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12 How Internet-Mediated Research Changes Science

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Introduction

Science and the Internet: Its most appealing, usable, and integrating component, the World Wide Web, came from its laboratories. Fifteen years after the invention of the web, it has become such an integral part of the infrastructure of modern societies that young people cannot imagine a world without it. It has become even easier to imagine a world without roads and cars than a world without the World Wide Web.

Time to ask in what ways the Internet had and is having an impact on science. How is what once came from the laboratory influencing that laboratory's structure and the researchers working in it? In particular, how is it influencing the way research is conducted? Tim Berners-Lee, who invented the World Wide Web at CERN in Geneva, wrote in 1998:

> The dream behind the Web is of a common information space in which we communicate by sharing information. Its universality is essential: the fact that a hypertext link can point to anything, be it personal, local or global, be it draft or highly polished. There was a second part of the dream, too, dependent on the Web being so generally used that it became a realistic mirror (or in fact the primary embodiment) of the ways in which we work and play and socialize. That was that once the state of our interactions was on line, we could then use computers to help us analyse it, make sense of what we are doing, where we individually fit in, and how we can better work together.

This quote describes two important issues that are crucial for the topic of this chapter, universality and transparency. *Universality* is a principle underlying both science (Merton, 1942) and the web. Neither works well, if the principle is violated. From the similarity of science and the web, it can be predicted that e-commerce business models only work if they do not violate this principle. Also, it can be predicted that science and the web work well together – possibly not so surprising, because the web was developed at a scientific institution. The second important issue mentioned by Berners-Lee is the notion that the web allows us to analyze interactions of its users and thus gain insight into our lives – the very idea of using the Internet for social and behavioral science: Internet science.

In 1997 I wrote a piece titled "Science in the Year 2007" (Reips, 1998), describing a day in the life of a scientist in 2007 that nowadays doesn't sound surprising at all, even though it contained many technologies and uses of technologies that were not common then. The scientist would wake up in the morning and take a look at the LCD screen hanging at the wall next to her bed, checking reports from remote servers that run her Internet-based research studies, that is, data mining projects, online surveys, and web experiments. She publishes in online journals and bases her text on automatically generated reports with integrated three-dimensional figures. She collaborates via screen sharing and by decentralized work with others on modules of the same project, and communicates in encryptable forum discussions with colleagues she found via a search engine search. Furthermore, she uses living documents that change depending on previously defined factors and uses a web browser that adapts to her language and preferred style of appearance. We are there now.

Finally, in 2003, a report of the American National Science Foundation on initiating the development of “cyberinfrastrucure” suggested that “a new age has dawned in scientific and engineering research” (Atkins et al., 2003). The report continues:

> The amounts of calculation and the quantities of information that can be stored, transmitted, and used are exploding at a stunning, almost disruptive rate. Vast improvements in raw computing power, storage capacity, algorithms, and networking capabilities have led to fundamental scientific discoveries inspired by a new generation of computational models . . . Powerful ‘data mining’ techniques operating across huge sets of multi-dimensional data open new approaches to discovery. Global networks can link all these together and support more interactivity and broader collaboration.

This chapter attempts to provide this new Internet-mediated approach to scientific endeavour with some firm grounding and offers examples of its possible application. First, typical activities by scientists are described and how they have changed under the influence of the Internet. Then, the areas of data mining, data collection, and publishing activities are explored in-depth. Examples show how more interactivity and broader collaboration has manifested itself in the scientific community and beyond.

Dimensions of Scientific Activity

Science and the daily life of scientists have changed in multiple ways because of the Internet. The changes have affected all dimensions of scientific activity: Communication, information gathering, data collection, publication, teaching, and grant acquisition. The Internet supports and integrates scientific activities, resulting in faster research cycles (Figure 12.1).

Communication with colleagues around the world has proliferated in speed and quality since e-mail became available to many universities as one of the early Internet services (e.g., on VAX mainframes), long preceding the WWW (e.g., Freeman, 1984). Because of the small bandwidth needed and its (mostly) text-only nature, e-mail is the most used of all Internet services. Nie and Erbring

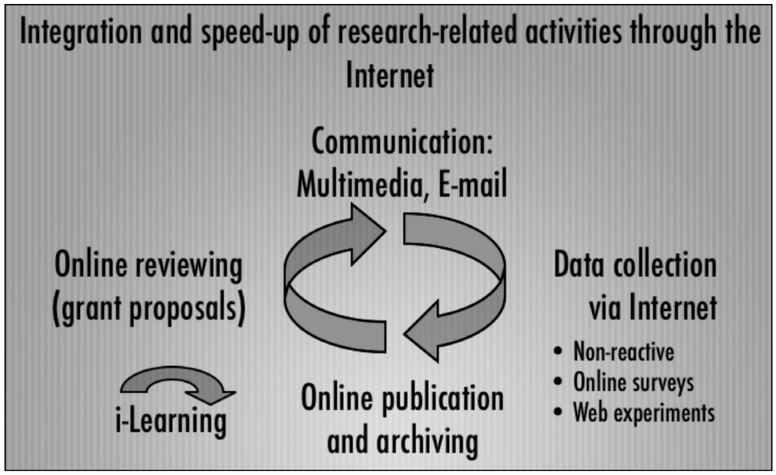

Figure 12.1. *A circle of scientific activities that is influenced and progressively integrated by the Internet.*

(2002) found that "email is by far the most common Internet activity, with 90% of all Internet users claiming to be emailers" (p. 277). However, new developments such as social networking technologies and the ever-increasing improvements in connection speed for a growing audience may change the proportions of user activities on the Internet. Currently, the proliferation of high bandwidth, the peer-to-peer principle, and "killer apps" like Skype (skype.com) is leading to a state of affairs where virtual meetings take place with fewer technical difficulties than ever before. Matzat (2002) reviews the implications of Internet discussion groups for informal academic communication. He concludes that there is no convincing evidence for unified effects of Internet-based communication, such as better transfer of information, production of new knowledge, or intensification of existing contacts. Neither the hypotheses of a growing global village nor the balkanization of academic communication (Van Alstyne & Brynjolfsson, 1996) are trends generalizable across all scientific disciplines and networks.

The core scientific activity, *data collection*, undergoes an unprecedented historical change in scale and number of opportunities in the social and behavioral sciences (Reips, 1997, 2000). Reips (2006) published data from a web service for scientists for the recruitment of online participants, the web experiment list at http://genpsylab-wexlist.unizh.ch/, showing an exponential increase in data collection activities on the Internet. Figure 12.2 depicts an updated chart of this increase, showing that the exponential increase may now turn into a steep linear trend.

Online publication, at least in the form of self-archiving and for per article download fees by journals, is rapidly changing the publication landscape. The activities around the key concept of open access show even aspects of a revolutionary movement (Harnad, 1995, 2001). Closely tied to publication issues is *citation analysis* and related forms of evaluation, which is nowadays

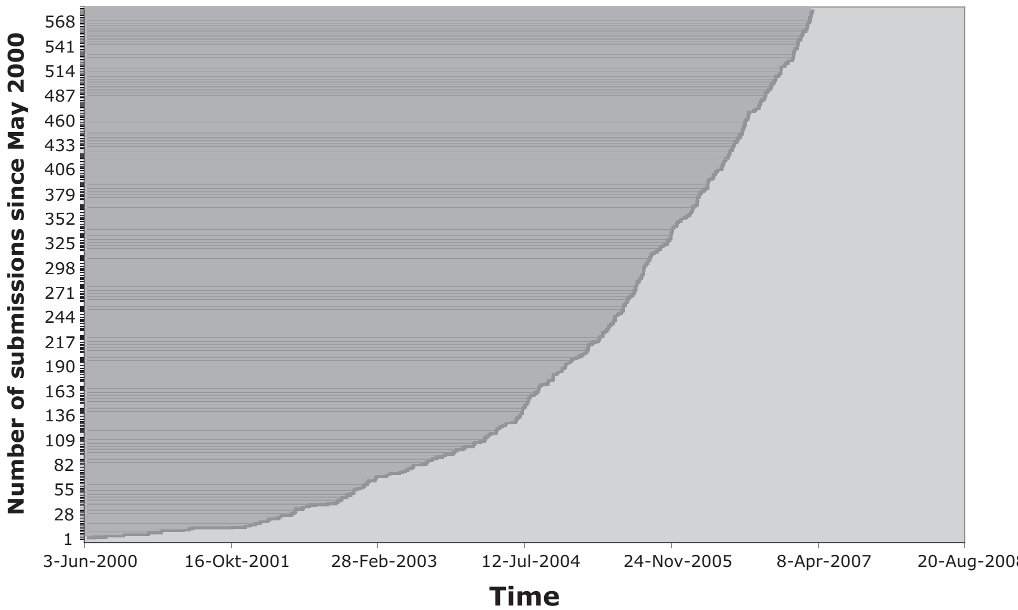

Figure 12.2. *Number of studies registered to the web experiment list and web survey list since May 2000 (earlier studies were entered en bloc and therefore are not included here).*

automatically conducted via large networked publishing databases. Citation analysis, online publication, and Internet-based data collection will be discussed more in detail later in this chapter.

Teaching and *grant acquisition* procedures have also been affected by the Internet. E-learning and i-teaching are proliferating, these activities are beginning to integrate with research activities, particularly in the social and behavioral sciences (Reips & Matzat, 2006). Funding agencies deliver guidelines and forms via their websites, funding proposals, and also proposal reviews can often be submitted via online forms or via e-mail.

And, of course, *information gathering* is supported generally by search engines, specialist websites, and aggregation engines (e.g., folksonomies like Flickr, 43things.com, or YouTube), and specifically by scientific data-mining services (e.g., Google Scholar and Web of Science in bibliometrics).

Internet-based research affects science in multiple ways during the research cycle. I will now take a closer look at one of the core activities in science: data collection and its methods, and how and when it was affected by the Internet.

History and Types of Internet-Based Research Methods

When the interactive WWW became available with the implementation of forms in HTML standard 2.0, the first few pioneers of

Internet-based research discovered that this technology can be used in social and behavioral research. The first HTML-based psychological questionnaires appeared on the Internet in 1994. Krantz, Ballard, and Scher (1997) and Reips (1997) conducted the first Internet-based experiments in 1995. In September, 1995, I opened the first web-based laboratory for experimental studies, the Web Experimental Psychology Lab (http://www.psychologie.unizh.ch/sowi/Ulf/Lab/WebExpPsyLab.html[1]). Early web-based assessments appeared around the same time (Buchanan, 2001; also see review by Barak & Buchanan, 2004). The number of studies conducted via the World Wide Web has grown ever since, the growth curve was empirically shown to follow an exponential path (Reips, 2006), which may now turn into a steep linear trend (see Figure 12.2).

Examples for social and behavioral studies currently in progress can best be found on designated websites, the reader may visit studies linked at the Web Experimental Psychology Lab or at the following Web sites:

- Web experiment list (Reips & Lengler, 2005): http://genpsylab-wexlist.unizh.ch/
- Web survey list: http://genpsylab-wexlist.unizh.ch/browse.cfm?action = browse&modus = survey
- Psychological Research on the Net by Krantz: http://psych.hanover.edu/research/exponnet.html
- International Personality Item Pool by Goldberg: http://ipip.ori.org/ipip/
- Online Social Psychology Studies by Plous: http://www.socialpsychology.org/expts.htm
- Decision Research Center by Birnbaum: http://psych.fullerton.edu/mbirnbaum/decisions/thanks.htm

Tools to create Internet-based studies or response items for web questionnaires, to recruit participants, to include an Internet-based Big Five personality test with one's own study, to analyze log files, and to learn about Internet-based research can be found at the iScience Server at http://www.iscience.eu/ (Figure 12.3).

Types of Internet-Based Research Methods

Internet-based studies can be categorized as *nonreactive Internet-based methods, web surveys*, *web-based tests*, and *web experiments*.

[1] Because Web addresses (URLs) may change, the reader is advised to use a search engine like Google (http://www.google.com/) to access the Web pages mentioned in this chapter. For example, type "Web Experimental Psychology Lab" into the search field and it will return the link to the laboratory as the first result listed. The Web Experimental Psychology Lab can also be accessed using the short URL http://tinyurl.com/dwcpx.

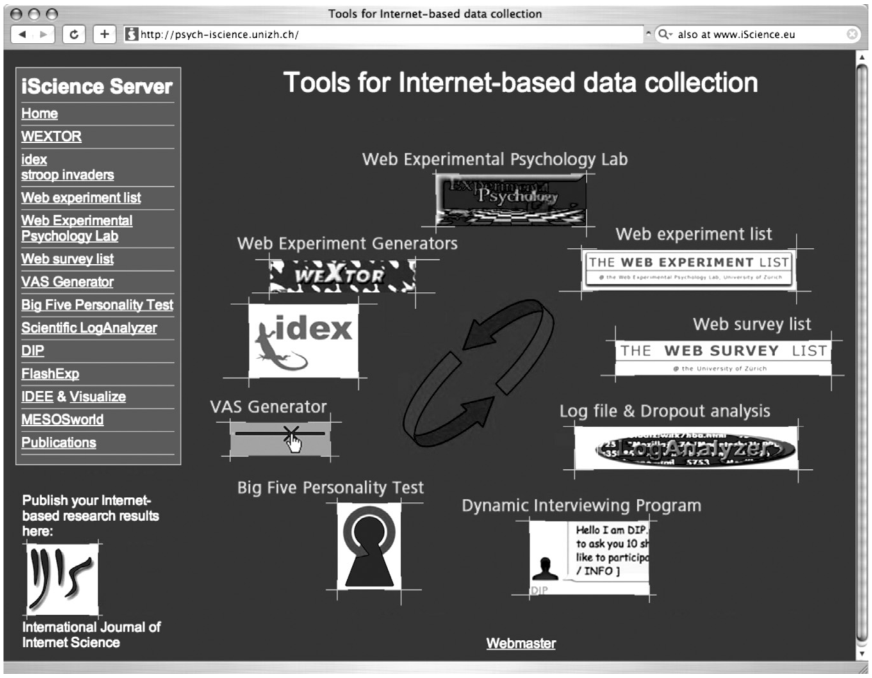

Figure 12.3. *The iScience Server at http://www.iscience.eu/.*

Nonreactive Internet-based methods refer to the use and analysis of existing databases and text collections on the Internet (e.g., server log files or contributions to mailing lists). The Internet provides an ocean of opportunities for nonreactive data collection and data mining. The sheer size of Internet corpora multiplies the specific strengths of this class of methods: Nonmanipulable events can be studied *in natura*, facilitating the examination of rare behavioral patterns (e.g., Fritsche & Linneweber, 2006). For example, Cohn, Mehl, and Pennebaker (2004) studied the online diaries of U.S. users of livejournal.com, a publicly accessible online diary site, for linguistic markers of psychological change surrounding September 11, 2001. With unprecedented precision, they were able to describe pronounced psychological processes in coping with the event. Barak and Miron (2005) examined the writing characteristics of suicidal people on the Internet by analyzing randomly selected freely written forum entries. Compared with other groups (e.g., highly distressed nonsuicidal persons or persons writing in a forum on watching television) suicidal persons had significantly more stable and global attributions, were distinctively more self-focused, and reported more unbearable psychological pain and cognitive constriction.

Recently, a new analytical level was reached with the development of publicly available real-time visualization devices as backends of large data collection services. For example, Akamai, a company that claims to monitor 20 percent of the world's Internet traffic, provides visitors at http://www.akamai.com/html/technology/visualizing_akamai.html with visualization of aggregated

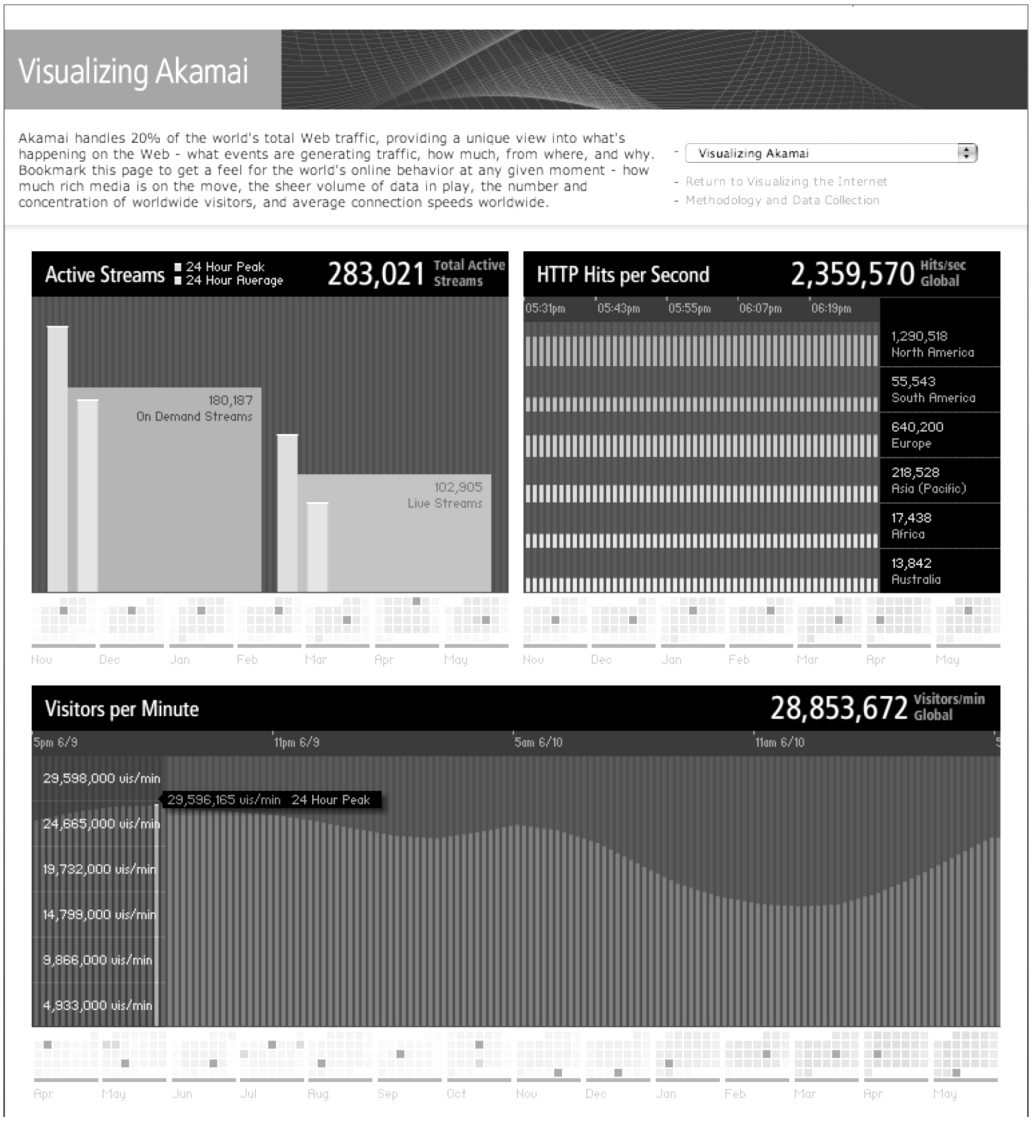

Figure 12.4. *The general Akamai Net Usage Index. Akamai claims to monitor 20 percent of the world's total web traffic.*

nonreactive behavior, including general net traffic by world region (Figure 12.4) and usage statistics for retail, music, and news consumption (Figure 12.5). Peaks in online media consumption, for instance, can be viewed by region and can be linked to compelling news events.

Many other websites, particularly many user forums, news sites, and music sites, begin to display statistics on certain user behaviors ("This story has been read 268 times") or even dynamically adjust their layout by reserving certain attractive spots for frequently viewed, commented, downloaded, or linked

Figure 12.5. *The Akamai Net Usage Index for News. It enables users to monitor sociological and geographic trends of online media news consumption in real time around the clock. The index also features a list of events that may have had an impact on online media consumption.*

items. Depending on the content and on the type of site, self-promoting tendencies may result from the frequency feedback and further limit the questionable value of the resulting statistics.

An early, and more fine-grained example of the use of nonreactive data is the study of communicative behavior among members of several mailing lists, conducted in 1996 and 1997 (at a time when SPAM was a rare phenomenon) by Stegbauer and Rausch (2002). These authors were interested in the so-called lurking behavior (i.e., passive membership in mailing lists, newsgroups, and other forums). By analyzing the number and time of postings and the interaction frequencies pertaining to e-mail headers in contributions, Stegbauer and Rausch empirically clarified several questions regarding the lurking phenomenon. For instance, about 70 percent of subscribers to mailing lists could be classified as lurkers, and "among the majority of users, lurking is not a transitional phenomenon but a fixed behavior pattern [within the same social space]" (p. 267). However, the analysis of individuals' contributions to different mailing lists showed a sizeable proportion of people may lurk in one forum but are active in another. With this result, Stegbauer and Rausch empirically supported the notion of so-called weak ties as a basis for the transfer of knowledge between social spaces.

An (important) example of a nonreactive web-based method is log file analysis. Log files are the raw data that are written each time some information is requested from the Internet. An array of tools is available for log file analysis from web servers. Most of these tools are geared toward web masters of business websites, for example, the public domain analysis tool *FunnelWeb*, available from http://www.quest.com/funnel-web-analyzer/, and the commercial Web log analyzer *Summary*, available from http://www.summary.net/. Data from Internet-based research studies, in particular web experiments, can be analyzed with Scientific LogAnalyzer (Reips & Stieger, 2004). Scientific LogAnalyzer (http://genpsylab-logcrunsh.unizh.ch) reorganizes the log file data to a statistical software friendly one line per participant format and also performs dropout analyses.

Web surveys: The most commonly used web-based assessment method is the web survey. Examples can be viewed at the web survey list (http://genpsylab-wexlist.unizh.ch/browse.cfm?action=browse&modus=survey). The frequent use of surveys on the Internet can be explained by the apparent ease with which web surveys can be constructed, conducted, and evaluated. However, this impression of ease is somewhat fallacious. Work by Dillman and his group (Dillman & Bowker, 2001; Dillman, Tortora, & Bowker, 1998; Smyth, Dillman, & Christian, 2007; Smyth, Dillman, Christian, & Stern, 2006) has shown that many web surveys are plagued by problems of usability, display, sampling, or technology. Joinson and Reips (2007) have shown in experiments that the degree of personalization and the power attributable to the sender of an invitation to participate in the survey can affect survey response rates. Data quality can be influenced by degree of anonymity, and this factor as well as information about incentives also influence the frequency of dropout (Frick, Bächtiger, & Reips, 2001; O'Neil & Penrod, 2001). Design factors like the decision whether a "one screen, one question" procedure is applied may trigger context effects that turn results upside down (Reips, 2002a, 2007). Despite these findings, converging evidence shows that web-based survey methods result in qualitatively comparable results to traditional surveys (e.g., Cole, Bedesian, & Field, 2006; Deutskens, de Ruyter, & Wetzels, 2006; Krantz & Dalal, 2000; Luce et al., 2007; Smither, Walker, & Yap, 2004; but see Buchanan, Johnson et al., 2005), even in longitudinal studies (Hiskey & Troop, 2002).

Where differences between results from online and offline methods are found, there is often an obvious explanation in format (see previous paragraph), sampling, or expertise in using the input device. Established recruitment practices from undergraduate student populations versus visitors of particular websites, for instance, may easily result in sampling differences in background knowledge (Reips, 2000). In a web survey from landscape architecture and environmental planning, Roth (2006) asked Internet participants to rate aspects of landscapes (e.g., visual variety, beauty, visual naturalness, and overall scenic quality) from many different areas in Germany. Reliability of the web-based survey was established via both the test-retest-method and the split-half-method. Validity was shown by comparing the records gathered on the web with data collected (much more costly) during an on-site survey and with a traditional color print–based questionnaire. Results indicate that scenic quality (visual variety, beauty, visual naturalness, and overall scenic quality) can be validly recorded on the Internet, while missing background knowledge on the landscapes presented interfered with the assessment of a landscape's typicality. However, it was also established that demographic differences between groups of raters accounted only for very small portions of variance. Consequently, the results from the web survey have a high generalizability.

Web-based psychological testing can be considered one specific subtype of web surveying. Buchanan and Smith (1999), Buchanan (2001), Preckel and Thiemann (2003), Wilhelm and McKnight (2002), and Wilhelm, Witthöft, McKnight, and Größler (1999), among others, showed early on that web-based testing is possible if the particularities of the Internet situation are considered (e.g., computer anxiety may keep certain people from responding to a web-based questionnaire).

Barak and Hen (2007, Chapter 6) provide an excellent overview of the variety of the areas and purposes, where psychological assessment has been conducted through online instruments and procedures in recent years. Among them they list:

- clinical diagnostics of a variety of problems and concerns
- neuropsychological and rehabilitation assessment needed to enhance a therapeutic technique
- educational assessment needed to evaluate learning
- school-related adjustment
- the selection of candidates for specific study programs
- vocational, organizational, and career-related assessments needed for job selection
- work-related assessment among applicants or employees
- career counseling assessment for identifying personal abilities, interests, values, and personality characteristics relevant for choosing and developing specific career paths
- group and social assessment in order to identify and detect specific factors at work in the group, focus group, community, or organization.

But even though Internet-based assessments are widely used – how is their quality and can the assessments be justified? Buchanan and Smith found that an Internet-based self-monitoring test not only showed similar psychometric properties to its conventional equivalent but also compared favorably as a measure of self-monitoring. Their results support the notion that web-based personality assessment is possible. Similarly, Buchanan, Johnson, and Goldberg (2005) showed that a modified International Personality Item Pool (IPIP) inventory they evaluated appears to have satisfactory psychometric properties as a brief online measure of the domain constructs of the Five-Factor Model. Across two studies using different recruiting techniques, they observed acceptable levels of internal reliability and significant correlations with relevant criterion variables. However, the issue of psychometric equivalence of paper-and-pencil versions of questionnaires with their web-based counterparts remains one that depends on other factors. For instance, Buchanan, Johnson et al. (2005) could only recover two of four factor-analytically derived subscales of the Prospective Memory Questionnaire with a sample of $N = 763$ tested via the Internet. Buchanan and Reips (2001) showed that technical aspects of how the web-based test is implemented may interact with demography or personality and, consequently, introduce a sampling bias. In their study, they showed that the average education level was higher in web-based assessment if no JavaScript was used, and that Mac users scored significantly higher on Openness than PC users (the “Apple effect”).

Web-based experimenting has become a widely used method of experimental research in the social and the behavioral sciences. A number of methods and techniques have been proposed (Reips, 2000, 2002b, 2002c) that promise to be useful to researchers and supportive to the method’s quality. Although some of these techniques have empirically been shown to work (e.g., password techniques, the seriousness check, the warm-up technique [Reips, Morger, & Meier, 2001], the multiple site entry technique [Hiskey & Troop, 2002]), others have not been investigated beyond a theoretical exploration.

A recent trend in web experimenting has been research on effects of procedures and conditions of Internet-based research, such as the influence of social desirability (Joinson & Reips, 2007), information about incentives (Frick, Bächtiger, & Reips, 2001; Göritz, 2006; Heerwegh, 2006), personalization (Joinson & Reips, 2007; Joinson, Woodley, & Reips, 2007; Heerwegh & Loosveldt, 2006), voluntariness and anonymity (Reips & Franek, 2004), progress indicators (Bandilla, Bosnjak, Kaczmirek, & Neubarth, 2004; Heerwegh & Loosveldt, 2006), use of JavaScript (Buchanan & Reips, 2001; Schwarz & Reips, 2001), visual stimuli (Krantz, 2001), visual analogue scales (Reips & Funke, in press), visual grouping (Smyth, Dillman, Christian, & Stern, 2006), animation methods (Schmidt, 2001), types of nonresponse (Bosnjak, 2001), forced response (Stieger, Reips, & Voracek, 2007), survey length statements and survey sponsor logos (Heerwegh & Loosveldt, 2006), or gathering of personal information on drop-out in web-based studies (Frick, Bächtiger, & Reips, 2001; O’Neil & Penrod, 2001). Such effects triggered the development of guidelines in Internet-based research (Reips, 2002c). Another piece of the frame has been the development and evaluation of several web experimental techniques, such as the *multiple site entry technique*, the *warm-up technique*, the *high hurdle technique*, *experimental design for dropout analysis* (Reips, 1997, 2000, 2002b, 2002c), and custom *randomized response techniques* (Musch, Bröder, & Klauer, 2001).

Although web experiments seem to produce valid results if conducted properly (e.g., Krantz & Dalal, 2000), there is an alarming potential for "configuration errors" (Reips, 2002b). Just as these errors on part of the experimenter can be shown to bias experimental results, there may be biases caused by interactions between psychological processes in Internet use and the widely varying technical context (Reips, 2000; Schmidt, 2007).

Online Publication

Publishing has probably been influenced by the Internet and the new media in general like no other area of profession. The rapid changes in technology, workflow, automatization, and integration of publishing processes reflected in terms such as *cross media*, *blogging*, and *digital preservation* have also captured scientific publishing. The relationship between scientists and publishers that had remained mostly unchanged for hundreds of years is in turmoil. From the viewpoint of scientists, the new developments offer the opportunity to get rid of a burdensome necessity that often procrastinated or even suppressed the free flow of ideas and communication.

Open Access Publishing

Scientists and their institutions are moving fast toward the adoption of open access publishing and institutional or individual self-archiving. In some sciences, like physics, this process began early and is almost completed – thanks to a strong community-based working attitude and efforts by individuals like Paul Ginsparg, who created the famous e-print server arXiv (Brown, 2006). Open access publishing and self-archiving has long been advocated by Stevan Harnad (e.g., Harnad, 1995, 2001). In his analysis of "Zeno's paradoxon" (Harnad, 2001), he writes:

> Researchers, librarians, publishers and university administrators have so far been held back from self-archiving by certain prima facie worries, all of which are easily shown to be groundless. These worries are rather like "Zeno's Paradox": "I cannot walk across this room, because before I can walk across it, I must first walk half- way across it, and that takes time; but before I can walk half-way across it, I must walk half-half-way across it, and that too takes time; and so on; so how can I ever even get started?" This condition might better be called "Zeno's Paralysis."

It seems time to state the end of Zeno's paralysis in scientific publishing. From a few pioneering open access journals like Harnad's *Psycholoquy*, their number has now grown to more than 2,200 (*Directory of Open Access*

Journals, 2006). Examples include journals published exclusively online, such as *Sociological Research Online* (founded in 1996), the *Journal of Computer-Mediated Communication*, the *International Journal of Internet Science*, or, recently, the *Journal of Medical Internet Research*. Some journals, for example, *Atmospheric Chemistry and Physics* and other journals by the European Geosciences Union, combine open access with collaborative public peer review. Submitted manuscripts pass a quick check by the editor(s) and then are published as "discussion papers" in the journal's discussion forum, which is ISSN registered, so all contributions to the discussion can be officially cited and are guaranteed to stay permanently archived.

Self-archiving of peer-reviewed publications is popular: 95 percent of authors will comply with institutional self-archiving mandates, as reported in an international author survey (Swan, 2005), and 93 percent of journals already officially endorse author self-archiving, according to a registry of over 9,000 journal policies (University of Nottingham, 2006). Articles that are available online are cited more often (Lawrence, 2001), probably because they are simply more accessible (Hitchcock, Brody, Gutteridge, Carr, & Harnad, 2003).

Citation Analysis

At the late end of the publication timeline are citations and their analysis. Services like Thomson Scientific Web of Science and Google Scholar aggregate millions of references that can be analyzed and put to use in manifold ways. For example, citation links between articles can be tracked backward and forward, similar articles can be found by overlap of reference lists. Evolving trends can be spotted by monitoring publications with quickly increasing citations rates. The Thomson Scientific Hot Papers Database (http://www.in-cites.com/a-prod/sw-hp.html) uses these and other data in defining and monitoring emerging fields.

The emergence of *social web software* turned out to be a hotbed for the development of new community-supported open access citation services. For example, CiteULike (http://www.citeulike.org/) (Figure 12.6). CiteULike was written by Richard Cameron in November 2004, and he is running it privately since then. In telling his thoughts behind the development of CiteULike he delightfully describes the stepwise collaborative and community-building processes behind social software:

> So, the obvious idea was that if I use a web browser to read articles, the most convenient way of storing them is by using a web browser too. This becomes even more interesting when you consider the process of jointly authoring a paper. There is a point where all the authors need to get together and get all the articles they wish to cite into the one place. If you do this process collaboratively on a web site, then it's easier.
>
> The next obvious leap is that if all the references are available via a web interface on a central server, it would be really nice to see what your colleagues

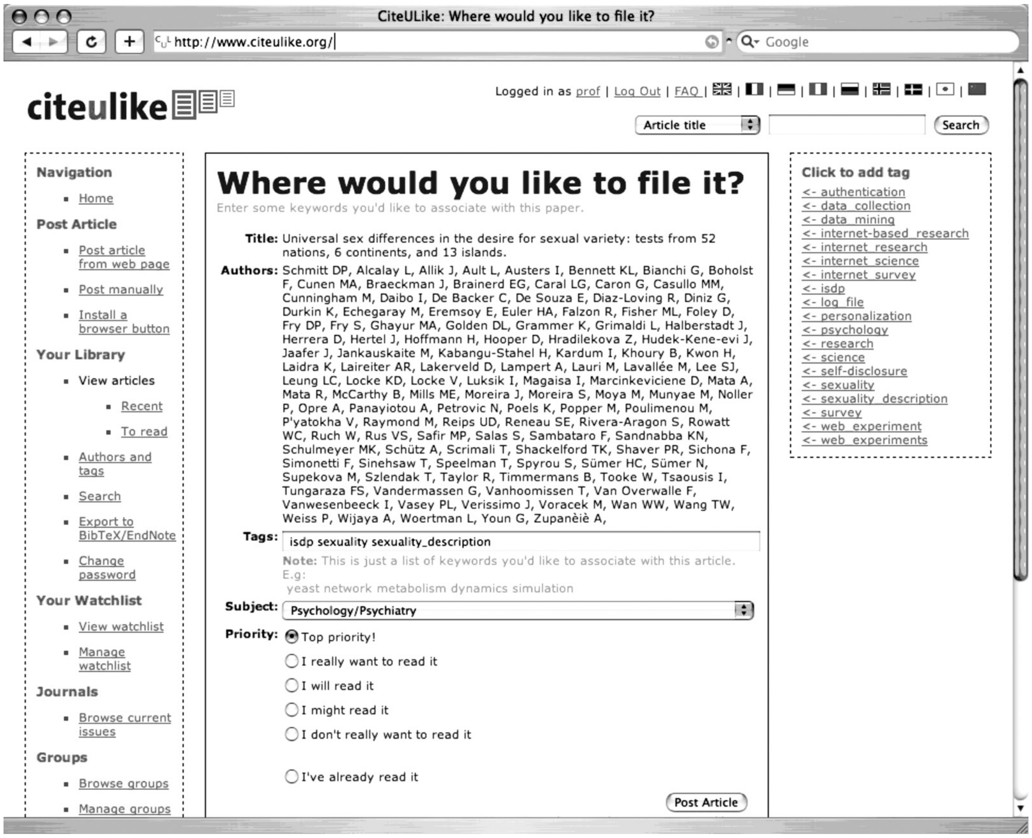

Figure 12.6. *The CiteULike citation service for easy bibliography building by click of a button in archives like CiteSeer or PubMed and many associated Web sites. CiteULike contains tagging features, reminder functions (watchlists), search and filtering, and export options, among others.*

> are reading and be able to show them what you're reading. It cuts down on the number of emails saying 'have you seen this article?'
>
> In fact, if enough users register on the system, you'll probably find people reading the same articles as you. That provides a great way of keeping on top of the literature – you simply share it with people who have common interests.
>
> If we have a model of everyone's library being completely open, then our reference manager has suddenly transformed itself into a piece of social software. That's what CiteULike aims to be.

Another citation service is Zotero (http://www.zotero.org/). It is a plug-in module for web browsers (not a web service like CiteULike) and integrates particularly well with the Firefox web browser. It can sense when users are viewing a book, article, or other bibliography item on the web. On many research and library sites, Zotero will find and automatically save the full reference information. Since it lives on one's personal computer, it can communicate with word processing software, where reference information is needed most.

Integration of Internet-Based Research and Online Publishing

The open access *International Journal of Internet Science* (http://ijis.net) requires authors to include links to the reported Internet-based studies in published articles, so readers can experience what study participants went through. In reference to the high prevalence of nonresponse in Internet-based studies (Musch & Reips, 2000; Reips, 2000, 2002b) authors are asked to report response rates, dropout curves (or dropout rates at least), and item nonresponse rates. It welcomes submission of studies that were planned to analyze types of nonresponse as dependent variables.

Because some scientists begin asking why peer-reviewed articles should be published in commercial publishers' journals at all, if hosting, archiving, and the peer-review process can be organized independently (e.g., via open peer commentary), we are likely to see further rapid development in the publishing market. Particularly, in those areas of the behavioral and social sciences where Internet-based research methods are feasible, an integration of the research with the reports they are published in (demonstrations of the experimental materials within the article or even "live articles" that adapt to changing results, in particular with nonreactive research and data mining) seems only a matter of time.

How Internet-Based Research Methods Change Science

Just as laboratory research was revolutionized by the introduction of computers in the 1970s (e.g., Connes, 1972; Hoggatt, 1977), we are now experiencing a revolution through Internet-based research (Musch & Reips, 2000). And just as computerized research allowed for advances in research methodology such as accurate measurements of response times, item-branching capabilities, and reduction of the tendency to respond in a socially desirable way (e.g., Booth-Kewley, Edwards, & Rosenfeld, 1992), the Internet offers new advantages to the researcher. Of course, because Internet-based research methods are rooted in computer-based assessments, all of the computer-related advantages and disadvantages apply. However, the Internet offers further possibilities. Reips (2000, 2002c) lists and describes about twenty advantages (see Table 12.1), for example, control of motivational confounding, better access to a large number of demographically and culturally diverse participants as well as to rare and specific participant populations, and avoidance of experimenter biases and demand characteristics (Reips, 2000).

Many of the scientifically most valuable advantages of Internet-based science become visible on second view only: ease of access to many participants is one of the first reasons many who contemplate conducting Internet-based studies (Musch & Reips, 2000) cite. But sheer numbers are often not necessary or even corruptive beyond an optimal point (the optimal number of research participants can be determined by a power analysis).

Table 12.1. *Web experiments: advantages, disadvantages, and solutions (adapted from Reips, 2002c)*

Advantages of web experiments	Disadvantages with solutions
(1) Ease of access to a large number of demographically and culturally diverse participants (e.g., a study conducted in three languages with 440 women from more than nine countries; Bohner, Danner, Siebler, & Samson, 2002); (2) . . . as well as to rare and specific participant populations (Mangan & Reips, 2007; Schmidt, 1997). (3) Better generalizability of findings to the general population. (4) Generalizability of findings to more settings and situations (because of high external validity). (5) Avoidance of time constraints. (6) Avoidance of organizational problems, such as scheduling difficulties, as thousands of participants may participate simultaneously. (7) Highly voluntary participation. (8) Ease of acquisition of just the optimal number of participants for achieving high statistical power while being able to draw meaningful conclusions from the experiment. (9) Detectability of motivational confounding. (10) Reduction of experimenter effects. (11) Reduction of demand characteristics. (12) Cost savings of lab space, person hours, equipment, administration. (13) Greater openness of the research process. (14) Ease of access to the number of people who see the invitation but do not participate. (15) Ease of comparing results with results from a locally tested sample. (16) Greater external validity through greater technical variance. (17) Ease of access for participants (bringing the study to the participant instead of the opposite). (18) Public control of ethical standards.	(1) Possible multiple submissions – can be avoided or controlled by collecting personal identification items, by checking internal consistency as well as date and time consistency of answers, and by using techniques such as *subsampling*, *participant pools*, or handing out *passwords* (Reips, 2000). There is evidence that multiple submissions are rare in Web experiments (Reips, 1997). Generally, (2) experimental control may be an issue in some experimental designs, but is less of an issue when using between-subjects designs with random distribution of participants to experimental conditions. (3) Self-selection can be controlled by using the *multiple site entry technique*. (4) Dropout is always an issue in web experiments. However, dropout can be turned into a detection device for motivational confounding. Also, dropout can be reduced by implementing a number of measures, such as promising immediate feedback, giving financial incentives, and by personalization (Frick, Bächtiger, & Reips, 2001). (5) The reduced or absent interaction with participants during a web experiment creates problems, if instructions are misunderstood. Possible solutions are pretests of the materials and providing the participants with the opportunity for giving feedback. (6) The comparative basis for the web experiment method is relatively low. This continues to change. (7) External validity of web experiments may be limited by their dependence on computers and networks. Also, many studies cannot be done by web. However, where comparable, results from Web and lab studies are often identical (Krantz & Dalal, 2000).

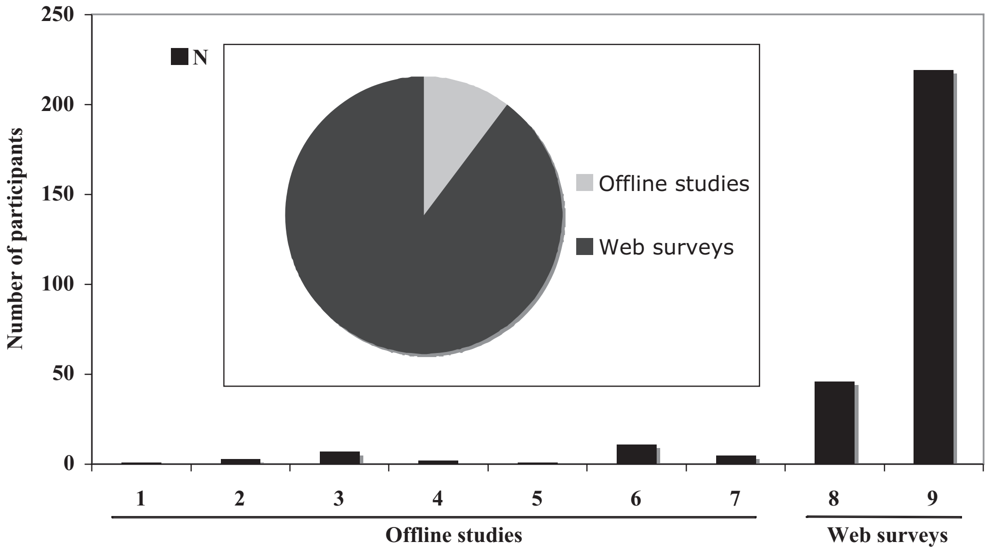

Figure 12.7. *Findings on all nine studies conducted in twenty years of research on the rare condition sexsomnia from Mangan and Reips (2007), highlighting crucial improvements in scientific endeavor regarding rare and sensible conditions made possible by Internet-based research. With two web surveys it was possible to gather data from five times as many people in the target population as in all other (offline) studies combined.*

And the greater variance in sample demographics that in some studies and on a macroscopic level may be seen as an advantage of Internet-based research (Reips, 1997, 2000, 2002b) may also be detrimental in other studies, where a homogeneous sample is sought (Brenner, 2002). Access to rare and specific participant populations, however, is a case particularly suited to advance science via Internet-based research. The following study serves as an example how this advantage nicely combines with the anonymity that can be achieved on the Internet.

Mangan and Reips (2007) conducted web-based research with people suffering from sexsomnia, a newly identified rare medical condition whose sufferers engage in sexual behavior during their sleep. Problematic cases have forensic implications and often are highly distressing. Sexsomnia may frequently go unreported because of shame and embarrassment. Thus, little is known about this condition's demographics and clinical features. Because of the anonymity of the survey situation, the Internet is particularly suited for surveys on sensitive topics, and thus is presented by Mangan and Reips as the method of choice for their research on sexsomnia. With two web surveys it was possible to gather data from five times as many people in the target population as in all seven other (offline) studies combined that cover twenty years of research on sexsomnia (Figure 12.7).

While not exactly a rare population overall, but sometimes so on the Internet, Birnbaum reports that one of his students was able to gather responses from more than 4,000 seniors within seven days. The student recruited her participants via genealogy newsletters (Birnbaum & Reips, 2005). Reported in 2001, Birnbaum sampled members of the Society for Judgment and Decision Making and compared their decision strategies in solving a series of decision gambles with those by students and with those predicted by the society member's own favorite decision theories!

The Wider Picture

The networking characteristic of the Internet is driving a number of revolutionary developments that are likely to profoundly change some areas in the basic and applied sciences. For example, over the past few years it has become possible to combine low-cost *digital health monitoring* devices with a networked database and intelligent software that renders crucial information in a graphical format that is meaningful to someone monitoring the patient or user (Obrenovic, Starcevic, Jovanov, & Radivojevic, 2002) and sends out alarms if necessary. Such i-health systems are able to measure temperature, heart rate, body fat, blood pressure, blood sugar, length of movements, and number of steps taken, among other parameters.

Data sets and interactive visualization of data have become available to a wide audience via the Internet and serve as resources for science, education, and business. A website that turns statistics available from the United Nations and other organizations into *interactive maps* is Globalis. "Globalis is an interactive world atlas . . . that aims to create an understanding for similarities and differences in human societies, as well as how we influence life on the planet." (http://globalis.gvu.unu.edu/). The site can be used to show seats in parliament held by women depending on country or compare the state of the world now with its prognosed state in 2050. Figure 12.8 shows a map of intact forests in North America, that is, larger blocks of forest areas that have seen little impact from human activity.

Pipeline Diversity Analysis (http://pda.uab.es/), is a web service in bioinformatics that can automate the process of searching for and analyzing genetic data via Internet. Biologists can search for small variations in the genomes of different individuals and different species using the data stored in large public genome databases, such as the Drosophila Polymorphism DataBase, which contains all the polymorphic sequences in the *Drosophila* genus. Biological Internet-based research methods of this kind are of immense help to the scientific community in dealing with the large amounts of molecular data that are generated worldwide.

One of the earliest websites for community building on the Internet by taking care of a real physical entity via remote control is the *Telegarden* at the University of Southern California (http://www.usc.edu/dept/garden/). It went

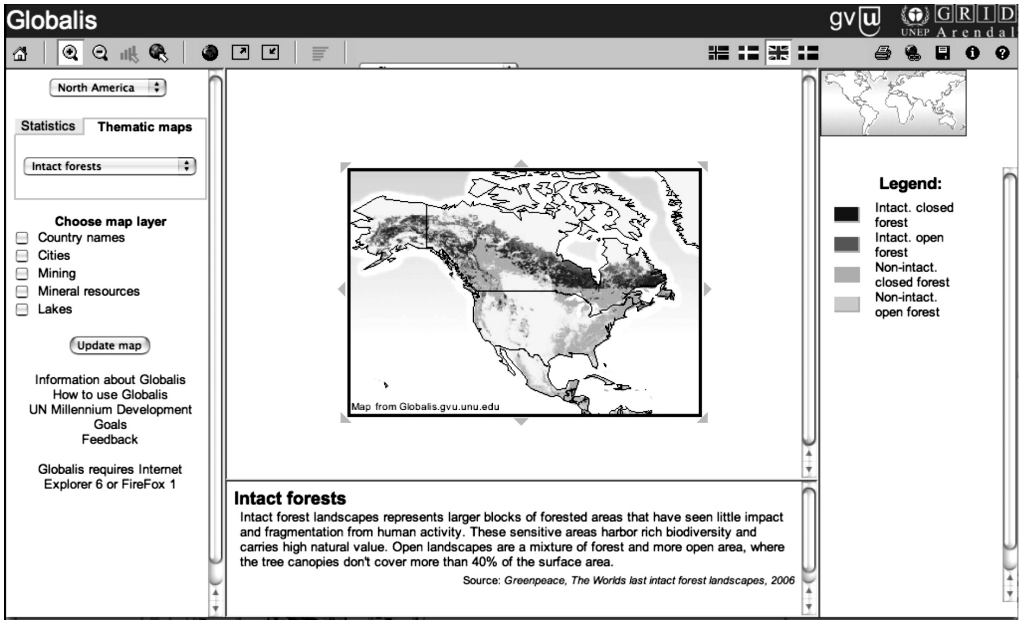

Figure 12.8. *Globalis interactive world maps, generated from statistics by the United Nations and other organizations. The figure shows intact forests, that is, larger blocks of forest areas that have seen little impact from human activity.*

online in June 1995 and later moved to the Ars Electronica Center in Austria (http://www.aec.at/). A robot was installed in the center of a circular garden and fitted with a plant growing light that slowly revolved around the garden (Figure 12.9). The robot could be controlled via Internet by guests or members of the Telegarden, with members having more privileges. Figure 12.10, from the Telegarden demonstration site shows how a user could try his gardening skills via remote mouse control. A forum and the website served as communication devices in community building – and so did the garden itself (McLaughlin, Osborne, & Ellison, 1997). As Randall Packer from the San Jose Museum of Art put it: “The Telegarden creates a physical garden as an environment to stage social interaction and community in virtual space. The Telegarden is a metaphor for the care and feeding of the delicate social ecology of the net.” (http://queue.ieor.berkeley.edu/∼goldberg/garden/Ars/). Eventually, the garden was retired in August 2004, but its memory lives on in the Telegarden archive at http://www.telegarden.org/tg/.

Summary

In this chapter, I have made an attempt to review some of the major influences Internet-based research methods and the Internet have had and continue to have on science. Dimensions of scientific activities were analyzed in respect to changes and innovations coming from the web. Communication,

Figure 12.9. *Telegarden with robot.*

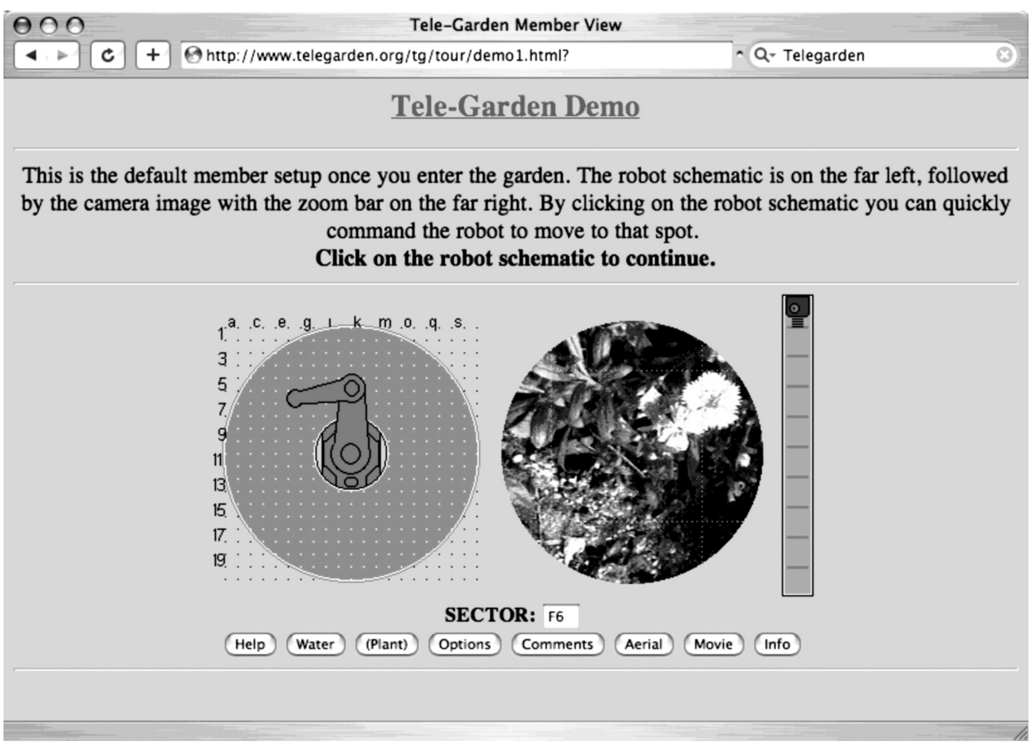

Figure 12.10. *Web-based Telegarden navigation device in demonstration mode.*

information gathering, data collection, publication, teaching, and grant acquisition are all affected, and they integrate progressively well. New technologies are developed that find their way into the laboratories and enable the true enactment of fundamental principles of scientific work: universality, transparency, internationality, and open access.

Internet-related influences on core scientific activities of data collection and publication were presented in detail. The history and types of Internet-based research methods, *nonreactive methods, web surveys, web-based tests*, and *web experiments* was explained. Many examples of Internet-based research were drawn from the behavioral and social sciences because they are more profoundly and in some respects uniquely (e.g., data collection opportunities) influenced by the Internet revolution. Disciplines like psychology, sociology, communication, economics, linguistics, and education experience a surge in Internet-related research. The natural sciences have been leading the path in other Internet-related activities. In particular, physics was at the forefront of adopting open access publishing, and of course, the World Wide Web was developed as a means of communication among physicists. The life sciences, arm in arm with computer sciences, are unsurpassed in developing large collaborative computation sites for analyzing molecular structures. No science seems unaffected, as was shown with examples from medicine, forestry, biology, and landscape architecture, among others.

Science is in the middle of a period of exciting developments that seem to affect the daily activities of scientists more profoundly than anything since the invention of the printing press. Thanks to the Internet, thanks to visionary minds.

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