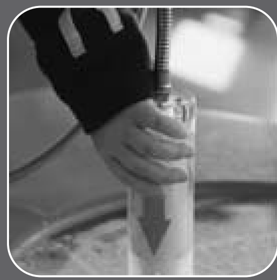
9780199552665_053_071_S2_01.qxd 4/18/08 13:45 Page 53



SECTION 2

Researching public engagement

Long before the official shift away from the deficit model, research at Lancaster, and elsewhere, contradicted the prevailing account of publics and their ways of reacting to science and technologies. . . . The commitment to 'public engagement with science' emerged, replacing the discredited but deeply entrenched 'public understanding of science' paradigm. . . . This reflected our own listening to ordinary citizens in qualitative fieldwork research situations: public meetings, structured focus group discussions, interviews, participant observation and so on.

Brian Wynne (2006). Afterword. In: Matthew Kearnes, Phil Macnaghten and James Wilsdon (ed.) *Governing at the Nanoscale*

2.1

Investigating science communication to inform science outreach and public engagement

Eric Jensen and Richard Holliman

Introduction

In recent years, research councils and organizations such as the Wellcome Trust and the Royal Society have joined high-level government officials in declaring a commitment to facilitating active public involvement in decision-making about techno-scientific developments and engagement with science (see Irwin 2006 and Chapter 1.1 this volume; Davies, Chapter 2.2 this volume; Holliman and Jensen, Chapter 1.3 this volume for a discussion of this new agenda for science–society relations). Notable in this regard is the House of Lords Select Committee on Science and Technology report on Science and Society, which concluded that:

> . . . direct dialogue with the public should move from being an optional add-on to science-based policy-making and to the activities of research organisations and learned institutions, and should become a normal and integral part of the process.
>
> House of Lords (2000, paragraph 5.48)

Such calls attempt to shift the practices of those scientists and other stakeholders who have interests in science–society relations from a deficit-informed to a more dialogue-informed agenda for public engagement with science. However, as Irwin (2006) has argued, deficit-informed activities are still being practised, 'although now under the ascendant and apparently conflated branding of public engagement' (also see Holliman 1
and Jensen, Chapter 1.3 this volume).

Calls for public engagement with science have been met by 'as many as 1500 initiatives or programmes' (Mesure 2007, p. 8) in the UK conducted by a wide range of citizens (including scientists and professional science communicators) who have taken up the challenge of engaging with audiences of all kinds, from 'gifted and talented' schoolchildren to socially excluded minority groups of adult citizens. Today there is a heterogeneous community of practice operating in the space between what can be characterized as deficit-informed 'science outreach'—aimed primarily at increasing scientific literacy—and dialogue-informed 'public engagement' seeking to foster productive exchanges between scientists and other stakeholders (including members of the public). This variegated community, comprising scientists, science teachers, professional–amateur (pro-am) enthusiasts (see Leadbetter and Miller 2004 for explanation), and professional science communicators, is the focus of the ISOTOPE (Informing Science Outreach and Public Engagement) project.[1] This chapter will describe our approach to using action research methodology and how it has informed our practice of conducting research on science outreach and public engagement to elucidate the science communication practices contained therein. (For a discussion of some of our findings, see Holliman and Jensen, Chapter 1.3 this volume.)

Background

There have been numerous studies of science–society relations over the years, including investigations and essays focusing on the interface between scientific and other forms of (citizen) expertise (Irwin 1995; Wynne 1996; 2003; Collins and Evans 2002; Jasanoff 2003; Rip 2003). The ISOTOPE study draws upon insights from such previous studies, adopting an interdisciplinary collaborative approach to co-producing an open access web portal of empirically informed resources, written in part by, and for, practitioners of science outreach and public engagement. The research underpinning this action, as well as the web resource itself, critically engages with the contemporary context for science outreach and public engagement, providing practical solutions, in particular for early career scientists. The driving ethos behind the co-production of these resources is a commitment to transcending simplistic divisions between practitioners and social researchers. Rather, the project ethos is about facilitating informed choice in this important area; providing resources that are informed by scientists, science outreach and public engagement practitioners and social researchers, for use by scientists, science outreach and public engagement practitioners and social researchers. The design and implementation of this study follow rigorous standards of quality assurance and evaluation in line with the most recent methodological literature on qualitative research and analysis. The discussion that follows will include examples and 'lessons learned' from the ISOTOPE project, while delineating the methodological options available to researchers examining these forms of science communication.

1. ISOTOPE is a NESTA-funded Open University project, which began in October 2006. At the time of writing (February 2008) we have completed the initial study (see below for further discussion) and produced an interim report (see Holliman *et al.* 2007).

Designing science communication research and action

Designing a good science communication study requires careful planning and preparation, which takes time and resources. Quantitative researchers may even specify their expected findings at the outset of the research endeavour in the form of testable hypotheses based on previous research. For qualitative researchers, however, it can also be important to balance the construction of a comprehensive plan with the need to maintain a degree of flexibility in order to 'follow the data' where they lead.

This concern to inductively 'ground' qualitative research by beginning a study with empirical data has been most prominently promoted by Barney Glaser and Anselm Strauss (1967), who argued that researchers can miss important phenomena if they impose a priori assumptions and deductive theoretical models in advance of their observations. Rather Glaser and Strauss contended that models of social life should be developed from the data of everyday experience, and then integrated with existing academic literature and theory at a later stage in the process. This perspective has persuaded many qualitative researchers to adopt an inductive approach, though not necessarily adhering to all the specifics of grounded theory. Indeed, this inductive orientation is reflected in the qualitative methods of researching the particular forms of science communication that are reviewed in this chapter. However, we acknowledge that it is neither possible, nor desirable, to approach research with a *tabula rasa*. As we have already noted, our approach has also been informed by theoretical perspectives and methodological approaches that we have found to be persuasive.

Research goals

As with any social research topic, studies of science communication must first establish their primary goals in order to select appropriate methods of data collection, analysis, evaluation and dissemination. In traditional social science, the research question or central intellectual, empirical or theoretical problem to be addressed by the study provides this generative foundation for the research design. However, in action research the goal of increasing social scientific understanding on a particular topic runs in parallel with the additional objective of mobilizing some form of pro-social 'action' on the basis of this newly generated knowledge.

First elaborated by field psychologist Kurt Lewin (1946), action research methodology is based upon the dual aims of: (1) increasing knowledge or understanding about a particular field of practice; and (2) acting on the basis of that newly produced knowledge to effect positive change within this field. The relative emphasis within the continuum between 'action' and 'research' varies from project to project. The process of conducting action research is cyclical, creating a continuous dialogue between investigation and action. This cycle is evident in the design of the ISOTOPE project, which involves a continuous cycle of planning/design, action, empirical data collection and analysis, and evaluating/reviewing findings and resources for the web portal. Finally, action research involves both researchers and practitioners, in this instance including practitioners of science outreach and public engagement, web designers and social researchers.

The qualitative surveys and focus group interviews conducted for the initial ISOTOPE study encompassed two main goals:

- Research: to investigate participants' experiences and views about science outreach and public engagement.
- Action: to identify the functionality and types of resources that participants might value for inclusion in the ISOTOPE web portal, and to co-produce these resources.

The ISOTOPE 'research' results (see Holliman and Jensen, Chapter 1.3 this volume; Holliman *et al.* 2007) informed the subsequent structure, content and delivery media to be used in the prototype web portal. A second phase for both the research and action goals is planned. Once the web portal prototype is in place, evaluation research and participant observation will be used to assess the efficacy of the web portal and its toolkits of informational resources in a second round of 'research'. This will be followed by a concomitant second round of 'action' to incorporate these research findings into a revised and updated web portal. Funding permitting, these iterative phases of action and research, research and action can continue indefinitely.

Research design

The fundamental principle guiding the design process must be the selection of methods of data collection, analysis and presentation that correspond with the research goals, as discussed above. For example, if one wants to learn about the perceptions of individual science communicators without restricting respondents' possible range of answers, then an open-ended qualitative survey may be appropriate.[2] If these science communicators tend to have internet access, and are spread out in geographically disparate locations, then a web-based survey instrument may be a suitable, if not unavoidable, choice. After navigating the 'Scylla and Charybdis' of the research ideal and practical constraints, the range of reasonable methodological passageways narrows significantly. Indeed, when practical constraints such as a lack of funding for recruiting focus group participants, postage costs for a questionnaire study or the researcher's limited range of methodological expertise enter the equation there will sometimes only be one viable research design available. That said, at least some of these constraints can be ameliorated by conducting research as part of a team (ideally with research funding that at least covers direct costs). For example, in addition to including science outreach and public engagement practitioners upstream to inform the study design process, the ISOTOPE project team brought to bear an overlapping, interdisciplinary range of methodological expertise to tailor the research design to the emergent needs of science outreach and public engagement practitioners and social scientific questions of interest to science and technology studies scholars.

2. A closed approach is best used with populations that have been studied previously. That way previous research can be used to inform the selection and framing of survey questions. The results from closed-ended surveys are easier to manage as they are frequently in a numerical form ready for statistical analysis as soon as the survey is completed. The data from open-ended questionnaires, on the other hand, must still be coded before they can provide useful results.

BOX 1 VALIDITY AND RELIABILITY IN SOCIAL RESEARCH

Validity refers to the degree to which the sample data authentically represent the concept or phenomenon under study. For example the ISOTOPE project sought to: (1) identify people engaged in science outreach and public engagement and (2) to record their authentic experiences and views o n science outreach and public engagement.

Reliability typically indicates the degree to which the same results will be found if multiple iterations of the same method of data collection are employed. In other words, this concept could be viewed in terms of test, re-test consistency. This criterion is most appropriate for psychometric tests aimed at certain characteristics within the same sample, whereas it is difficult to assess reliability for cross-sectional research on social scientific phenomena that are contingent and mutable from day to day or year to year.

Data collection

Science communication research relies upon empirical observation, that is, the collection of social scientific data. Ideally, data collection should be systematic and customized to the research question in order to provide valid and reliable information about the social world. Indeed, the concepts of validity and reliability can help to guide the selection of a particular subgroup or sample out of the larger population of interest, as well as the preferred means of collecting data from this sample (Box 1).

For qualitative researchers validity is highly prized; whereas quantitative researchers tend to privilege reliability based on statistically representative samples. For example, a closed-ended quantitative survey of individuals reported level of beef eating following the BSE/vCJD episode might yield statistical representativeness and therefore some level of reliability, but it would provide a less valid account than an inductive qualitative study of how and why individuals made these decisions.

The ISOTOPE project employed three different methods of qualitative data collection, each aimed at maximizing validity by accessing the authentic views and experiences of science communicators. Initially, participants completed questionnaires, providing basic demographic details and their individual perceptions in response to open-ended questions. Focus groups created a more naturalistic group setting in which participants co-constructed discursive representations of their experiences as science communicators through conversation (Kitzinger 1994; Holliman 2005). Participant observation will generate ethnographic data regarding the efficacy of particular science outreach and public engagement activities without the strictures of a formal interviewing structure. Together, these methods of data collection access multiple, overlapping dimensions of the social reality of science communication practitioners. However, this consistent emphasis on validity can come at the expense of the reliability associated with larger sample sizes, making research findings based on small samples contingent to the context within which they were generated. To an extent, however, the limited reliability of small-sample studies can be addressed by methodological triangulation—the use of multiple methods to address a single research question.

Methodological triangulation 'entails the use of different methods to collect information' in order to lessen the particular 'limitations . . . validity threats and distortions' that inevitably crop up in any single method (Tindall 1994, p. 147). Combining questionnaires with focus groups, and later participant observation, exemplifies methodological triangulation in which the weaknesses of each method are reduced due to their collaboration such that the whole is greater than the sum of its parts. For example, questionnaires offer each individual the space to express their particular point of view without interruption or disagreement. At the same time, focus groups provide naturalness and a dialogical dimension lacking from questionnaires. Thus, if used effectively these methods can overlap and complement each other, ultimately yielding greater validity for the study, and also a greater measure of reliability if the results of the mixed methods from the same sample yield analogous findings. Moreover, participant observation will provide direct access to the practices of people engaged in science outreach and public engagement, minimizing the reliance on potentially malleable self-report data and 'completing', at least in terms of the ISOTOPE project's research design, the methodological triangle.

Sampling

A complete census of a given population is rarely a feasible goal, given resource constraints and population variability; even the UK national census is only conducted once every 10 years. As such, social researchers (and opinion pollsters) must conduct their investigations with a smaller subgroup selected from within the larger population. This is known as sampling, a process that can take a number of forms, including random, quota[3] and qualitative or structured sampling. In quantitative data collection, such as large-scale social surveys, sampling would typically be random to maintain its fidelity to the rules and assumptions of inferential statistics (Blalock 1972). However, some quantitative studies merely seek to provide numerical descriptions of their samples without pretence to identifying patterns of statistical significance.

Results from random samples can be identified as statistically significant, for example if two sample means are dissimilar enough to reject the null hypothesis that there is no difference between them. A false positive in such a situation is known as a Type 1 or 'alpha' (α) error. The generally accepted convention is that if Type 1 error is less than a 1 in 20 probability, the result can be described as statistically significant. Thus $\alpha < 0.05$ means that there is a less than 5% chance that the apparent statistical difference is actually random and non-significant (based on all the assumptions of statistical theory). Of course, it follows that, in principle, for every 20 findings that are published using these measures of statistical significance one can be attributed to 'chance'.

There are numerous statistical tests available for this purpose, including *t*-, *z*- and *F*-tests. The first two of these—the *t* and *z* tests—assume that the sample represents a

3. Quota sampling typically involves some form of consistently applied rule, for example sampling all the even-numbered houses in a housing estate.

random selection from a normally distributed population. Such assumptions restrict the range of phenomena that can be addressed using quantitative, statistically representative sampling (also see Ritchie 2003).[4] Indeed, it is possible to argue that quantitative methods are most powerful for measuring central tendencies within a data set and macro-level social stability or change within a society. As such, they were deemed to be of less use to the requirements of the ISOTOPE project.

In contrast, much early qualitative research targeted borderline phenomena occurring within less well-defined, difficult to access or emerging populations unlikely to satisfy the requirements of random or quota quantitative sampling. The nascent community of practice around science outreach and public engagement is just such an ill-defined, hard to reach and still coalescing population. No one knows the boundaries of this population, nor its precise descriptive statistics (cf. Mesure 2007), a situation that is unlikely to change in the near future. Thus, obtaining a representative sample of this population in quantitative terms would be very challenging, requiring significant resources to do so effectively and with any confidence. Therefore, the ISOTOPE project employed qualitative or structured sampling techniques to examine the views of this heterogeneous population.[5]

The primary goal in qualitative sampling is to maximize validity within the bounds of practical constraints. One sampling technique used when practical constraints are high is *snowball sampling*. This involves identifying one member of a difficult-to-reach population and asking them to connect the researcher with other members of the group. This same procedure is repeated with the new contacts and so on, snowballing until the sample is complete. Another method of gathering participants is *convenience sampling*. As the label suggests, this refers to the selection of easily accessed participants, even if they are not ideal from a methodological or theoretical perspective. Both snowball and convenience sampling should only be used as a last resort. Each of these techniques may introduce substantial researcher-based bias, which can potentially compromise the validity of the study's results. That is, if participants are selected based on the researcher's convenience, the sample is generally less likely to be representative of the larger population under study.

The ISOTOPE project made limited use of convenience sampling by including Open University staff in the sample and holding one focus group at the main Open University campus in Milton Keynes. However, sampling for the ISOTOPE project was primarily conducted through open invitations e-mailed to universities, non-governmental organizations (NGOs), schools and amateur science groups asking to hear from people with

4. Ritchie (2003) argues that social researchers routinely employ these statistical tests in violation of such assumptions, suggesting that social scientists tend to use inferential statistics metonymically to communicate probabilistic metaphorical messages about their data just as one might say in normal conversation, 'I am 99% certain about this'.

5. We note, however, that it is possible to investigate clearly defined sections of this larger, diffuse community of practice using quantitative sampling techniques. For example, the jointly funded Royal Society, RCUK and Wellcome Trust (2006) survey investigated scientists' and engineers' perceptions of science communication, in particular focusing on aspects of the science outreach and public engagement agenda.

experience in science outreach or public engagement. This yielded a *self-selected* sample wherein individuals decided for themselves whether they met the criteria for inclusion in the study. From a quantitative perspective, self-selected samples are problematic as they are inherently non-random. However, for a qualitative study such as the ISOTOPE project, self-selection is preferable to researcher-imposed selections in most instances. This is because the goal of qualitative research is to gather authentic views and experiences from participants' perspectives; in other words, the aim is to maximize validity.

The range of available qualitative data collection methods

Having established that a qualitative study was most likely to be appropriate for exploring key questions about diffuse communities of practice such as science outreach and public engagement, the ISOTOPE project still needed to select the particular methods of data collection that would best access this population and address the dual research aims identified above. The main methods of qualitative data collection in the social science literature are open-ended questionnaires, interviews, focus groups and ethnographies, the last of which is based on participant observation.

Using questionnaires

Also known as survey research, questionnaires are most frequently used as a means of obtaining breadth of knowledge about a research topic. They can be completed over the phone, in hard copy or online—and by respondents or (social/market) researchers. They provide a straightforward method for collecting demographic details, also relatively surface-level information from respondents, for example in the form of tick-box, multiple-choice or yes/no answers.

Questionnaires can also contain fixed response options for each survey item. For example, a survey question from one component of the UK *GM Nation?* government-sponsored public consultation (see Irwin, Chapter 1.1 this volume; Thomas 2009 for discussion) asked for respondents' level of agreement with the following statement: 'I believe GM crops could help to provide cheaper food for consumers in the UK'. The response options were 'Agree Strongly' to 'Agree' to 'Don't know/unsure' to 'Disagree' and 'Disagree Strongly'. This 'level of agreement' measure is known as a Likert scale, and it is a common structure for many questions within quantitative social surveys. For such fixed response questions, the phrasing of the statement or question is crucial, and should be carefully designed to minimize bias.

This pre-framed survey method is often aimed at producing quantitative data that can be subjected to statistical analyses—see above for discussion. This is an efficient method for producing generalizable findings about large, well-defined populations. Moreover, it tends to yield results that can be tested and re-tested to assess their reliability. Without a qualitative component though, the validity of the survey measures can be difficult to gauge. However, the questionnaire method can also be calibrated to assess participants' views in more depth by introducing open-ended questions, inviting respondents to provide more extended answers in the form of qualitative data. Instead of imposing fixed response options, open-ended questions relocate some of the framing power of the survey instrument by allowing participants to define the parameters of their responses—length, structure and content. This is particularly important in exploratory research, such as ISOTOPE, when there is a greater danger of prematurely foreclosing on specious conceptualizations of the population under study. In addition, it can infuse the results of accompanying quantitative measures with greater validity.

Using focus groups

Sociologist Erving Goffman (1961, p. 18) explicated the methodology of focus groups under the synonym 'focused gatherings', defining them in terms of their 'single cognitive focus of attention; a mutual and preferential openness to verbal communication . . . an eye-to-eye ecological huddle'. Kitzinger and Barbour (1999, pp. 4–5) extend this definition by arguing that:

> Focus groups are group discussions exploring a specific set of issues. The group is 'focused' in that it involves some kind of collective activity – such as viewing a video, examining a single health promotion message, or simply debating a set of questions. Crucially, focus groups are distinguished from the broader category of group interviews by the explicit use of interaction to generate data. . . . Focus group researchers encourage participants to talk to one another: asking questions, exchanging anecdotes, and commenting on each others' experiences and points of view.

It follows that, if the structure and purpose of focus groups are carefully designed, they have the potential to facilitate analysis of the similarity and diversity of opinions on a particular issue from a variety of research participants (Kitzinger 1994). Thus, they were selected as the main research method for the initial ISOTOPE study because they allow a number of participants to discuss a particular issue—their experiences of science outreach and public engagement—in a supportive environment, using their own language and terminology (Kitzinger 1994; Holliman 2005). By setting the stage for primarily participant-generated data, focus groups can have clear benefits for increasing the validity of a study. (For a more detailed explanation for how focus groups were used in the ISOTOPE study, see Holliman and Jensen, Chapter 1.3 this volume.)

Using ethnographic methods: participant observation

Etymologically, 'ethnography' literally means writing about people. It is often based upon the data collection method of participant observation. The most vocal early advocate of this method was the anthropologist Bronislaw Malinowski (1922), who conducted his first ethnographic fieldwork in the Trobriand Islands near Australia around the time of World War I. Malinowski exhorted academics to immerse themselves in the environment of their subjects; to become an active participant within the community under study. The argument was that through extended first-hand participation and observation it might be possible to penetrate the surface level of a particular culture or subculture to address what Malinowski called 'the imponderabilia of actual life':

> Here belong such things as the routine of a man's working day, . . . the subtle yet unmistakable manner in which personal vanities and ambitions are reflected in the behaviour of the individual and in the emotional reactions of those who surround him.
>
> Malinowski (1922, pp. 18–19)

Moreover, 'thick description' of everyday life allows for a highly valid account of the behaviour of participants. Anthropologists conduct their research over extended time periods, often for years at a time. However, the underlying anthropological method of participant observation can be abstracted from this context and used in research conducted over any period of time—even just a few hours.

Rather than generating transcripts of spoken interactions or questionnaire data, participant observation tends to be recorded in the form of descriptive field notes, written by the researcher participating in the phenomenon under study. Within the spectrum of research methods, participant observation is therefore skewed towards the qualitative goals of 'depth' and fullness of description (as well as validity).

Participant observers seek to immerse themselves in the research context and to experience the phenomenon from the participants' point of view. While interviews and self-report data can still be important supplements to ethnographic field notes, the additional experiential dimension of direct observation lends a level authenticity and texture to the researcher's account that cannot easily be secured through other methods of data collection.[6] As with other depth methods, the trade-off is that the sample sizes tend to be small. Given the challenges of negotiating access, ethnographers frequently must rely on the less desirable methods of snowball and convenience sampling in order to recruit participants willing to be observed and recorded over long periods of time.

The ISOTOPE project will use an adapted form of participant observation to examine the efficacy of the prototype web resources, currently being commissioned based on the findings from the preliminary questionnaire and focus group study. One of the main web portal resources will be science outreach or public engagement (SCOPE) activity templates authored by practitioners to address the needs identified through the preliminary study. These templates are designed to act as 'off-the-shelf' recipes that SCOPE practitioners can download and use effectively. To evaluate these templates, ethnographic evaluation research will be conducted. First, a more or less typical SCOPE practitioner will be asked or commissioned to enact one of the activity templates created for the web portal. ISOTOPE researchers will then evaluate the efficacy of the activity using a combination of participant observation, questionnaires completed by other participants and interviews with practitioners about their experience using the template. The participant observations will provide direct evidence about the activity and its impact, unmediated by practitioner self-reports. This will also provide an interesting source of comparative data between the observers' field notes, audience questionnaires and practitioner perceptions of the SCOPE event.

6. Philosophically, the experiential dimension of ethnographic research reflects Heidegger's (2000/1962) insights regarding the uniquely human sense of 'being there' [*Dasein*], fully engaged and self-aware within the social world.

Quantitative versus qualitative data analysis

Under normal circumstances, each of the above methods of data collection is ultimately reduced to textual data in some manner.[7] Open-ended questionnaire responses, focus group transcripts and field notes are all forms of qualitative data, which should be analysed systematically in order to draw reliable and/or valid conclusions about the phenomenon under study.

Most qualitative data can be analysed using either a quantitative or qualitative framework, or both. Quantitative analyses will often involve counting words, concepts or other responses within a defined sample of textual data. Qualitative analyses could include forms of discourse analysis, metaphor analysis, ideological analysis, etc. Quantitative coding can offer a reliable, statistical description of the data in terms of the concentration of particular packets of meaning within the sample. This includes the calculation of *inter-coder reliability* (see Holliman and Jensen, Chapter 1.3 this volume). Based on a second coder reanalysing 10–20% of the data set, a *kappa* statistic or Pearson's *r* can be determined using a statistical software package such as SPSS (Statistical Package for Social Sciences). While unable to offer such statistical verifications of reliability, qualitative data analysis can provide 'thick description', in-depth understanding and highly valid accounts of participants' lived experiences. An additional alternative is the construction of a 'mixed' analysis utilizing both quantitative and qualitative analyses in concert. This approach was used in the ISOTOPE project to analyse the preliminary questionnaire study, first using quantitative analysis, and then developing these findings further through qualitative analysis. This mutually supportive analytic structure yielded many of the benefits of 'complementary assistance' discussed by methodologist David Morgan (1998, in press). Research motivated by 'complementary assistance' 'uses different strengths by connecting methods so that one contributes to the performance of another' (Morgan, in press, p. 75). Finally, whether quantitative, qualitative or mixed, most systematic approaches to data analysis rely upon a process of coding and thematization in order to make the data manageable and coherent.

Quantitative and qualitative coding of qualitative data

It is through rigorous and systematic analysis that research results can be derived from data in a reliable and valid manner. With qualitative textual data, most researchers begin their analyses by conducting line-by-line coding. Specifically, 'open coding' can be a useful way to begin when one is facing a corpus of unstructured text-based data. Strauss and Corbin (1990, p. 74) define open coding as 'the analytic process by which concepts are identified and developed in terms of their properties and dimensions'. This is accomplished by asking mental questions about the data, making comparisons, developing labels and groupings for similar phenomena, and beginning to form categories

7. If quantitative data have been obtained, such as responses to a closed-ended Likert scale, then data analysis will be relatively straightforward.

(e.g. Strauss and Corbin 1990). The next step is to apply 'axial coding' which essentially consists of reconstructing data 'in new ways by making connections between a category and its subcategories' (Strauss and Corbin 1990, p. 97).[8] In the ISOTOPE study both of these coding procedures were carried out on the entire sample using computer-aided qualitative data analysis software (CAQDAS). Such software performs a similar function for qualitative data analysis as a word processor does for writing.

Quality in qualitative research

There is a growing body of methodological literature advocating quality assurance techniques (cf. Kvale 1996) to facilitate 'distinguishing properly from improperly conducted qualitative research' (Thorne 1997, p. 117), and assessing the 'calibre of the study' (Johnson and Waterfield 2004, p. 129). Flick (2002, p. 280) argues that 'the failure of qualitative research is discussed much too seldom', thus giving the false impression that all issues related to the validity of qualitative research are already settled. Although further elaboration is certainly needed to develop firm, accountable criteria about what represents 'good practice' in qualitative analysis (Gaskell and Bauer 2000, p. 336), there is substantial agreement about some of the ways in which quality can be evaluated in a qualitative study. While some (e.g. Silverman 2000, p. 175) have attempted to apply the concepts of validity and reliability directly from the domain of quantitative methodology (albeit with a revised logic), many methodologists have begun using alternative criteria designed specifically for evaluating qualitative studies. Indeed, Thorne (1997, p. 118) argues that 'much of the "bad" qualitative research' in the social science literature is the result of 'the inappropriate application of quantitative quality measures'. As Gaskell and Bauer (2000, p. 342) note, 'sampling, reliability and validity have served quantitative research well, but are just not appropriate for the evaluation of qualitative inquiry'. The functionally equivalent evaluation criteria they recommend include: reflexivity, thick description, transparency and procedural clarity and deviant-case analysis (ibid.). The ISOTOPE project employed three of these techniques in order to maintain and self-assess quality in the preliminary studies: thick description, transparency and procedural clarity.

First, thick description involves the presentation of extended verbatim extracts from the data, which empower the reader to either agree with the researcher's conclusions or to come to different interpretations. 'The term "thick description" or "dense description" is used when context, meanings and interpretations that elucidate the research process are provided, rather than mere statement of facts independent of intentions or situations' (Johnson and Waterfield 2004, pp. 127–8). Done correctly, this procedure should bring readers 'into the social milieu of the social actors', providing 'insights into the local colour, the language and the life world' of the agents under study (Gaskell and Bauer 2000, p. 347). This form of quality assurance was thoroughly developed in the presentation of ISOTOPE research results elsewhere (Holliman *et al*. 2007; Holliman and Jensen, Chapter 1.3 this volume). Rather than proffering isolated quotes of one to three words

8. The third form is selective coding, which is used to deductively test a core category once it has been constructed.

or a single sentence, longer segments of text have been displayed wherever possible to exemplify more of the depth and richness of the original data set.

In addition to providing thick description within the research report, Johnson and Waterfield (2004, p. 127) identify the importance of maintaining a methodological 'audit trail'. This idea 'derives from a fiscal audit that looks for sources of error or deception by examining the way in which the accounts are kept'. This method of quality assessment was addressed in this study primarily through the use of CAQDAS. Gaskell and Bauer (2000, p. 346) argue that CAQDAS compels transparency and procedural clarity 'by technological fiat'. The use of CAQDAS software allowed each step of the analytical process to be digitally captured and maintained for later re-evaluation. This software-based capability can be invaluable when it comes to maximizing procedural clarity and transparency in the data analysis process, in particular when working with large data sets.

Incorporating research findings into an action plan

Within the action research framework, data collection and analysis must feed into some form of related action. This imperative can be explicitly designed into the data collection methodology, with specific questions or observations centred on potential options for action. However, action researchers do not always begin their study with specific actions in mind. In such cases the action plan is emergent from the data. That is, an initial phase of data collection is conducted to produce knowledge about the research topic. The results are then used to guide the selection, design and content of the researcher's intervention.

This emergent approach to action research was employed in the ISOTOPE project. Relatively broad and open-ended questions were put to science outreach and public engagement practitioners, the analysis of which yielded participant-driven specifications of the required actions. Several desired resources were identified by multiple participants within the study, providing the researchers with a clear direction for action (Holliman *et al.* 2007). These ideas were then considered in light of the existing academic literature in order to fashion an action plan that is both practitioner guided and critically informed.

The challenges and promise of investigating public engagement with science

There were few rigorous studies of the role of science communication in science–society relations until about three decades ago. Today, this is a flourishing field of social research (see Hansen, Chapter 3.1 this volume). As sciences change and expand in new and sometimes unexpected directions, social researchers should adapt their methods to develop studies that are both relevant to practice and revelatory of social scientific phenomena. The contemporary context offers analysts a rich buffet of important research questions to explore, not to mention sponsors of social research. At the same time, there are certain challenges specific to this field of study.

One key challenge is the problem of identifying and recruiting participants from amongst the population of non-institutional science communicators. Indeed in the ISOTOPE project, 'pro-ams' (Leadbetter and Miller, 2004) proved to be one such difficult-to-reach population. Invitations were sent to dozens of amateur groups, including amateur ornithologists, astronomers and geologists. In the end though, there was only one positive response. Given the difficulties, such populations may require the use of sampling techniques originally developed for research on 'at risk' populations such as sex workers and drug users, who are difficult to reach for obvious reasons. One such technique is snowball sampling (reviewed above).

A second challenge in conducting studies of science–society relations concerns the potential problem of an often unspoken and uncomfortable lack of engagement between scientists and social researchers. Specifically, there is sometimes a lack of trust between these communities, exemplified most recently by the 'science wars' (Mellor 1999). This attitude can make recruitment of scientists to social research difficult at times, especially if the aims and objectives are not clearly apparent or discussed and agreed with research participants. Of course, discussion of topics not seen to benefit the 'image of science', e.g. by delving into a potentially controversial aspect of science such as nuclear weaponry, genetic engineering or vivisection, may also be met with a lack of enthusiasm from potential research participants.

If resistance is encountered consistently, one potential strategy is to employ a modified snowball sampling technique wherein a scientist is asked to serve as a gatekeeper to help recruit other scientists at her or his institution. Alternatively, the imprimatur of the head of department or some other high-status scientist indicated on the contact letter or advertisement can ameliorate such resistance. However, the shift towards the discourse of public engagement may be lessening historical resistances such as this.

The ISOTOPE project attempted to negate such issues in advance, both in how the research was initially conceptualized, by choosing an active research approach that incorporated a co-production dimension within the project (emphasized in recruitment letters), and second by the development of a core management team that included scientists from a range of disciplines and social researchers. Members of this team were based within the Science Faculty at the Open University, having worked together successfully on previous collaborative projects. As such, a level of trust and mutual respect was apparent within the team prior to the start of the project.

Final reflections

This chapter has emphasized the importance of making active research choices on the basis of one's goals, while identifying the potential pitfalls that may detract from these goals. By maintaining the research question(s) as one's methodological sextant, the research design will be able to withstand the inevitable adjustments and course corrections required as a study unfolds without veering off course. The ever shifting horizon of scientific practices in a globalized world requires vigilance and forward planning in order to develop high quality investigations of science–society relations in the 21st century.

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FURTHER READING

- Babbie, E. (2000). *The Practice of Social Research*, 9th edn. Thomson Wadsworth, Belmont, CA. This classic text provides a highly readable overview of social science research methods striking a perfect balance between breadth and depth in the descriptions of the various methodological options (as well as their benefits and drawbacks).
- Kitzinger, J. and Barbour, R. (ed.) (1999). *Developing Focus Group Research: Politics, Theory and Practice*. Sage, London. This edited collection provides an extended presentation of the methodology, theory and practices of focus group research, drawing on a series of case studies.
- Silverman, D. (2000). *Doing Qualitative Research: a Practical Handbook*. Sage, London. As the title suggests, this well-written book is particularly useful for providing specific, practical advice about conducting qualitative data collection, analysis and write-up.
- Somekh, B. (2006). *Action Research: Methodology for Change and Development*. Open University Press, Buckingham. In this book the author draws on over 15 years of experience of using action research to effect change, primarily in educational settings. In so doing, Somekh introduces eight methodological principles for action research that are applicable to anyone considering this approach.

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USEFUL WEB SITES

- **Online Questionnaire Builder and Host Site**: **http://wufoo.com/**. This site offers ready-to-use, flexible templates for constructing and hosting a qualitative, quantitative or mixed questionnaire online, with no software or programming knowledge required. Results are automatically captured in a spreadsheet format downloadable directly into Microsoft Excel. There is an option to run a questionnaire using this site for free.
- ***International Journal of Qualitative Methods***: **http://www.ualberta.ca/~ijqm/english/engframeset.html**. This free-to-view open access online journal provides easy access to high-quality articles about qualitative methodology, including both practical and philosophical issues.
- ***Social Research Update***: **http://sru.soc.surrey.ac.uk/**. Using a newsletter format, this free-to-view open access online publication offers useful and interesting articles on various aspects of qualitative research practice and methodology, including most of the topics addressed in this chapter.

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