disposition towards the social integration of technological innovation and "scientific progress" and concur with Evans and Durant, who argue that such a construct has real social force and meaning in that it represents evaluations of science as "a set of principles, a way of understanding the world, or as a profession".[56]

As regards our measures of scientific and political knowledge, we accept that knowing the answers to these items in isolation cannot be conceived of as very interesting or useful for understanding someone's attitude toward science in society. How can knowledge or ignorance of a set of true/false questions in a survey tell us anything of value about someone's real understanding of science or politics? This line of criticism, however, fundamentally misses the point of measurement using diagnostic indicators. For as we have already pointed out, there is good evidence to suggest that people do not tend to learn things in isolation.[57] It is likely, for example, that a person who obtains a high score on this particular science quiz also has a range of other relevant scientific knowledge and understanding that, taken together, influence the formation of their attitude toward science. Confusing the contents of the measurement instrument with the attitude or trait underlying responses to it is a common mistake among critics of quantitative approaches to PUS. But, as Philip Converse has remarked, "it does not take much imagination to realize that knowledge of minor facts . . . are diagnostic of more profound differences in the amount of contextual information citizens bring to their judgments."[58] The items selected for this analysis should accordingly be seen as diagnostic indicators rather than fully constitutive of the actual scientific and political knowledge relevant to attitude formation.

One need not disagree with our position here, however, to argue that our measure of political knowledge is not tapping the kind of awareness of "patronage, organization, and control" that is stressed within the contextualist treatment of "institutional knowledge of science." While acknowledging the need for further work and replication for delineating the measurement properties of this construct, we believe that we have summoned ample evidence pointing to the validity and reliability of such measures in general. And, furthermore, there is no particular reason why awareness of science and technology policy and regulation should not be among the other political issues, knowledge of which is known to correlate with these sorts of items. Finally, if it could be shown that the type of policy-related political knowledge that we have used here has, in fact, little to do with the type of "institutional—relational" knowledge that we are attempting to tap, it begs the question of why this type of political knowledge *is* related to the formation of attitudes towards science in the way we have shown it to be.

7. Conclusion

The results as they stand lend some support to the contextualist perspective, although not perhaps in the way we might have expected. The effect of scientific knowledge on attitude toward science is not a straightforward linear main effect, but does indeed appear to be "contextualized" by at least one other domain of knowledge. This domain, we have argued, is that which Wynne has described as representing an individual's understanding of the "patronage, organization, and control" operating in and around science and the scientific community.[59] Contrary to what the contextualist critique of the deficit model would lead us to expect, however, the effect of this knowledge domain seems to operate in ways similar to "textbook" scientific knowledge, augmenting the already positive influence of the latter domain on favorability of attitude toward science. This unexpected result leads us to suggest a possible mechanism underlying these findings.

Popkin and Dimock observe that respondents with low levels of political knowledge tend to see political scandal as much more serious than those with higher levels of political knowledge and understanding.[60] They use attribution theory and, in particular, the notion of the "fundamental attribution error" to explain why this might be so.[61] Attribution research has shown that people tend to interpret the behavior of others as indicative of character, while tending to attribute their own behavior to circumstances.[62] In other words, if a Member of Parliament writes a bounced check it is because he or she is untrustworthy; if I write a bounced check it is because I was so busy that I forgot to first make sure I had sufficient funds. Furthermore, because we also tend to overestimate the reasonableness of our own actions, we also overestimate the probability that others would do the same as us. When this is not the case, we tend to attribute the difference to "bad character."[63] Because a key moderating factor in the tendency to make internal attributions is the amount of contextual information available to observers, Popkin and Dimock argue that those with more political knowledge better understand the constraints on and contexts within which political behavior takes place. The more situations and contexts in which one has observed these actions, the less likely it is that behavior will be attributed to character.

This, of course, is entering the realms of post hoc speculation but has, we feel, important implications for the interpretation of the findings that we have presented in this paper, in addition to highlighting a promising avenue for future research. The effect of scientific knowledge on the attitudes of respondents whose knowledge of politics is high is greater than it is for those with less political knowledge. With a greater degree of political understanding and awareness, it may be that people are less likely to attribute the less fortunate outcomes of scientific development to the bad character of scientists or politicians but to a more complex set of institutional, political, and other "situational" factors. Hence, whatever leads knowledge of science to increase one's favorability towards it, is even more effective when people are familiar with the complex range of circumstances surrounding scientific and technological development within the wider political landscape.

In making these observations we are convinced that, first, both deficit *and* contextualist perspectives help to explain how, why, and under what conditions knowledge of many kinds is important in determining public attitudes towards science and, second, that survey-based approaches are by no means unsuitable for research into public understanding of science from a "contextualist" theoretical perspective.

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52 Age was entered as a continuous variable with gender, religiosity, social class, scientific qualifications, educational qualifications, employment status, marital status all entered as dummy variables.

53 The predicted scores are derived from combinations of ten percentile values on each of the two knowledge variables, assuming zero values on all other independent variables in the model. It is important to note that because this is a just-identified model, these predicted scores cannot be interpreted as "fitted values". Rather, Figure 1 should be seen as a graphical representation of the interaction coefficients presented in Table 1.

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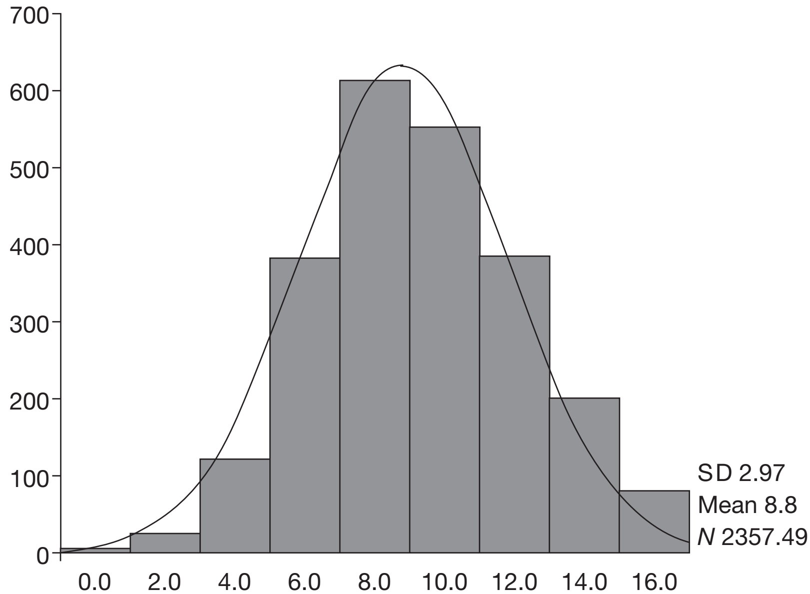

Figure 2. Histogram of attitudes toward science scale.

Appendix

Wordings and coding of items in attitude toward science scale

1. Science and technology make life healthier, easier and more comfortable.
2. We depend too much on science and not enough on faith.
3. Science makes life change too fast.
4. It is not important for me to know about science in my daily life.

All items are five point Likert response scales ranging from strongly disagree (0) to strongly agree (4).

Wordings and coding of items in political knowledge scale

The political knowledge measure is a summed scale of the following six items:

These next questions are about things that different parties are in favor of. If you feel you don't know, just tell me and we'll go to the next question. Firstly which party would you say is . . .

1. Most in favor of changing the voting system to a form of proportional representation? (For the knowledge scale this was recoded: Liberal Democrats = correct (1), all other answers = incorrect (0).)
2. Most in favor of reducing government spending in order to cut taxes? (For the knowledge scale this was recoded: Tories [Conservatives] = correct (1), all other answers = incorrect (0).)
3. Most in favor of schools being under local authority control? (For the knowledge scale this was recoded: Labour = correct (1), all other answers = incorrect (0).)
4. Most in favor of independence for Scotland? (For the knowledge scale this was recoded: SNP = correct (1), all other answers = incorrect (0).)

5. Most in favor of letting private industry run the railways? (For the knowledge scale this was recoded: Tories = correct (1), all other answers = incorrect (0).)
6. Most in favor of setting a minimum wage level, below which no one can be paid? (For the knowledge scale this was recoded: Labour = correct (1), all other answers = incorrect (0).)

Wordings and coding of items in scientific knowledge scale

The scientific knowledge measure is a summed scale of the following ten items:

1. Some news stories talk about the results of a "scientific study." When you read or hear this term, can you tell me in your own words what you think it means to study something scientifically.

   Verbatim responses coded to:

   1. Theory construction and testing
   2. To undertake tests/experiments
   3. Open-minded, rational in-depth explorations of phenomena/problem to be examined.
   4. To measure or classify but no mention of any rigour in process.
   5. Other answers
   6. Don't know
   7. Refusal/not applicable

For the knowledge scale this was recoded: 1–4 = correct (1), all other answers = incorrect (0).

2. Suppose a drug used to treat high blood pressure is suspected of not working well. On this card are three different ways scientists might use to investigate this problem. Which one do you think scientists would be most likely to use?

   1. Talk to patients to get their opinions
   2. Use their knowledge of medicine to decide how good the drug is
   3. Give the drug to some patients but not to others. Then compare what happens in each group.
   3. Don't know
   4. Refusal/not applicable

For the knowledge scale this was recoded: 3 = correct (1), all other answers = incorrect (0).

3. Doctors tell a couple that their genetic make-up means that they've got a one in four chance of having a child with an inherited illness. Does this mean that? . . . or

   1. If they have only three children, none will have the illness? . . . or
   2. If their first child has the illness, the next three will not? . . . or
   3. Each of the couples's children has the same risk of suffering from the illness? . . . or
   4. If their first three children are healthy, the fourth will have the illness?

For the knowledge scale this was recoded: 3 = correct (1), all other answers = incorrect (0).

4. Here is a quick quiz. For each thing I say, tell me if it is true or false. If you don't know, say so and we will skip to the next.

1. The centre of the earth is very hot.
2. It is the father's genes that determine whether a child is a girl
3. Lasers work by focusing sound waves.
4. Antibiotics kill viruses as well as bacteria.

For the knowledge scale these were recoded: correct (1), all other answers (0).

5. Does the . . .

   1. earth go round the sun
   2. or the sun go around the earth?
   3. Don't know
   4. Refusal/not applicable

For the knowledge scale this was recoded: 1 = correct (1), all other answers = incorrect (0).

6. Here is a statement about which people disagree.

   Human beings as we know them today developed from earlier species of animals—would you say this was . . .

   1. Definitely true
   2. Probably true
   3. Probably untrue
   4. or, definitely untrue
   5. Don't know
   6. Refusal/not applicable

For the knowledge scale this was recoded: 1 = correct (1), all other answers = incorrect (0).

7. When scientists use the term DNA, do you think it is to do with the study of . . .

   1. stars,
   2. rocks,
   3. living things,
   4. or computers?
   5. Don't know
   6. Refusal/not applicable

For the knowledge scale this was recoded: 3 = correct (1), all other answers = incorrect (0).