Using the Internet in mathematics education research

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The Internet is a new and exciting technology. It offers enticing and seductive possibilities as a research tool. Simultaneously, it presents a number of challenges to current accepted research practices. Access to its capabilities and the amount of information available have expanded rapidly. In this paper we discuss several issues in the use of the Internet to conduct research. We also outline some of the difficulties we encountered in our initial explorations of the Internet's potential as a source of gathering survey data.

The Internet: Background

The Internet refers to a collection of thousands of interconnected computer networks that function as a single, large virtual network. Data can be stored in a variety of forms, eg., text, graphics, audio, video/movie, and computer language (software) and are found on different types of sites eg., Gopher servers, World Wide Web (WWW) sites, FTP (File Transfer Protocol) sites, and Telnet sites. Information and other data can be transferred, downloaded (saved), viewed and printed via Web browsers (eg., Netscape) and associated software. Usernet news groups, listservers (electronic mailing lists) and e-mail are communication options available via the Internet. IRCs (Instant Relay Chats) allow real-time 'conversations' and interactive games can be played through MUDs (Multi User Dimensions) and MOOs (Object Oriented MUDs).

Access to the Internet has expanded rapidly in the last decade. De A'Morelli (1995/6) notes that the number of computers connected to the Internet has grown from 5,816 in 1985 to 1.2 million in 1995. The number of people sending and receiving e-mail is purported to have increased from 27.5 million in October 1994 to 35 million in July 1995 (The Internet group, 1995). Most Australian academics now communicate via e-mail. It may prove frustrating at times (eg., decoding attachments), yet the ability to send and receive messages quickly and to transfer large amounts of data over vast distances spur us on. The Internet is also beginning to be exploited as a research tool. This presents several challenges and invites cautions.

In this paper we explore the Internet's potential as a research tool and discuss some of the methodological and ethical issues raised. We also describe a study in which the Internet was used as a data gathering source. Some of the difficulties encountered are outlined.

The Research Potential of the Internet

The Internet offers numerous research and publication possibilities which we discuss briefly.

Information sources

Gathering background information for a research project is fairly simple once Internet search techniques have been mastered. Access is available to library catalogues around the world, to a range of databases (eg., ERIC and CARL), to government statistics, and to a plethora of other material stored on the vast number of national and international Gopher and WWW sites. For mathematics education, the number of WWW sites continues to grow. The accessible material shows variety both in content and in quality. Research articles, teaching resources and relevant downloadable software can be found. Electronic mailing lists provide avenues for discussions and information sharing.

For research purposes, the authenticity and reliability of much of the material found on the Internet are dubious and subject to individual judgment. As yet, no hierarchy of electronic journals and WWW sites or guidelines to direct the researcher have been established. MacLennan (cited in Okerson, 1995) advocated the establishment of standards for electronic serials collections and improved search mechanisms to exploit their value.

Citing Internet sources is also problematic. The most recent edition of the American Psychological Association [APA] style manual (APA, 1994) contains a section on the citation of on-line information: "as with any published reference, the goals of an electronic reference are to credit the author and to enable the reader to find the material" (p.28). At this stage, the guidelines provided are indicative, rather than prescriptive. Li and Crane (1995) suggest a number of bibliographic formats in line with APA guidelines, but they do not suggest how to cite within the text. In this paper, we have followed their recommendations and were guided by the APA manual for in-text references.

As noted by Minchew (1996), there are other difficulties associated with electronic source citations: "there is an increasing need for a standard way of citing on-line research. On-line sites may change addresses, move to new locations, be revised, and/or disappear". Thus, article references to Internet addresses may be obsolete before the toner has adhered to the paper. We have followed Li and Crane's (1995) suggestion that access dates be shown in square brackets at the end of the reference. At the time the WWW pages were accessed, hard copies were printed and filed.

Publishing on the Internet

Loading and 'publishing' material on a WWW site is a straightforward process. While some electronic journals claim that articles are subjected to the usual refereeing procedures associated with scholarly publications, many papers located on the Internet do not seem to have passed through any peer review process. McEldowney (1995) claims that "definitions of 'electronic scholarly journals' are still in transition" and that no agreement on 'scholarly' exists.

Copyright and other legal implications associated with loading, reproducing and downloading material to and from Internet sites have been discussed on the Internet (eg., Bailey, 1996; Godwin, 1993; Templeton, ND)

and should keep lawyers busy for some time. According to Alexander (1995)

> ...people with access to these networks have a novel inducement
> to act contrary to the property laws - especially copyright laws -
> which allocate rights over intellectual goods, and it seems likely
> that in fact there is widespread flouting of such laws. (p.1)

In an US Office of Technology Assessment study, *Intellectual property rights in an age of electronics and information*, Garcia (1990) noted that:

> Just as the technologies of printing gave rise to the need for a
> copyright system in the first place, so too the new technologies
> were creating major problems for the system - problems that
> might be solved only by significant changes in the intellectual
> property system itself. (Garcia, 1990, p.1)

Professional safeguards form another related area of concern. Is the same protection enjoyed by academics with respect to traditional publications guaranteed for Internet publications that might subsequently be subject to litigation? It may take test cases to come before the courts for this issue to be resolved. Meanwhile, the Australian Vice-Chancellors' Committee (1995) has noted that electronic data bases are among the categories for which "confusion may result" (p.29) with respect to ownership and intellectual property issues. The ease of publishing on the Internet poses an additional dilemma pertinent to tertiary funding and as an indicator of worthwhile academic pursuits. To what extent will (or should) Internet publications be counted in the research quantum? Recent information on the 1996 research quantum (Smith, 1996) makes no mention of electronic publications.

Research involving the Internet

A distinction needs to be drawn between the types of research involving the Internet. Some work has been reported on the effects of the Internet on student learning. For example, McGill and Jessup (1995) explored the impact of the part delivery of a university education course via e-mail. Traditional survey and interview techniques were used. In addition, the flow of e-mail exchanges between students and their tutors were archived. Despite the students' initial unfamiliarity with the technology, it was concluded that e-mail could be used successfully for course delivery.

Arguably, the research methods used by McGill and Jessup (1995) did not challenge conventional research practice. The participants were a closed and known group. Established ethical considerations with respect to confidentiality of data would have been under the researchers' control. However, when the Internet is used as a substitute for established data gathering methods, sampling concerns and ethical issues arise that challenge accepted research practice.

The Internet as source for data gathering

The Internet appeals as a data gathering tool. E-mail, IRCs and electronic mailing lists are potentially promising sources of participants for research

projects and offer the means to gather survey responses and conduct 'pseudo'-interviews. These Internet facilities appear to offer distinct advantages over traditional research methods eg., the costs and time factors associated with producing, distributing, administering and returning surveys. Since e-mail messages are accompanied by the sender's 'address', incomplete surveys or unclear item responses can be readily followed up, thus reducing missing and unusable data.

On the other hand, the operational aspects of the technology raise interesting challenges about conventional sampling techniques and question the practicality of some of the concerns of Human Ethics Committees.

Sampling issues. For results to be generalisable, samples need to be representative of the population and "this generally requires some aspect of random selection" (Wiersma, 1986, p.263). Can a random sample be obtained on the Internet? Consider mounting a survey via e-mail. Sampling is immediately limited to individuals who access the technology. Questionnaires, distributed through closed distribution lists or mounted on one or more listservers, can easily be forwarded beyond the groups initially targeted. In these circumstances, the researcher loses control over the sampling process.

A recognised advantage of questionnaires is that they permit anonymity, thus increasing the chances of receiving genuine responses (Henerson, Morris, & Fitz-Gibbon, 1978). Is anonymity possible on the Internet? Since e-mail responses automatically provide the sender's 'address', respondents are clearly identifiable and true anonymity cannot be assured. Even with a specifically targeted population, the researcher cannot be confident of the authenticity of respondents. McEldowney (1995) discusses the possible use of "password protections to verify and maintain identity of respondents".

Ethical considerations. Those familiar with the procedures of Human Ethics Committees will be aware of issues of confidentiality and informed consent. While Ethics applications are often tedious to complete, the principles underpinning current recommended procedures aim to protect the rights of the participant. A research project involving school children, for example, requires the permission of the relevant school authorities and school principals, and informed consent is required from all participants including the parents of students. If school children were the target population of a survey or 'pseudo'-interviews conducted via the Internet, could the usual means to obtain the required permissions and informed consent be assured? Have Human Ethics Committees responded to the challenges posed by research designs of this kind?

Gathering data via the Internet does not seem to conform fully to traditional research methods. The Internet cannot and will not be ignored, however. With time, the challenges posed will have to be resolved. At this stage, the prudent researcher would wisely be cautious in the gathering of data from the Internet and in their interpretation.

In the next section a case study in mathematics education is described

in which data were gathered from the Internet.

Using the Internet as a research tool: A case study

In a recent study, the facilities of the Internet were used to gather data. Sampling, ethical and copyright concerns arose, and difficulties with the technology itself were experienced. A brief overview of the aims of the study and of the methods is presented first.

Aims

The study had two inter-related aims:

To determine: (1)   how mathematics and related areas are portrayed in the print media, and

        (2)   whether individual sex-role orientations appear to affect the 'reading' and interpretation of media reports

Method

It is inappropriate to describe the study's methodology, instruments, or results in detail here. Instead, the information provided focuses on the aspects most relevant to the e-mail component of the study and the special issues that arose from using this method of data gathering.

Instruments

(i) Questionnaire. A questionnaire to determine gender role orientations was devised. After extensive trialing of new items and those modified from other relevant surveys and materials, 35 items were retained. In addition to the five-point ratings (from Strongly Agree to Strongly Disagree) elicited from respondents, participants were asked to give reasons for their answers. A sample item is shown below:

    1. Some jobs are unsuitable for women. SA A U D SD

(ii) Print media extracts. Three newspaper articles dealing with gender-related educational and career issues were identified. The first was concerned with increasing enrolments for women at Australian universities, the second with negative social outcomes of feminism, and the third with strategies to attract women to engineering. Respondents were asked to read the articles and answer a series of questions about their content. Thus a link could be made between individuals' questionnaire responses and their reactions to the media reports.

(iii) Biographical information. Respondents were also asked to complete a small number of biographical items (e.g., age, sex, nationality, educational and occupational levels attained) and to indicate where they found the survey.

Procedure

The biographical items, questionnaire and print media materials were e-mailed to five electronic mailing lists: AERA-G, a list for the discussion of the social context of education, GENDER-SET, a list for the discussion of gender, science and technology, XTAR, a teacher research list, EDSTYLE, a learning styles theory and research list, and GRANITE, a gender and information technology list. The following initial information and instructions were given:

Hello! This questionnaire has been posted to mailing-lists concerned with women, gender, feminism, education or a combination of these topics. Sorry for any multiple posts. If you do not wish to take part, please delete this message. If you know of anyone who would be interested in taking part, feel free to circulate. For those taking part, thank you in advance.

Because of the nature of e-mail, responses are not anonymous. They are, however, confidential. If you feel uneasy about responding via e-mail, feel free to use the conventional post. My postal address is attached.

The questionnaire is designed so that you can use the 'forward' or the 'reply' command of your mailer to allow you to fill in your responses and send them back to me. If you have any trouble with the process or your particular mailer won't allow you to enter text into a forwarded message please contact me. My e-mail address is... Please use 'survey' in the subject line...

Please enter your answers directly after each question.

Internet issues

A number of special issues arose. Not all had been anticipated.

Getting approval

Rigid steps to satisfy copyright requirements were added to conditions normally dictated by the University's Ethics committee. (Perhaps our decision to consult the University's solicitor was too cautious. But given the novelty of using the Internet to gather data we felt this to be appropriate.) We required written permission from the three publications in which the articles we used had appeared, as well as from the writers of the three articles. Considerable follow-up was required before six positive responses were received.

The sample

From the outset we acknowledged that our sample was not random. Rather, we anticipated getting responses from self-selected groups with interests in gender, education, research, science and technology. Our mailing-lists had been chosen accordingly. However, by using e-mail as the medium for dissemination of the questionnaire and associated materials, we expected to reach a geographically much more diverse group than would otherwise have been possible with the limited financial resources available. Given that the first 40 responses we received (within two days of 'posting' the material) came from 10 different countries, we can claim to have been successful on that score. What we had not anticipated was the extent to which users of the mailing-lists we had selected would take up the suggestion to circulate the material. The first 40 responses received had travelled via 12 different mailing-lists. Our plans of carefully targeting certain mailing-lists were thus contaminated.

Beyond the questionnaire responses

The ease and speed of communicating via e-mail led to several advantages not usually afforded by questionnaire-based research. Not only were participants quick to respond, but incomplete responses could be followed-up immediately and, in most cases, participants were happy to provide the missing data.

This efficiency was complemented by the flexibility of the e-mail page when compared to a hard-copy questionnaire. In addition to their multiple-choice responses, participants were encouraged to make comments at any stage throughout the questionnaire. The flexibility of an on-line document facilitated this. There was no restriction on the length of comments for those participants with a lot to say, nor any compulsion for those who might otherwise not have completed the rather long questionnaire. Thus, a rich body of data was collected, with volunteered comments available to confirm, clarify or problematise multiple-choice answers.

A further advantage of this electronic medium was that the data did not require transcription. Completed questionnaires received via e-mail were easily transferred to a local hard-disk using FTP. This saved the time and tedium associated with more traditional questionnaire data, particularly because comments and extended answers were collected.

Final comments

In the first part of the paper we indicated how information technology is challenging the boundaries of traditional research. Conventions about random sampling, anonymity, informed consent, citations, copyright and intellectual property, for example, need to be reconsidered.

In the case study described some potential hazards were anticipated. Others emerged as the study progressed. The scope of the study, and the efficiency of its implementation, were clearly affected by the characteristics of the e-mail technology used. Given the undoubted promise of the Internet as a research tool, academic institutions and their staff should address relevant research, educational, legal, and ethical issues, such as those raised in this paper, as a matter of urgency. This will ensure the maintenance of the high research standards to which we have become accustomed.

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