Original Investigations JAMIA

Research Paper ■

Building a Virtual Network in a Community Health Research Training Program

FRANCIS LAU, PHD, ROBERT HAYWARD, MD, MPH

Abstract **Objective:** To describe the experiences, lessons, and implications of building a virtual network as part of a two-year community health research training program in a Canadian province.

Design: An action research field study in which 25 health professionals from 17 health regions participated in a seven-week training course on health policy, management, economics, research methods, data analysis, and computer technology. The participants then returned to their regions to apply the knowledge in different community health research projects. Ongoing faculty consultations and support were provided as needed. Each participant was given a notebook computer with the necessary software, Internet access, and technical support for two years, to access information resources, engage in group problem solving, share ideas and knowledge, and collaborate on projects.

Measurements: Data collected over two years consisted of program documents, records of interviews with participants and staff, meeting notes, computer usage statistics, automated online surveys, computer conference postings, program Web site, and course feedback. The analysis consisted of detailed review and comparison of the data from different sources. NUD*IST was then used to validate earlier study findings.

Results: The ten key lessons are that role clarity, technology vision, implementation staging, protected time, just-in-time training, ongoing facilitation, work integration, participatory design, relationship building, and the demonstration of results are essential ingredients for building a successful network.

Conclusion: This study provides a descriptive model of the processes involved in developing, in the community health setting, virtual networks that can be used as the basis for future research and as a practical guide for managers.

■ **J Am Med Inform Assoc.** 2000;7:361–377.

Affiliation of the authors: University of Alberta, Alberta, Canada.

This work was supported by the Alberta Heritage Foundation for Medical Research.

Correspondence and reprints: Francis Lau, PhD, Business Faculty, University of Alberta, Edmonton, Alberta, Canada T6G 2R6. E-mail: ⟨francis.lau@ualberta.ca⟩.

Received for publication: 11/8/99; accepted for publication: 3/14/00.

In recent years, such concepts as electronic work groups,[1–3] virtual teams,[4,5] and network organizations[6,7] have become increasingly popular as new ways for groups and organizations to embrace the information age and globalization of business. *Virtual* is defined as "being in essence or effect but not in fact or name," and *network* as "an interconnected or interrelated chain, group, or system." In the context of

work groups and organizations, the notion of a virtual existence suggests that the persons dealing with one another are no longer required to be in the same place. Instead, through information and communication technologies, they can communicate, interact, collaborate, and negotiate in a distributed fashion across time, space, and organizational boundaries.[8–10]

Of particular interest is the recent emergence of virtual teams and networks that are touted as the foundation for new forms of organizations and ways of conducting business in a rapidly changing environment.[11–13] Thus far, the literature has focused on different aspects of virtual forms. These include the nature of the individual and group interactions involved,[4,5] the underlying context,[14–16] and the consequences.[17,18] Still, there is much to learn about the development of these virtual forms and their effects in different organizational settings. For instance, what are effective ways of developing these virtual forms? What are the major issues and challenges faced by group members day to day? And what lessons can be drawn from the implementation of these virtual forms in particular contexts?

This paper describes the experiences, lessons, and implications of a two-year action research effort to build a virtual network as part of a community health research training program in a Canadian province. In the paper, the term *virtual network* refers to teams that span multiple geographically dispersed organizations. First, relevant literature on virtual teams and networks is reviewed. Second, the training program is described as the study background. Third, the study design is outlined in terms of the participants, staff and sites, technology, research methodology, and data sources. Fourth, implementation experiences from the study are presented. Fifth, key lessons are summarized. Last, implications of the lessons are discussed.

Relevant Literature

Different models for developing virtual teams and network have been described in recent literature. For instance, Johansen et al.[19] have proposed the use of a team performance model to establish virtual teams within organizations. This model has seven stages of team building—orientation, trust building, goal and role clarification, commitment, implementation, high performance, and renewal. Each stage is built on the prior ones in an inclusive way. For example, trust building and goal clarification are based on good implementation and are even more important for high performance. Renewal is seen as a way of revitalizing the goal and commitment of a team. Technology plays an important part through all seven stages by supporting communication, interactions, and collaboration among team members and their environment.

Lipnack and Stamps[20] have proposed five principles for developing networks as a new form of organization. These principles consist of a unifying purpose, independent members, voluntary links, multiple leaders, and integrated levels. According to these researchers, networks are an organic form of organization that is both a process and a structure. They progress through distinct stages of development, from startup and launch, through performance and testing, to final completion. Again, technology is crucial in enabling these developmental stages to form the desired social-technical networks.

Thus far, empirical studies on virtual organizational forms have focused on the patterns of interactions, underlying contexts, and broader consequences. For example, Eveland and Bikson[21] have reported that electronic groups evolve differently from face-to-face groups and require significant investments of time and energy on the part of members to master the technology as well as a high level of assistance during the learning process. Huff et al.[22] have observed that active participation in electronic communication can lead to increased relationship and commitment within groups. Hiltz[23] has found that users will accept a system if they believe the task is worth the effort, if there is an active facilitator, if the system can expand their social network, and if they perceive improvement in the quality of work.

Zack and McKenney[16] have found that different groups using the same functional structure and performing the same task with identical communication technologies, but in different social contexts, would appropriate technology in ways that are consistent with their existing social structure. Different effects of virtual work groups have been reported, including subjective satisfaction, personal career advancement, and productivity gain in the organizations involved.[23–25] To ensure sustainability, Miles and Snow[26] have maintained the need for network organizations to adapt or renew continually over time through external and voluntary relationships with others.

These findings suggest that virtual networks go through different developmental stages as they evolve and mature over time. Different factors such as independent members, voluntary links, relationships, commitments, and adaptations can influence ways in which these networks emerge to become functional entities. More important, interactions among and performance of network members can vary, depending on organizational and social contexts. These findings

provided the initial conceptual foundations on which this study was based. For instance, we used the notion of developmental stages as a guide when developing the network in this study. Other aspects of virtual networks such as purpose, links, relationship, technology use, and renewal helped sensitize our study design and interpretation of findings. It is important to note that, while our virtual network emerged over time in the study, its members had to contend with a wide range of group development issues on a regular basis. These issues led to our understanding of other group-related concepts in developing virtual networks, which are discussed in lessons learned.

Study Background

Currently, there is a problem in the Canadian health system in that relevant research findings are not being used by health professionals to enhance their decision making.[27–29] For instance, the Evidence-based Medicine Working Group has reported that the most common source of information for decision making is still colleagues, and the information is based primarily on personal opinions and prior experiences.[30] Even more alarming, a recent survey in Canada by Woodward et al.[31] has revealed that most health professionals had infrequent contact with researchers, and about half thought the research community was not helpful to them. To help overcome this problem, a community health research training program was implemented in a Canadian province as a two-year pilot project from May 1996 to April 1998. This program was sponsored through a partnership among regional health authorities (17 in all, referred as the health regions), the provincial health department, two universities, and a funding agency.

In this program, each region sent one or two health professionals to participate in a seven-week training course (in two 3.5-week sessions) on health policy, management, economics, research methods, data analysis, and computer technology. On returning to their regions, these participants were to apply the acquired knowledge to community health research projects, policies, and issues. Ongoing faculty consultation and support were provided over two years as needed. At different points during the two-year period, participants were evaluated on their knowledge, performance, and influence as measures of the effectiveness of the program.

A crucial component of this program was the use of computer technology as an enabler to establish a virtual network, in which participants could access various information resources, engage in problem-solving tasks in groups, and communicate with faculty and colleagues to share ideas and knowledge and collaborate on initiatives. As part of the training program, each participant was given a notebook computer with the necessary software applications, Internet access, and technical support for two years.

Study Design

Participants, Staff, and Sites

Twenty-five health professionals from 17 health regions were enrolled as participants in this program. These participants were selected by their regional executives and given responsibilities to design and conduct research projects, provide information to support decision making, and act as expert resources on community health issues. The participants ranged from nurses to planners and community health research officers. Their experiences included community health, prevention and promotion, administration, and continuing care. All had at least a bachelor's degree, and five had master's degrees in health-related disciplines. One third of the participants had positions that had been newly created to enable them to work full-time in the training program. Two thirds retained their existing positions and worked only part-time, between 20% and 80% of their regular hours, in the program.

The staff consisted of the program coordinator, 2 training coordinators, up to 35 instructors and expert resources (the number varied over time), and 4 support staff. The program coordinator was responsible for all aspects of the program, from planning, budgeting, and staffing to implementation. The training coordinators were university faculty members who worked half-time as liaisons between participants and faculty resources and as advisors for participants with their projects. Most instructors and expert resources were academics from universities, who taught the courses or acted as domain experts as needed. Two technical, one library, and one clerical staff person provided part-time technology, administrative, and research support. Two action researchers worked on this study with help from two assistants. The organizers also hired two independent consultants to evaluate the overall effectiveness of the program.

Multiple sites were involved in this study. These included the 2 training sites where courses were held at the beginning of the program, the 17 health regions where participants worked, and the central office where program and technical support were administered, as well as annual conferences, teleconferences, and workshops attended by participants. A larger number of interactions took place virtually, via the Internet, fax, phone, and conventional mail.

The Technology

Each participant was given a notebook computer with dial-up Internet access and remote technical support for two years. Five types of software tools and resources that made up the customized system were installed: productivity tools for spreadsheets, word processing, data management, and statistical analysis; communication tools for Internet access, e-mail, Web-based computer conferencing, newsgroup, Telnet, and file transfer; system monitoring tools for access control, usage statistics, and automated surveys; system utilities for backup and remote management; and information tools and resources that comprised online bibliographic databases, health information resource inventories, and a resource inventory organizer. A Web site was maintained by support staff to provide program, participant, and project information and links to relevant Web sites.

Research Methodology

The methodology used in this study was action research, which links theory with practice through an iterative process of problem diagnosis, action intervention, and reflective learning.[32–35] Action research is used in social science to solve real-world problems while contributing to new knowledge through reflections on the experiences. Often, an intellectual framework is included to guide the problem-solving process and extraction of lessons.[32] To ensure rigor,[34] the action researcher should provide a detailed account of the research that includes defining the study design, declaring one's role, taking part in the change process, reiterating the process, exiting the situation, and reflecting on the study in a systematic fashion so that results are transferable.

In this study, our objectives were to build a virtual network as an integral part of the program and to share our insights from this experience as new knowledge. The literature on developing virtual networks and factors that influence their interactions and performance provided an initial framework for our study design and the interpretation of findings. For instance, we envisioned this network evolving over time in stages. While respecting participants as independent members, we encouraged them to forge links, collaborate on projects, and integrate the technology into their daily practices. The findings were described and interpreted within the community health setting, taking into account the context, perceptions, and practices of the health professionals involved.

As action researchers, our roles were to suggest the technology to be adopted, facilitate the use of certain software tools and information resources, collect data for analysis, and offer feedback to participants and staff on a periodic basis. We did not take part in any final decision making regarding use of the technology and suggested changes. Instead, these decisions were always left to the organizers, participants, and staff. (See Appendix A for more information on action research.)

Data Source and Analysis

Different subjective and objective data were collected during the two-year period. Sources of subjective data included program documents, participant interviews, staff interviews, meeting notes, automated online surveys, computer conferences, program Web site, additional training course feedback, and program evaluation documents. Sources of objective data included computer usage statistics and help-desk logs. Examples of questions used in our interviews are given in Appendix B. For ethical reasons, we did not track any private e-mail communication among participants and staff. The type, volume, and source of data collected are summarized in Table 1.

To provide an overall impressionistic view of the study, our initial data analysis consisted of a detailed review of program documents, meeting notes, and interview transcripts. These findings were then compared with online survey responses, usage statistics, and course feedback for consistency. At the end of the project, we analyzed the interview transcripts again using NUD*IST* to produce a set of concepts and themes to validate earlier findings. Any discrepancies were resolved by careful re-examination of the original data. (See Appendix C for more information on data analysis techniques.)

Implementation Experiences

The training program went through several transitions from Jan 1996 to Apr 1998. These changes are categorized into five distinct but overlapping stages: defining expectations, initial deployment, coping with technology, improvement over time, and working as a virtual network. The key events that occurred are shown in Table 2 and described below.

*NUD*IST refers to non-numeric unstructured data indexing, searching, and theorizing software, from QSR Ltd. It was used to identify concepts from raw data, such as interviews, in order to further categorize them as themes.

Table 1 ■

The Types, Volume, and Sources of Data Collected over Two Years

Type	Volume	Source
Program documents. These included pretraining surveys, computer instructional objectives, course outlines, technology feasibility study, project selection criteria, project milestoning map, computer support policies, development of second training program.	10 sets of documents	Staff, organizers, coordinators, and participants. Given to researchers.
Participant interviews. Three sets of telephone interviews conducted in Dec 96, Jun 97 and May 98.	63 interviews	Participants. Collected by researchers.
Staff Interviews. Face-to-face interviews with project sponsor, coordinators, and support staff conducted in Dec 96, Apr 97, and Apr 98.	12 interviews	Staff. Collected by researchers.
Meetings. Notes from meetings with coordinators, curriculum subcommittee, technology and content support staff, and facilitation sessions.	34 meetings	Minutes recorded by staff; notes by researchers.
Online surveys. Automated online surveys from program integrator consisted of one set of registration surveys and three sets of interval surveys collected in Oct 96, Apr 97, and Apr 98.	46 surveys	Participants. Summarized by researchers.
Discussion groups. Computer discussion conference were for participants and were moderated by participants.	16 conferences 14 surveys	Participants. Summarized by staff.
Program Web site. The Web site was maintained by program staff with 15 hypertext-linked sections and monthly Web site hit rate statistics.	15 sections 19 months-hits	Participants, Web stats by staff. Given to researchers.
Help desk logs. Logs recorded the history of technical assistance provided to participants and staff from Jul 96 to Jan 97.	267 log entries	Technical staff, participants. Given to researchers.
Computer usage. Three sets of application usage and online survey data from the program integrator of each participant's notebook were collected in Oct 96, Apr 97, and Apr 98.	30 sets of usage data	Participants. Collected by researchers.
Training courses. Workshops on resource inventory, needs assessment, grant proposal writing. Microsoft Access, and distance education used face-to-face meetings, an interactive Web site, and video conferencing	31 feedback 1 group input	Participants. Collected by staff; forwarded to researchers.
Program evaluation. Evaluation reports produced by independent consultants provided by participants, regional executives, and managers at seven weeks, six months, one year, and 18 months were evaluated by independent consultants.	4 reports	Collected by independent consultants.

Defining Expectations

Prior to Jan 96

Discussions on the need for this program began with the funding agency nine months prior to the inception of the program in May 96. The vision was to build capacity for health regions to synthesize community health research information in ways that can be used by health professionals. The organizers believed that, with an appropriate technology platform, system support, information resources, and academic faculty, health professionals can work more effectively within and between regions to increase the use of research findings in community health practice. As one organizer said "... the idea is to work together on research projects and be able to use the computer to assist them, whether it is data collection and interpretation or getting a report together and transferring data."

Jan–Apr 96

During this time, intensive program preparation took shape. For example, training objectives were defined by the curriculum committee make up of coordinators, regional executives, and selected experts from universities. Specifically, participants were to become proficient in using the computer to communicate, exchange information, and collaborate with one another. Also, they were to become local resources for their region to facilitate health research and to access and use research information for decision making.

Mar 96

Pre-training surveys obtained from participants in March indicated varying levels of computer literacy, consisting mainly of experience in word-processing and spreadsheets, with limited Internet exposure and data analysis. Since computer skills were expected a three-day computer training module was planned to cover all the tools and resources supplied with the notebook. While general computer training was to be provided, no instructions would be given on how to use technology in specific projects. The program also required each participant to engage in three or four projects over the two-year period, at least one project being a group project requiring collaboration among participants between regions.

Table 2 ■

Key Events During the Five Developmental Stages

	Problems/Needs	Interventions	Reflections
Defining expectations, Jan 96–May 96	■ Infrastructure needed to facilitate research ■ Technology needed for the training program ■ Need to define objectives ■ Concerns with roles, time, and computer skills	■ Explored alternatives ■ Organizers selected technology ■ Clarified vision, roles, objectives, expectations	■ Leadership in technology deployment ■ Unclear role expectations from participants, staff, and regions ■ Concern with time, skills not fully addressed
Initial deployment, May 96–Aug 96	■ Integrator not ready ■ Participants lacked skills ■ Software problems, tensions over support ■ Participants overwhelmed by information	■ Installed Windows95 in May; Integrator in July ■ Computer training added to training sessions ■ Developers/support staff corrected problems	■ Technology leadership, facilitation ■ Training according to skills, need ■ Concern with role, time ■ Integration in regions
Coping with the technology, Sep 96–Jan 97	■ Lack of time, skills need, and role clarity ■ Lack of follow-up with some participants ■ Need for training/support ■ Limited technology use	■ Technology facilitation for participants ■ Coordinator reaffirmed role in regions ■ Training workshops provided	■ Concern with roles ■ Facilitation useful ■ Technology use with time, need, skills, and roles ■ Support networks ■ Practical training
Improvements over time, Jan 97–Oct 97	■ Need to maintain contact ■ Concerns with role, time, support, skill, integration ■ Need to document and track projects	■ Held a one-year reunion ■ Offered workshop ■ More proactive facilitation ■ Registered projects in Web site inventory	■ Alternative delivery ■ Role refinement ■ Technology facilitation ■ Work integration ■ Support networks
Working as a virtual network, Nov 97–Apr 98	■ Only some technologies used but not others ■ Regions supportive, but expectations unrealistic ■ Participants comfortable with technology but need more time, support, and training ■ Request for second program	■ Assessed need, concerns, opportunities, impacts, suggestions ■ Over 70 projects in Web site inventory ■ Trainees conducted surveys for feedback ■ Organized second program ■ Produced second reports	■ Improved second program initiated ■ Program raised use and awareness of research information in regions ■ Impacts too early to quantify ■ Ten lessons learned summarized

Initial Deployment

May 96

The technology was deployed in two phases, because the system monitoring software, called the program integrator, was not ready when the program started in May. The installation took place during the first onsite training session, when most of the communication, information, and productivity tools were introduced, with Windows 95 as the temporary program manager.

Jul 96

The program integrator† was installed during the second training session in July. Shortly after its introduction, many software bugs were detected in it, which required immediate fixes by the developers. The complex configuration of different software on the notebooks and the support staff's lack of prior exposure to the integrator made it difficult to diagnose and correct many of the technical problems that occurred.

May and Jul 96

Computer training was provided as part of the onsite training sessions in May and July. Conducting these sessions had been difficult because of intermittent system crashes and different skill levels among participants, which proved very distracting. In post-training evaluation, participants reported that they were overwhelmed by the volume of information that was presented and felt that the computer training was ineffective because of time pressures, lack of basic computer skills, and information overload.

Jun and Aug 96

Even after participants had returned to their regions, the help-desk logs revealed that there continued to be hardware and software problems with their note-

†The program integrator is a custom operating environment similar to the Windows program manager, which controls access to all the applications on the system.

books, requiring frequent phone calls for technical support. This was complicated by the need to link participants' notebooks with their local Internet service providers and to share network printers in their organization. As a result, many participants were frustrated with the unstable system and the process by which they had to go through to use it.

Coping With the Technology

Sep–Oct 96

We formed a technology facilitation group with the coordinators and support staff to understand better how participants were using the system. The automated online survey and application usage log collected from participants through their notebooks in October revealed that the most frequently used tools were word processing, Netscape, e-mail, computer conferencing, and some online bibliographic databases. More advanced tools, such as an information resource organizer, statistics and desktop database software, and Internet health information resources were not used (see Appendix D for usage analysis).

Nov–Dec 96

By November, the technology had stabilized, with many fewer phone calls and e-mails for support. Our phone interviews in December revealed that participants had been grappling with technical issues, use of various applications, and their changing roles. For instance, several participants had difficulties integrating their notebooks with their regional information systems to share patient and other information. Some reported not having enough time to learn to use the tools and resources. A few had problems with what their role should be in the region. As one participant sand "My role is still evolving, and my colleague and I are working on being utilized more effectively in the region."

Dec 96

The program coordinator visited the executives in each region to inquire about their perception of the program and to reaffirm roles and expectations for participants. The responses were positive in terms of the quality and amount of research information being made available, types of initiatives launched, and opportunity to build relationships with other regions. There remained some concerns over roles and expectations, since a few participants had had their roles redefined several times in the region.

Dec–Jan 97

Despite technical problems, participants maintained that they were positive with their experiences and the concept behind the technology, especially in electronic communication and online information searches. Many participants still felt inadequate with their technical skills and had requested more training and support. One participant explained, "You tend to use only what you are familiar with because you don't have time to find out what the [other] technology does." In response, the coordinators planned several training courses to be offered in 1997.

Improvements over Time

Jan 97

It became apparent in early November 1996 that the amount of project, resource, and online discussion information accumulated on the Web site had become disorganized, clumsy to access, and confusing to manage. In January 1997, under out guidance, the support staff reorganized the Web pages, computer conference, information resource inventory, and project registration process on the Web site. The intent was to move toward an online knowledge inventory where projects, research information, and online discussions would be registered and summarized.

Jan–Apr 97

Participants reported in early 1997 that 60 individual projects were planned or under way. Seven collaborative projects had taken shape, involving many participants using different communication media, including face-to-face, phone, and computer conferencing. Some had assumed a greater research role in their regions by being asked to produce information for senior executives, provide education to managers and staff, and work on different projects. One participant said, "[We are] able to identify, develop, implement and report research projects that are recognized as valuable in the region."

Jan–May 97

Having protected time to work on projects was a concern of participants, since many had other areas of responsibilities. A few participants reported uneasiness with using technology for such tasks as information search and document preparation, since some coworkers did not regard it as real work. In several smaller regions, technology was the only link to the outside world, providing the means to share ideas and information that was not feasible otherwise.

Jun 97

Data from interviews, online surveys, and computer usage by June revealed a drastic increase in participants' reliance on technology, especially e-mail, the

Internet browser, online databases, selected information resources, and productivity tools. Many participants still wished for more computer training, particularly in information searches, data analysis, and resource inventory building. Some suggested having support staff to do literature search, data entry, and analysis. Most indicated that they used software they were familiar with or needed to get the work done, but not tools with which they lacked skills, need, or time to learn. Comments to such effect include "I need to create more time to use the technologies" and ". . . some time dedicated regularly to updating my skills and knowledge of technology."

Jan–Oct 97

Four training courses were held using different delivery modes. These were in grants proposal writing, needs assessment, information resource management, and database using Access. The delivery modes consisted of face-to-face meetings, Web site and e-mail, video conferencing, and computer conferencing. The attendance at these sessions ranged from 6 to 12 participants depending on the topic, location, and availability. Most participants were satisfied with the courses, but some suggested an emphasis on experiential learning, provided in a just-in-time fashion as needed.

Working as a Virtual Network

Sep–Dec 97

The virtual network emerged by mid-1997, with most participants having integrated technology as part of their work routines. Many used technology frequently to prepare, search, manage, and analyze research information; to interact with each other to share ideas, information, and experiences; and to collaborate on projects. The computer usage statistics and self-reported use from online surveys suggested that the most frequently used tools and resources were e-mail, Internet browsers, Word, Powerpoint, online bibliographic databases, and selected information resources from the inventories (see Appendix B). The use of computer conferencing peaked in early 1997 but ceased shortly after that because of lack of time, facilitation, and meaningful discussions.

Dec 97

The 18-month evaluation conducted by consultants in December suggested that the most important program component was establishment of the virtual network for information sharing and peer support. As one participant said, "The best part of [this program] was meeting a group of enthusiastic, creative, committed [colleagues] that I can now share ideas and strategies with." The regions were seen as supportive of the program but not always realistic in their expectations or resource need. Coworkers were supportive, but some did not fully understand the role of participants in the region. Most participants reported high comfort levels with technology, information searches, and applying knowledge in decision making but identified the need for more research time, support staff, and training in data management, statistics, and evaluation.

Jan–Apr 98

By early 1998, participants had completed 76 research projects. Summaries of these projects, including relevant literature, research design, and results were posted on the program Web site with help from support staff. Online surveys and interviews in April revealed that most participants were very positive about their overall experience over the two years. Many participants indicated that they were so dependent on technology that they could not do their work without it. Some mentioned that they were able to work closely with senior management in their regions and believed they had made a positive influence on the way research was conducted and findings were used.

Mar 98

Because of the positive responses received from the regions, health ministry, and professional associations, the organizers initiated a second training program to commence in May. Feedback was gathered from coordinators, participants, and us as researchers to help plan this second offering. Goals were to simplify the initial computer training, develop appropriate role expectations, maintain close interactions, offer more follow-up courses with different delivery modes, maintain more customized project support, ensure adequate time and resources, provide needs-based training, and actively promote achievements of the program.

Post-May 98

The consultants wrote in their final evaluation report that the program had been successful in raising the awareness and use of research information in the regions, but it was still too early to quantify the impacts. The participants completed 70 individual projects and 6 group projects in total. Although they were satisfied with the program, they had many suggestions to improve its organization and delivery, such as more training, support, protected time, and recognition. Overall, the consultants reported that "[the program] was a very positive professional experience for participants due to the networking opportunities

and increase in their research skills and knowledge base.''

Lessons Learned

Ten lessons have been identified from the implementation experiences. The basis for these lessons in the community health setting and how they compare with related literature are discussed in this section. The lessons are summarized in Table 3.

Lesson 1: Ensure Role Clarity on an Ongoing Basis

In this study, many participants had expressed concern about their roles in the health region and expectations from their managers and coworkers; some had their roles redefined several times over two years. There was also evidence that the extent of technology use was influenced by the participant's perceived role. For instance, participants reported that they conducted frequent literature searches because they were expected to provide current research information. In their team performance model, Johansen et al.[19] emphasize the importance of goal and role clarification in the establishment of virtual teams. The need for role clarity is supported by other studies on effective work groups,[36–38] particularly in dynamic teams with shifting roles, tasks, and membership.[4,39,40]

These findings led to lesson 1, that in the planning of a virtual network, the roles of its members must be established early on to provide them with a clear sense of purpose and expectations. This is especially important with health professionals, who often have multiple roles in the organization. The role should be reiterated periodicaly to re-emphasize its importance, and it should be flexible to enable the member to adapt to changing organization goals and priorities over time.

Lesson 2: Provide an Initial Technology Vision to Foster Shared Understanding

In retrospect, the intended uses of the technology included in the network were never clearly articulated. For instance, while computer proficiency was expected, no directions were provided on how participants should learn the technology or use it in their projects. Even though follow-up workshops were offered, many participants were left on their own to adopt the technology. The introduction of computer conference summaries, Web-based resource inventory, and online project registration are examples of areas in which it was necessary for organizers to show new ways in which technology could be used to enhance the network.

Table 3 ■

Summary of the Ten Key Lessons Learned in this Study

	Description
Lesson 1	*Ensure ongoing role clarity.* Establish role early, reiterate to renew importance, and be flexible over time.
Lesson 2	*Provide technology vision to foster shared understanding.* Articulate vision on intentions for technology to achieve network purpose.
Lesson 3	*Encourage participatory network design.* Engage members in design, implementation, and evaluation of network through action research.
Lesson 4	*Allow implementation staging to stay focused.* Implement technology incrementally for members to learn and use tools meaningfully.
Lesson 5	*Provide protected time for work and learning.* Provide adequate time for members to learn technology to conduct work.
Lesson 6	*Provide technology, content, and process facilitation.* Ensure proactive ongoing facilitation to improve effectiveness of network.
Lesson 7	*Encourage technology integration with work practices.* Integrate technology with work practices and routines of network members.
Lesson 8	*Provide just-in-time, experiential, needs-based workplace learning.* Provide ongoing training to use technology and interact with others.
Lesson 9	*Build relationships with peers and external members.* Establish linkage with peers and others to share ideas and information and collaborate on work.
Lesson 10	*Promote network's accomplishments.* Promote results and achievements to others to ensure acceptance and recognition of network.

These findings emphasize the importance of defining intentions for technology use in a virtual network. For instance, Caldwell and Gambon,[11] and Mohta[41] discuss the essential elements of virtual teams, such as having a centralized Web-based data network, and ways by which technologies can be used to enhance effectiveness. Others address consequences of interactive communication on social presence,[42] norms, and control.[43] The key is to ensure that a technology vision is synchronized with the organization's purpose.[20]

These findings led to lesson 2, that a vision is needed to articulate how technology can enable development of the network to achieve its purpose. This vision must be communicated to members early on and reiterated over time to ensure a common understanding of the intentions for the technology. This is important with health professionals, who often have little computer experience and need to be shown by way of

examples what technology can do and how they can use it appropriately and effectively.

Lesson 3: Encourage Participatory Design of the Network

In this study, the use of action research was viewed favorably by participants; they offered valuable reflections on technology use and suggestions for its improvement. Examples of participant engagement included their written feedback on initial training, ongoing requests for more training and support, and recommendations for the second program. Many suggestions were implemented eventually with favorable consequences.

Lipnack and Stamps[20] emphasize the need to empower network members by involving everyone in the process of network development. This participatory approach has been used in designing organizations,[44,45] developing communities,[46] and introducing information systems.[47] It advocates that those affected by change should play an active role to influence the design process and its outcome.

These findings led to lesson 3, that the development of a virtual network can be enhanced by a participatory approach to engage health professionals in its design, implementation, and evaluation. Action research, with its iterative process of problem diagnosis, action interventions, and reflective learning through participation, is well suited for this type of network development.

Lesson 4: Keep Implementation Staging Focused

In our study, because of technical problems, information overload, and varying computer skill levels, participants viewed the initial implementation of technology as mostly ineffective. As a result, only the technology that was most familiar to the group was adopted and used. Subsequent feedback from participants suggested an incremental but more focused approach to implementation and the need to integrate technology with learning and work practices.

In his study of information technology design and organizational change, Eason[59] argues that the technical system must be designed to serve the functional needs of the individual users in a usable and acceptable way. More recent studies suggest that virtual teams require more time and effort to establish their communication skills and social norms over a distance.[21,42] Thus, the introduction of technology must be carefully staged to ensure that network members learn to understand its meaning, use, and benefits.[4,11,14]

These findings led to lesson 4, that in the development of a virtual network, technology should be implemented in stages to ensure that members can learn to use the tools in meaningful ways. This incremental approach provides the focus for health professionals to bring the meaning and relevance of technology to different types of work that they face during different stages of a project, such as communication, information search, data collection and analysis, and report writing.

Lesson 5: Provide Adequate Protected Time for Work and Learning

Having protected time for work and learning was an important issue in this study. Many participants complained about the lack of time to learn the technology, conduct research, and interact with others. This was most obvious for part-time participants in the program. Some would have preferred the provision of support resources to expedite their work, such as having an assistant do data entry, analysis, and literature retrieval.

In their team performance model, Johansen et al.[19] describe the need for dynamic roles, shared leadership, multiple media, and shifting relationships. These are all time-consuming undertakings that require team members to constantly learn to interact with others under different circumstances. Eveland and Bikson[21] have found that electronic work groups require members to make significant investments of time and energy to master the technology. To be effective, network members must be given adequate time and support to learn and use the technology effectively in the virtual environment.[5]

These findings led to lesson 5, that in the development of a virtual network, its members must be given adequate time to learn how to use technology to conduct their work. Health professionals, especially those with multiple roles, need time and guidance to learn the technology and use it effectively in projects. To expedite work, support such as data entry and analysis, information search, and clerical support should be provided as needed.

Lesson 6: Provide Ongoing Technology, Content, and Process Facilitation

In our study, distinct forms of technology, content, and process facilitation were needed to help participants become more effective in their work. Technology facilitation relates to technical support, such as troubleshooting, assisting with software and hardware use, and helping users integrate technology into their organization. Content facilitation relates to expert consultation on specific projects in terms of is-

sues, research design, and interpretation of results. Process facilitation expedites research with such support as literature retrieval and delivery, data entry, and analysis.

The importance of facilitation on enhancing group performance is well documented for synchronous groups.[49–51] To connect virtual networks, Lipnack and Stamps[20] suggest the use of coordinators as the "glue" to match needs to resources. Similarly, Grenier and Metes[52] introduce the notion of "circuit riders" to deal with concerns, listen to complaints, take on problem solving, and keep the network alive.

These findings led to lesson 6, that ongoing technology, content, and process facilitation is needed to improve the effectiveness of a virtual network and of its members over time. Proactive forms of facilitation, in which facilitators periodically reach out to health professionals to probe their needs and offer direct assistance, should be encouraged.

Lesson 7: Encourage the Integration of Technology with Work Practices

In this study, participants adopted technology and used it to conduct various tasks that ranged from information searches, data collection and analysis, document preparation, and communication to project collaboration. Many were so dependent on technology that they could not function without it. However, our results also revealed that many participants used only a subset of the technology, based on their needs, availability, and skills. Some participants had difficulty integrating the technology into their regional systems to access patient information and printing resources. A few even felt uneasy using the technology, since others did not see it as real work.

Lipnack and Stamps[20] propose that a network's purpose has to be translated into concrete work activities, from which physical channels of communication can be set up for interactions. Anson et al.[53] suggest that group support systems can be used to support a wide range of research tasks, including library search, idea generation, data collection and analysis, and publication of results. Grenier and Metes[52] argue that technology use, to be effective, must be regarded as work and not as support or an adjunct to work.

These findings led to lesson 7, that in the development of a virtual network, one must ensure that the technology is integrated into the work practices and routines of participating health professionals. This includes the compatibility of the technology, its fit with the type of work, and recognition of its use as an integral part of the health professionals' work.

Lesson 8: Provide Just-in-time, Experiential, Needs-based Workplace Learning

Most participants requested more ongoing technical training, but they preferred training to be customized to their project needs, competency levels, available time, and location. Many mentioned the need for experiential learning to better relate training to their workplace. To be effective, some suggested that training be provided just in time, immediately before the start of a project that requires the new skills.

Townsend et al.[5] argue that virtual team members must be trained to quickly move into new teams because of the dynamic nature of their memberhsip. Grenier and Metes[52] suggest that the learning process with virtual team members is expected to be driven by a need or desire to develop competencies, by continuous learning that supplants learning events, and by the acquistion of knowledge in context and through work.

These findings led to lesson 8, that network members require ongoing training to learn to use technology effectively to carry out their work and to interact with others. The training should take into account the competency of members, their availability, and the nature of work involved. Health professionals prefer just-in-time, experiential, and needs-based learning through different modes of delivery to enrich their learning environment.

Lesson 9: Build Relationships through Peer Support and External Members

One positive aspect of the program that was emphasized by participants was the emergence, among themselves, of a peer support network for information sharing, exchange of ideas, problem solving, and counseling support. Participants also expressed the importance of interacting with coworkers and linking with other organizations especially those in smaller, remote regions, to share expertise and collaborate on projects.

Small-group research suggests that it is important to maintain internal and external relationships to ensure the effectiveness and well-being of work groups.[37,54,55] In their study of virtual student teams, Knoll and Jarvenpaa[4] describe the need to learn different forms of collaboration, socialization, and communication skills to be effective. Ancon[56] stresses that groups, to be successful, need to establish contacts and initiate programs with others both inside and outside the organization.

These findings led to lesson 9, that in the development of a virtual network, the establishment of ongoing peer support among health professionals should be en-

couraged, so that members can share ideas, exchange information, and counsel each other. Also, members must be encouraged to develop ongoing relationships with coworkers and external organizations to share their expertise, skills, technology, and experiences.

Lesson 10: Promote the Network by Demonstrating Its Accomplishments

About nine months into the program, some participants reported that the regions were pleased with their work in terms of the quality and volume of research information being made available, the types of initiatives launched, and the relationships established with other regions. By the second year, participants reported having completed 76 projects. Many felt they had made a positive difference in the ways that research was conducted and findings were used in their region. When planning for the second program, participants emphasized the need to actively promote results and achievements within and outside the regions.

The team performance model by Johansen et al.[19] describes the need for high team performance to ensure its sustainability over time. There are different levels of results, ranging from group to department to corporate. Ideally, each level should match its intended goal and feed into the higher level to achieve the aggregate benefits. Ancona[56] observes that successful teams promote their team's achievements in their organization, even though member satisfaction and cohesiveness may suffer in the short run.

These findings led to lesson 10, that the results and achievements of a virtual network should be promoted to others, both inside and outside the organization, as a way of ensuring acceptance and recognition. This is important in the health setting when there are limited resources and competing priorities in the organization.

Implications

This study has provided some new insights into the development of virtual networks in the community health setting. The lessons can also serve as a practical guide for managers who want to establish virtual networks for health organizations. First, we outline a conceptual model for developing virtual networks observed in the study (Figure 1). The model is not intended to be a generalized framework for establishing virtual networks. Rather, it is derived from our findings during the development of the network in a community health context, in which participants used technology to enhance their day-to-day work practices and to make greater use of research information in decision making. This means that caution is needed when generalizing these findings in other contexts.

Our conceptual model illustrates how a virtual network in the community health setting progresses through various developmental stages, as health professionals learn more about the technology and use it increasingly to support their work practices. Over time, increased use of technology can lead to modifications in how participants work and interact with each other. These new routines, in turn, may lead to further improvements as participants reflect on how the technology can be better used. The ten lessons identified here have significant implications for the ways the network evolves over time. While these lessons have an ongoing impact on the overall network and its members, the extent of their influence is thought to vary during different stages of evolution.

Specifically, having a technology vision for the network (lesson 2), providing role clarity for involved health professionals (lesson 1) and engaging members in the design of the network (lesson 3) can enhance its development during the early stages of defining expectations and initial deployment. As the network evolves, it can be strengthened and reinforced through the proper staging of the technology (lesson 4), peer and external relationship building (lesson 9), proactive facilitation (lesson 6), and provision of protected time for the health professionals (lesson 5). As the network matures, the ability to sustain it depends on how well health professionals can integrate technology into day-to-day practices (lesson 7), provide workplace learning as needed (lesson 8), and promote their accomplishments (lesson 10).

This study has contributed to our understanding of developing virtual networks in a community health con-

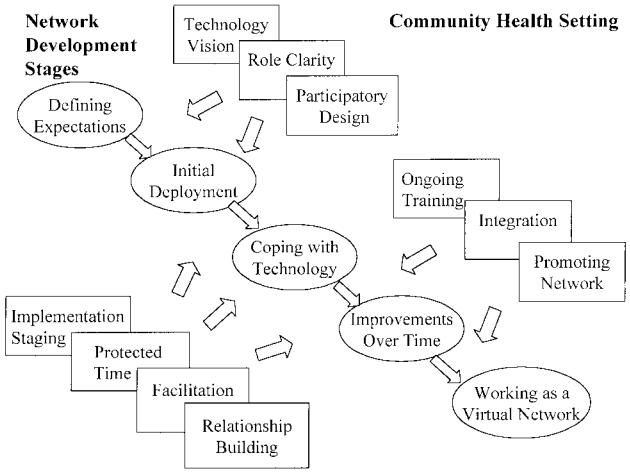

Figure 1 Conceptual model used to describe the development of virtual networks in the community health setting.

text. The use of action research with an interpretive stance provides different perspectives from network members on how technology can be used over time to foster communication, collaboration, and learning. This view is consistent with our belief that the intentions for technology are socially constructed in specific contexts. Thus, its use can be refined over time by network members to improve their work practices as they learn the benefits and limits of the technology.

This study has some limitations that require further research. First, our virtual network evolved over a two-year period and made use of a given set of technology. The results could be different if some other technology were used or if the study had continued for a longer period, since network members are known to refine their technology use and practices over time. Second, our findings are based on the development of a virtual network in a community health research training program. Further studies are needed to determine how the findings compare with findings from the development of virtual networks in related health settings, such as mental health. Last, as action researchers, we were intimately involved in developing the network and interpreting the findings. Readers should be aware that researchers from a different tradition or those who use another method, such as the case study, could reach different conclusions from ours.

The authors thank the organizers, instructors, coordinators, participants, and support staff of the research training program described in this paper, for their valuable feedback over the past two years.

References ■

1. Finholt T, Sproull LS. Electronic groups at work. Org Sci. 1990;1(1):41–64.
2. Wilson P. Computer-supported cooperative work: origins, concepts and research initiatives. Comput Network ISDN Syst. 1991;23:91–5.
3. Nunamaker JF, Dennis AR, Valacich JS, Vogel DR, George JF. Electronic meeting systems to support group work. Commun ACM. 1991;34(7):40–61.
4. Knoll K, Jarvenpaa SL. Working together in global virtual teams. In: Igbaria M, Tan M (eds). The Virtual Workplace. Hershey, Pa: Idea Group Publishing, 1998:2–23.
5. Townsend AM, DeMarie SM, Hendrickson AR. Are you ready for virtual teams? HR Mag. 1996;41(9):122.
6. Bush J, Frohman L. Communication in a network organization. Organ Dynamics. 1991:23–36.
7. Baker WE. The network organization in theory and practice. In: Nohria N, Eccles RG (eds). Networks and Organizations: Structure, Form and Actions. Boston, Mass: HBS Press, 1992: 397–429.
8. Gay G, Lentini M. Use of communication resources in a networked collaborative design environment. J Comput Med Commun. 1995;1(1):45–50.
9. Solomon CM. Sharing information across borders, time zones. Workforce. 1998;3(2):12–8.
10. Lim LH, Benbasat K. A theoretical perspective of negotiation support systems. J Manag Inform Syst. 1992;9(3):27.
11. Caldwell B, Gambon J. The virtual office gets real. Informationweek. Jan 22, 1996:32.
12. May M. Preparing organizations to manage the future. Manag Account. 1997;75(2):28–32.
13. Valikangas L, Hoffmann M. Virtual organizations: defining issues. 1996. Available at: http://future.sri.com:8080/BIP/briefs/B0054.html. Accessed Jun 20, 1999.
14. Grudin J. CSCW: History and focus. 1994. Available at: http://www.ics.uci.edu/~grudin/Papers/IEEE94/IEEE Complastsub.html. Accessed Jun 22, 1999.
15. Speier C, Palmer J. A definition of virtualness. Association for Information Systems 1998 Americas Conference Proceedings. Available at: http://www.isworld.org/ais.ac.98/proceedings/vo.htm. Accessed May 3, 1999.
16. Zack MH, McKenney JL. Social context and interaction in ongoing computer-supported management groups. Organ Sci. 1995;6(4):394–421.
17. Fulk J, DeSanctis G. Electronic communication and changing organizational forms. Organ Sci. 1995;6(4):337–49.
18. Orlikowski WJ, Yates J, Okamura K, Fujimoto M. Shaping electronic communication: the metastructuring of technology in the context of use. Organ Sci. 1995;6(4):423–44.
19. Johansen R, Sibbet D, Benson S, Martin A, Mittman R, Saffo P. Leading business teams: how teams can use technology and group process tools to enhance performance. Reading, Mass: Addison-Wesley Publishing, 1991.
20. Lipnack J, Stamps J. The age of the Network: Organizing Principles for the 21st Century. New York: Wiley, 1994.
21. Eveland JD, Bikson TK. Work group structures and computer support: a field experiment. ACM Transactions Office Info Syst. 1989;6:354–79.
22. Huff C, Sproull L, Kiesler S. Computer communication and organizational commitment: tracing the relationship in a city government. J Appl Soc Psychol. 1989;19(16):1371–91.
23. Hiltz SR. Online Communities: A Case Study of the Office of the Future. Norwood, NJ: Ablex, 1984.
24. Hiltz SR, Johnson K. Measuring acceptance of computer-mediated communication systems. J Am Soc Inform Sci. 1989;40(6):386–97.
25. Hiltz SR. Productivity enhancement from computer-mediated communication: a systems contingency approach. Commun ACM. 1988;31(12):1438–54.
26. Miles RE, Snow CC. Causes of failure in network organizations. Calif Manag Rev. Summer 1992:53–72.
27. Dunn EV, Norton PG, Stewart M, Tudiver F, Bass MJ (eds). Disseminating Research and Changing Practice. Thousand Oaks, Calif: Sage Publications, 1994.
28. Lomas J. Finding audiences changing beliefs: the structure of research use in Canadian health policy. J Health Pol Law. 1990;15:525–42.
29. National Health Forum. Canada health action: building on the legacy. Synthesis Reports and Issues Papers. Ottawa, Canada: NHF, 1997.
30. Evidence-based Medicine (EBM) Working Group. Evidence-based health care: a new approach to teaching the practice of health care. J Dental Educ. 1994;58(8):648–53.
31. Woodward CA, Feldman W, Snider A. Health services researchers and decision makers: are there really two solitudes? Ann R Coll Physicians Surg Can. 1997;30(7):417–23.
32. Checkland P. From framework through experience to learn-

ing: the essential nature of action research. In: Nissen HE, Klein HK, Hirschheim R (eds). Information Systems Research: Contemporary Approaches and Emergent Traditions. Amsterdam, The Netherlands: Elsevier Science, 1991:397–403.
33. Hult M, Lennung S. Towards a definition of action research: a note and bibiliography. J Manage Studies. 1978;17(2):241–50.
34. Jonsson S. Action research. In: Nissen HE, Klein HK, Hirschheim R (eds). Information Systems Research: Contemporary Approaches and Emergent Traditions. Amsterdam, North Holland: Elsevier Science, 1991:371–96.
35. Lau F. A review on the use of action research in information systems studies. In: Lee AS, Liebnau J, DeGross JI (eds). Information Systems and Qualitative Research. Norwell, Mass: Kluwer/Chapman & Hall, 1997.
36. Bettenhausen KL. Five years of groups research: what we have learned and what needs to be addressed. J Manage. 1991;7(2):345–81.
37. Hare AP. Roles and relationships. In: Hare AP, Blumberg HH, Davies MF, Kent MV (eds). Small Group Research: A Handbook. Norwood, NJ: Ablex, 1994:141–154.
38. Zigurs L, Kozar KA. An exploratory study of roles in computer-supported groups. MIS Q. Sep 1994:277–97.
39. van der Smagt AG. Enhancing virtual teams: relations vs. communication technology. Association for Information Systems 1998 Americas Conference Proceedings. Available at: http://www.isworld.org/ais.ac.98/proceedings/vo.htm. Accessed May 12, 1999.
40. Salazar AJ. An analysis of the development and evolution of roles in the small group. Small Group Res. 1996;27(4): 475–503.
41. Mohta P. Virtual networking via the Internet. Comput Tech Rev. Winter 1996:12–3.
42. Warkentin ME, Sayeed L, Hightower R. Virtual teams versus face-to-face teams: an exploratory study of a Web-based conference system. Decis Sci. 1997;28(4):975–96.
43. Rogers E, Albritton M, Marcel M. Interactive communication technologies in business organizations. J Business Comm. 1995;32(2):177–92.
44. Liu M, Denis H, Kolodny H, Stymne B. Organization design for technological change. Hum Rel. 1990;43(1):7–22.
45. Pava C. Redesigning sociotechnical systems design: concepts and methods for the 1990s. J Appl Behav Sci. 1986; 22(3):201–21.
46. Cassell C, Fitter M, Fryer D, Smith L. The development of computer applications by nonemployed people in community settings. J Occup Psychol. 1988;61:89–102.
47. Badham R, Couchman P, Little S. Getting smart: developing an action research approach to the integrated management of technical and organizational innovation. Human Syst Manag. 1995;14:91–104.
48. Reason P. Three approaches to participative inquiry. In: Denzin N, Lincoln Y (eds). Handbook of Qualitative Research. London, U.K.: Sage Publications, 1993:324–39.
49. Clawson VK, Bostrom RP, Anson R. The role of the facilitator in computer-supported meetings. Small Group Res. 1993;24(4):547–65.
50. Dickson GW, Partridge JL, Robinson LH. Exploring modes of facilitative support for GDSS technology. MIS Q. Jun 1993:73–194.
51. Wheeler BC, Valacich JS. Facilitation, GSS, and training as sources of process restrictiveness and guidance for structured group decision making: an empirical assessment. ISR. 1996;7(4):429–50.
52. Grenier R, Metes G. Going Virtual: Moving Your Organization into the 21st Century. Upper Saddle River, NJ: Prentice Hall, 1995.
53. Anson R, Fellers J, Kelly GG, Bostrom RP. Facilitating research with group support systems. Small Group Res. 1996; 27(2):179–214.
54. Brett JM, Rognes JK. Intergroup relations in organizations. In: Goodman PS, and associates. Designing Effective Work Groups. San Francisco, Calif: Jossey-Bass, 1986:72–119.
55. Babarro JJ. The development of working relationships. In: Galegher J, Kraut RE, Egido C (eds). Intellectual Teamwork: Social and Technological Foundations of Cooperative Work. Mahwah, NJ: Lawrence Erlbaum Associates, 1990:79–109.
56. Ancona DG. Outward bound: strategies for team survival in an organization. Acad Manage J. 1990;33(2):334–65.
57. Ngwenyama OK. Groupware, social action and organizational emergence: on the process dynamics of computer mediated distributed work. Account Manage Info Technol. 1998;8:127–146.
58. Lewin K. Action research and minority problems. J Social Issues. 1946;2(4):34–36.
59. Eason K. Information Technology and Organizational Change. London, U.K.: Taylor & Francis, 1988.
60. Timpka T, Sjoberg C, Svensson B. The pragmatics of clinical hypermedia: experiences from 5 years of participatory design in the MEDEA project. Comput Methods Prog Biomed. 1995;46:175–86.

Appendix A

Use of Action Research in Information Systems Studies

Kurt Lewin[58] introduced action research in the 1940s, to study social change in naturalistic settings. Since then it has been used by information systems researchers to instigate change using technologies and to study their effects.[32,33,35] For instance, Eason[59] used action research to study information systems and organizational change by developing techniques that could be used in the design process and studying how effective the techniques were so that they could be refined over time. Another example in medical informatics is the MEDEA project by Timpka et al.,[60] to develop clinical hypermedia through participatory design that refined the system in iterations.

There are three steps in action research, which are carried out in iterations in a social context: *problem diagnosis, action intervention*, and *reflective learning*. Often, an intellectual framework is used to guide the problem solving process and extraction of lessons. The outputs of action research are solutions to the problem and lessons as new knowledge. These components are shown in Figure A1 described below:

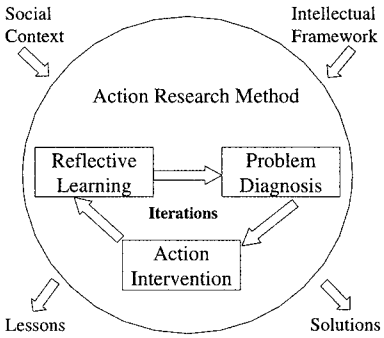

Figure A1 Schematic representation of the components of action research.

- *Problem diagnosis:* A specific problem or need is identified by engaging those directly affected as participants in the study.
- *Action intervention:* Interventions are planned and implemented with the help of participants, to address the need or problem.
- *Reflective learning:* Researchers and participants engage in reflections to assess what they have learned from the experience of addressing the problem or need.
- *Social context:* The problem or need must be situated in a given setting directly involving the participants as part of their daily work.
- *Intellectual framework:* Theoretic or conceptual formulations help the researchers and participants understand the nature of the problem or need and determine how to address it.
- *Iterations:* The problem-solving process is often carried out in iterations, whereby the experience from each cycle is fed into the next to improve the solutions.
- *Solutions:* After one or more iterations, based on the original or revised intellectual framework, an improved and satisfactory solution is implemented.
- *Lessons:* Experiences are generalized as new knowledge in the form of lessons learned.

Appendix B

Examples of Questions Used in the Study

Sample trainee phone interview questions (varied slightly over time):

- What technologies are you using for your initiatives?
- Please elaborate on how you are using the technologies.
- Please rate the impact of the technologies on your work in the program as being very positive, positive, neutral, negative, or very negative. Please elaborate on the impact.
- Do you have any suggestions to help you improve your use of the technologies?
- To what extent have you used technologies to collaborate with other members of the program? Please rate this as none, sometimes, often, or exclusively. Please elaborate.
- How has the learning you have experienced so far been facilitated through the use of the above technologies?
- Is there a need for you to integrate your laptop with the information systems department in your region? Please elaborate.

Sample coordinator interview questions:

- What technologies are you using for your initiatives?
- Why do you use the ones that you do? The ones that you don't?
- What technologies do you think the participants use in the program?
- Why do you think they use the ones that they do? The ones that they don't?

Sample online survey questions for trainees, about their notebook computers:

- Does your current job entail computer knowledge—yes, no, or not sure?
- Rate your skill level of computer knowledge, from 1 (poor) to 5 (excellent).
- Repeat the above two questions for research analysis, dissemination of research findings, public/clinical policy analysis, general management, daily management.
- At this time, how would you define successful outcomes as related to this program for the region, board, community, and yourself?
- At this time, what problems, issues, or opportunities do you expect to encounter as related to this program for the region, board, community, and yourself?
- How often do you expect to use (each tool listed)—1 (not at all), 2 (less than once a month), 3 (less than once a week), 4 (more than once a week), 5 (daily).
- Which computer system features do you like the most? The least? What suggestions do you have to improve the computer system?

APPENDIX C

Data Analysis Techniques

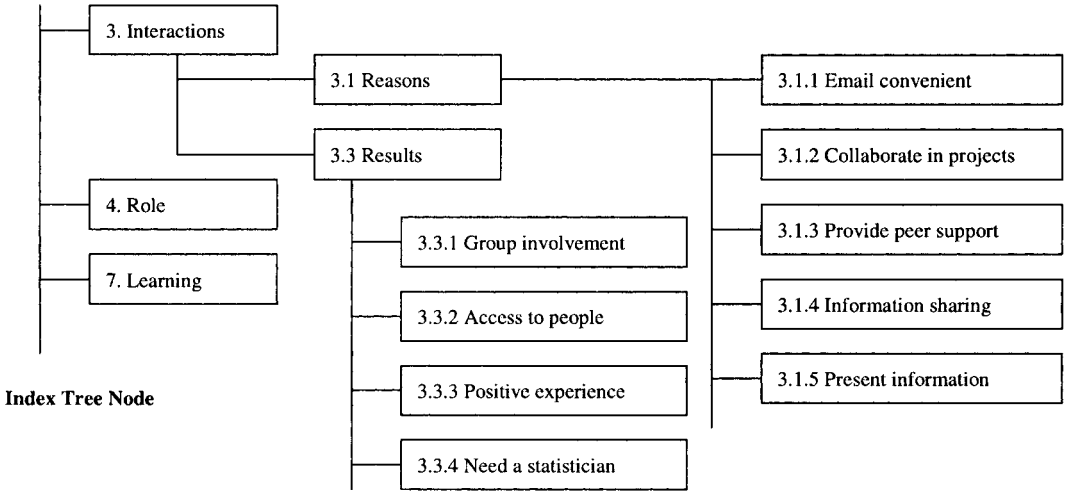

Figure A2 A NUD*IST index tree node, showing three nodes representing three themes: interactions, roles, and learning. The interactions theme is expanded to show the associated concepts as subnodes.

Both objective and subjective data were collected and analyzed over the two-year period. The initial analysis, which was impressionistic through content analysis, was made by manually studying the data and making mental interpretations of what they meant. Then the data were analyzed again using the software NUD*IST followed by triangulation of the findings. The types of analysis are summarized below.

- *Objective data* consisted of the help-desk log and computer usage by participants. Help-desk log entries were tabulated by the type of call and its frequency. Usage data were tabulated by application type and frequency of usage.
- *Subjective data* included participant and staff interviews, online surveys, documents, meeting notes, and course feedback. Participant interviews were recorded on tape and transcribed verbatim. Summary notes were kept during staff interviews. Content analysis was performed on all subjective data collected.
- *Content analysis* is the interpretation of textual data such as interview transcripts to identify distinct concepts. Once identified, the concepts were further categorized into themes on the basis of their inter-relationships.
- *NUD*IST* is computer software used to tag concepts buried in textual data, such as interview transcripts. These concepts were identified by interpreting the meaning of the text. Once tagged, the concepts were organized into nodes and trees representing different themes. The themes were then used to construct a storyline. Examples of nodes defining various concepts under the interactions theme, obtained from interviews with participants, are shown in Figure A2.
- *Triangulation* is the comparison of data from different sources to confirm their consistency. For instance, comments in participant interviews on use of selected software were verified against the computer usage log retrieved from participant notebooks.

APPENDIX D

Technology Usage Analysis

Technology usage findings are shown in the tables on the facing page. Table A3 shows that:

- The average number of sessions per user remained about the same during the first year and dropped slightly in the second year.
- The average number of hits per user increased steadily in year one then decreased somewhat to reach a steady level in year two. Hits refer to the times an application was active.
- The average number of applications used per user dropped slightly in year one but increased in year two.
- The number of hits per session increased in year one then reached a steady level in year two.

Table A1 ■

Ratings of the Impact of Technologies on Participants' Work in the Training Program

Rating	Dec 96	Jun 97	Mar 98
5 (greatest)	30.5%	72.7%	76.5%
4 (great)	26.1%	27.3%	17.6%
3 (some)	39.1%	0%	5.9%
2 (little)	4.3%	0%	0%
1 (none)	0%	0%	0%
Average rating	3.8	4.7	4.7
Respondents	23/25	22/25	17/25

Table A2 ■

Percentage Use of Self-reported Top Five Applications by Participants

Dec 96		Jun 97		Mar 98	
Word	100	Word	100	Word	100
E-mail	100	E-mail	100	E-mail	95
Web board	100	Netscape	100	Netscape	90
Netscape	96.5	Access	63.6	Online libraries	85
FTP	91.3	Online libraries	54.5	Power-point	85

Table A3 ■

Computer Usage Analysis, by Session, by Hit, by Application, and by HITS per Session

	Aug–Oct 96	Nov 96–Jan 97	Feb–Apr 97	May–Jul 97	Aug–Oct 97	Nov 97–Jan 98	Feb–Apr 98
Average sessions	23.2	22.6	24.7	24.1	20.3	21.9	21.1
Average hits	40.3	69.5	72.7	82.6	57.3	55.3	56.6
Average applications	4.0	3.9	3.5	5.7	5.5	5.1	6.1
Hits per session	1.7	3.1	2.9	3.4	2.8	2.5	2.7