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Original Research

Step-by-Step: A Model for Practice-Based Learning

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Introduction: *Innovative technology has led to high-precision radiation therapy that has dramatically altered the practice of radiation oncology. This qualitative study explored the implementation of this innovation into practice from the perspective of the practitioners in a large academic radiation medicine program and aimed to improve understanding of and facilitate the educational process of this change.*

Methods: *Multiprofession staff participated in a series of seven focus groups and nine in-depth interviews, and the descriptive data from the transcripts were analyzed using grounded theory methodology.*

Results: *Practitioners believed that there had been a major effect on many aspects of their practice. The team structure supported the adoption of change. The technology changed the way the practices worked. Learning new skills increased workload and stress but led to a new conception of the discipline and the generation of new practice-based knowledge.*

When the concepts were examined longitudinally, a four-step process of learning was identified. In step 1, there was anxiety as staff acquired the skills to use the technology. Step 2 involved learning to interpret new findings and images, experiencing uncertainty until new perspectives developed. Step 3 involved questioning assumptions and critical reflection, which resulted in new understanding. The final step 4 identified a process of constructing new knowledge through research, development, and dialogue within the profession.

Discussion: *These findings expand our understanding of how practice-based learning occurs in the context of change and can guide learning activities appropriate to each stage.*

Key Words: *health professional learning, team learning, practice-based learning, implementation of innovation*

Background and Purpose

Radiation oncology is a rapidly evolving discipline that has experienced many changes as new radiation therapy technologies are being developed and implemented at a very fast pace.[1] A cluster of complex new technologies that have been introduced over the past few years have resulted in a dramatically different and innovative approach to radiation treatment as compared to the traditional process and provide the means and techniques to deliver high-precision radiation treatment (HPRT) that conforms to a planned target more accurately than was previously possible, reduce toxicity to healthy tissues, and improve cancer control.[2,3] The radiation oncology literature focuses on physical calibration information, clinical reports of its application, and financial issues of implementation. The technologies are extremely expensive and require very complex commissioning and installation.

Instruction in the use of the equipment and computer software is provided either by the various manufacturers or by education programs within each radiation medicine department and traditionally is delivered separately to each professional group. However, if the technologies are very new, and new applications are constantly evolving, there are no standard texts to assist learning and often the vendors' instructions are basic. If the multiple technologies and applications are interlinked, learning each one in isolation is inefficient. If many staff are learning this together, yet still have to meet service demands and deliver high-quality patient care, resources are strained. The implementation of change could be facilitated with an improved understanding of the process of the practitioners' learning.

The implementation of innovative clinical programs within organized health care is influenced less by scientific evidence than by local and organizational context[4] and economic health policy[5] and conducted in a manner that

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is quite different from that in business organizations.[6] Putting a new idea into use is only one element in the diffusion of innovations[6,7] and is considered to be an area in need of greater research.[6] During the implementation process, both the innovation and the organization are changed,[7] in a manner that can be dynamic and nonlinear as new interpretations lead to further adjustment and changes.[8] Unlike for new drugs, in North America, US Food and Drug Administration and Health Canada approval for technology is for safety standards, not clinical applications, which are developed in practice. New medical equipment is not always ready to use from the manufacturer; it requires new skills, and, within the public system, new institutional arrangements to develop its utility in clinical practice.[8] It can be difficult to capture and study this type of practice-based medical knowledge,[9,10] as it falls into the category of tacit or experiential knowledge,[11–13] but it can be made explicit and inform propositional theory.[10]

Achieving mastery with new technology is difficult and involves a collaborative learning process across disciplines and status lines at the individual, group, and organizational levels.[14] Modern medical practice is increasingly conducted in health care organizations,[15] with teamwork a central feature at all levels,[16] and examples of teams reducing workload and providing a supportive learning environment.[17] Learning organization models have been proposed for medical practice,[18,19] integrating continuous improvement principles, managing ongoing change and continuing medical education (CME),[20,21] with workplace learning informing practice and education.[18]

Within organizations, collective learning introduces many challenges,[22] and the group process and team learning in medical education remain poorly understood.[20] Collaborative activity does allow expert knowledge to be developed through a process of interaction with colleagues,[9] and the cross-fertilization of influences from different disciplines is considered to make the understanding of adult learning more robust.[23] On a practical note, clinician-to-clinician interaction has been described as the best mode of education about an innovation.[4] Although didactic CME activities may not improve performance outcomes in practice directly,[24] knowledge sharing is a function of scientists and health care workers[25] and occurs during presentations at scientific and professional meetings, participation in CME activities, and communities of practice.[26]

Many self-directed and facilitated opportunities that have been identified to enhance physician learning[27] do not require leaving the work environment. Practice review rounds, such as Quality Improvement Rounds or Tumour Boards, are forums for new knowledge to be shared and critiqued and provide excellent opportunities for practice-based learning, with reviews of protocols and standards.[28,29] Rounds can also generate interdisciplinary and interprofessional dialogue that enables tacit knowledge to become explicit and formalized[30] and new knowledge to be constructed[31] and provides peer pressure to motivate physician learning.[32]

This research project examined the process of the implementation of innovative technological applications in a large academic multiprofessional practice and explored the impact of these changes from the perspective of practitioners responsible for the technical aspects of radiotherapy. This practice is called the Radiation Medicine Program (RMP); it is a program within a cancer hospital that is part of a large university health science group in Canada. RMP is multiprofessional with radiation oncologists, radiation therapists (including dosimetrists), and medical physicists working together in an interdependent fashion and organized into cancer site teams (e.g., breast cancer, lung cancer) since different types of cancer are treated in different ways. Many key aspects of this practice were undergoing marked change by 2001, and the practitioners were required to learn new skills, knowledge, and processes and adapt to a new way of practice. This research project was prompted by the result of a needs assessment that was initially undertaken to develop a possible CME activity to help the physicians in the practice learn the skills to use the new technology. Three physicians, five therapists/planners, an administrator, and a physicist participated in a focus group in June 2001 and not only described what they needed to learn in terms of technical skills, but also indicated that learning to interpret and apply this new knowledge was associated with a much broader shift in practice than was originally anticipated. Furthermore, it became even more apparent that the oncologists were not learning in isolation, but as members of a complex, interdependent team. The purpose of this subsequent project became an exploration of the impact of this technological change on the nature of the practice, in order to use this understanding to organize learning in this workplace context and facilitate implementation of future new technologies.

Methods

This was a qualitative study. The descriptive data were collected from a series of focus groups and in-depth interviews over a period (May 2002–January 2003) when many changes were occurring in the practice. After solicitation by e-mail, more than 60 of the program's staff oncologists, therapists, and physicists involved in the technical aspect of radiation treatment (total number eligible = 150) volunteered to discuss the changes that had occurred in their practice in a series of focus groups. Sampling was purposive, based on participants' willingness to discuss issues and the need to explore emerging concepts. A total of seven focus groups were held, with 40 participants from all three professional groups (14 oncologists, 23 therapists and dosimetrists, 3 physicists; approximately proportional to staff numbers). Senior managers and academic leaders of the program (four oncologists, three therapists, and one physicist) participated in one-on-one interviews, so that their presence would not inhibit a frank exchange of views in the focus groups.

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The investigator acted as facilitator and interviewer. The audio recordings were transcribed, and data collection continued until theoretical saturation was obtained. No students, trainees, or patients were included. All participants provided informed consent and were assured of confidentiality. Approval was obtained from the Research Ethics Boards of the host hospital and university.

Grounded theory methodology (GTM) was used to analyze the descriptive data as it provides a way to conceptualize data from multiple perspectives and is useful for examining process and change, as well as providing a guide for action.[33] After a line-by-line examination of the material, the data were coded into concepts and organized using computerized software (NUD*IST, Version N6, QSR International Pty Ltd., Doncaster, Victoria, Australia, 2002). As the themes that were raised were coded, definite concepts emerged relating to the different elements of practice already identified in the preliminary needs assessment. The concepts, with categories and subcategories, were compared and examined in terms of their dimensions and properties to generate explanations for phenomena. This process was facilitated by the use of flow diagrams and matrices. Once this was completed for the major concepts, the phenomena were reanalyzed longitudinally over the period of the study using a temporal matrix to identify process issues. During this phase, a theoretical framework was generated from the data. The theoretical framework used in interpreting these explanations is from a constructivist tradition.

Detailed field notes, personal records of the investigator's own learning experiences, nonrestricted departmental committee minutes, relevant staff memoranda, and records of presentations were all collected to supplement the personal opinions that were collected in the focus groups and interviews and, consistently with GTM, were used for verification.[33] Attendance at specialty meetings and conversations with colleagues from other cancer centers suggested that the phenomena described were common.

Results

Consistently with the preliminary findings from the pilot study, three dominant concepts were identified: the organization of the practice, the nature of the work or service provided by the practice, and learning new competencies. As these concepts were analyzed temporally, a theoretical model of staged learning and change emerged, and, to prevent repetition, the body of the results is presented within the model.

In terms of the practice organization, the team structure and function appeared to facilitate both the adoption and the expansion of HPRT. Participants described the impact of HPRT on the nature of their work as "a totally new world" of practice. The introduction had been eagerly anticipated and welcomed by the practitioners, although changes happened so fast, and there were so many of them, that a comparison was made to being "swept along by a tidal wave." This period was seen as exciting and stimulating, but simultaneously as exhausting and stressful as it resulted in a major increase in each individual's workload. There was a time lag before new efficiencies emerged to balance out this extra work. Eventually, the new technologies reduced the time and effort of many tasks and increased capacity to treat patients.

The introduction of so many new techniques and computer programs and the emergence of a whole new range of conceptual issues meant that RMP staff had to deal with very large amounts of new information and develop new skills. The learning process was complicated by the lack of information available on the new technologies; instructions from the vendors were basic and did not have sufficient context specificity. Applications were continually being developed in practice. Participants frequently referred to their position on the slope of a learning curve that would flatten out "[once] everybody knows what to do step by step" or acknowledged that they were going through "a stepwise process, . . . building the whole basis of knowledge of this new technology" and that there was "a whole set of steps in this high technology [that] forces us to think very differently."

When participants were questioned about their learning, they usually referred to formal teaching and training but were unaware of the vast amounts of valuable experience and knowledge that they were building as they worked out problems and exchanged information with colleagues. Participants also found that involvement in writing new guidelines and protocols, along with research and development programs, enhanced learning.

A Four-Step Model of Practice-Based Learning

Four distinct steps along the process of learning and change emerged when temporal features were integrated to provide a longitudinal perspective. The data were collected at several points during a period of dramatic change from participants, who had various levels of experience and expertise and were not a homogeneous cohort. Some had been pioneers in the development and implementation of new techniques and treatments, while others, particularly at the beginning, were just starting to use them. It was evident that people were learning and adapting during this period. When temporal elements were used to connect the conceptual themes in a series of memos, matrices, and flow diagrams, common steps in the process of learning and implementation of change became apparent. Thus a theory emerged that was grounded in the practice experience and modeled a staged process of learning. Different educational activities were identified for each sequential step.

Step 1: "Learning the Tricks of the Trade"

Learning how to use the new technologies and the multiple computer applications was a source of anxiety and frustration for almost all staff, despite being a very computer-savvy group. An oncologist said of one application, "I can

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never remember which button to press and I'm always bothering people, and I certainly don't know the best way of doing it, I do a lot of working around . . . and I absolutely detest [it." Most of the new skills involved generating either radiological or graphical representations. The end point of this first step was the ability to create new images of radiotherapy.

Conventional in-house training was found to be useful to the key staff involved in a procedure. Timing and relevance were critical; for example, vendors' instructions were often incomplete or not sufficiently context-specific. The most commonly used and effective form of training was informal, with more experienced staff interrupting their work to assist anxious colleagues who needed immediate assistance. The process of writing instructions and guidelines to be posted on the department intranet was also identified as an important learning activity.

Step 2: "It's a Real Eye-Opener"

Once they were familiar enough with the technology to generate the computer-based images and graphs, staff had to learn how to interpret these. At first, it was difficult to recognize what the images, such as unfamiliar radiological screens or graphs of doses to the tissues, represented, and participants said that they had no familiar frame of reference. Participants expressed their amazement over what they could see with the new tools, prompting a therapist to say, "We're seeing things we never saw before." They were surprised, and at times horrified, to see how some older treatments inadequately covered the target volume and/or excessively irradiated normal tissues. The realization that some traditional treatment plans were inaccurate, along with the loss of standardized templates, was associated with a sensation of uncertainty, as people saw that the techniques, which they had used comfortably throughout their careers, were no longer adequate; as explained by a senior oncologist, "This is a dramatic difference . . . not necessarily . . . that the disease needs to be treated differently. But . . . we can now see . . . issues . . . relevant to . . . changing . . . how we actually deliver treatment." In this situation, the old terms of reference were gone. People felt uncertain and insecure until they learned more about the images and developed trust and confidence in the new technology. In doing so they developed new perspectives on treatment possibilities.

Most of the learning in this phase was self-directed, as people "figured it out" and learned "on the fly," often staying late after work to practice simulations on their computers.

Step 3: "Moving the Frame"

New perspectives on radiation oncology practice prompted examination not only of concerns such as the volume and dose of a treatment, but also of fundamental issues, such as the role of radiation treatment and many of the discipline's long-held assumptions. As a physicist questioned, "What are we actually treating? What are the goals? What is acceptable?" Past experience was not necessarily rejected, but reconciled and integrated into a new body of experience, as the clinical outcomes were redefined and challenges identified, such as one identified by another physicist, who stated that "we're plagued by what we did in the past." Broader concerns about access to treatment, fiscal responsibility, and societal issues were also debated.

This process involved reflection, deliberation, and critical questioning as the practice was reconstructed that, according to one experienced therapist, "forces us to think very differently; that's the biggest thing." The end point was the development of a new understanding of the practice.

The forum for this type of interactive learning was the workplace, especially multiprofessional team-based activities, such as site-group meetings, where new treatment protocols were worked out, and quality assurance rounds, where improvements to both individual treatments and system issues were explored in a very collaborative fashion.

Step 4: "We're Always Moving Forward"

Step 4 advanced the new understanding that was produced in step 3 to generate new knowledge, including the building of new rules, such as dose constraints, by testing evidence. It took the reconstruction of the practice to another level, legitimizing it through scientific research, and led to the further development of new technology and applications; as a therapist said, "The development of one new technology leads to another." The end result is a formalized body of new knowledge that is shared and published. It is also associated with new confidence, illustrated by the opinion of one oncologist: "I can do all sorts of things with radiation that I could never do before. [How to apply this to something useful is the most exciting aspect of the change."

Several different educational opportunities assisted this stage of learning. Research and development activities, rounds, and traditional CME events helped organize the new knowledge so that it became more accessible. This phase was very dynamic, as knowledge and applications were continually refined and expanded.

Discussion

The four steps describe a theoretical staged process that distinguishes (1) the earliest concerns about learning how to use the new technology, (2) interpretation of the new clues and information provided by the technology, (3) development of new understanding, and (4) building new knowledge for practice.

Other theories of physician learning and change have described different stages in the learning process,[32,34–37] and most are consistent with particular aspects or steps in this model. However, there are significant differences. These

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earlier theories stress the importance of assessing the individual's learning need and consider the cognitive aspects of an individual physician's learning process. Although the interaction with other physicians and informal peer pressure have been identified as major contributions to learning,[33] in general, these studies were more isolated from the social context and interaction that occur in practice-based team learning and multiprofessional organizations. They focus on the reasons physicians learn, suggesting greater control over changes in their practice, and often the changes were less complex; the practitioners in this study did not make the decision to adopt the innovations; rather it was an administrative decision that was largely based on external forces, and the changes were large, multiple, and complex. The innovations did not have established guidelines. However, there was little resistance to these changes, as the perceived clinical importance was already high, driving individual physicians to integrate changes into their practice.[38] As described by Rogers and others, those practitioners who were the earliest adopters and champions of the new technology led reinventions of the innovations and assisted their colleagues' learning.[6,7]

The first step of the model describes how the participants learned the functional skills of the new technology. The original needs assessment that was the impetus for this project focused on this stage and was prompted by the complaints voiced at staff meetings, informal settings, and observations from the literature that physicians' lack of skill caused delay in implementing CT-simulation technology.[39] Anxiety was a characteristic of this step, a surprising finding in a technological discipline so familiar with computer applications. However, most of the practitioners only use technology and are not the "wizards" involved in its design.[40] The marked anxiety of the initial step also partly obscured the multiprofessional team-based nature of the learning and the much larger implications for change in practice. When anxiety is evoked by a discrepancy between what one needs to know and what one actually knows, it can be a force to initiate learning.[33]

Formal instruction, or training, appeared at first to be highly valued, although there was recognition that it needed to be timely and context specific, and not led by an outsider, for example, the vendor. It was certainly more recognized than the informal learning that occurred with colleagues. Much semiformal training that occurred was inefficient, since it interrupted colleagues' work, but contextually it may have been more valuable.

Step 2 featured a transition from anxiety to uncertainty as the participants interpreted the new findings and learned to recognize what the new radiological and graphical images represented clinically. Applying clinical judgment in situations of uncertainty is central to professional practice,[41,42] and the self-directed and experiential learning that occurred in this phase are consistent with the concept of professional competence as an individual responsibility,[43] and the drive by a desire for enhanced competence.[33]

Step 3 described a phase of inquiry and building new understanding through a process of reflective examination of practice. Because the knowledge was so new, and many applications were still undeveloped, there were no evidence-based guidelines to follow. Instead, the practitioners had to integrate previous knowledge with the new experience and obtain this from as many sources as possible. Reflection on experience can provide insights that can be used to solve problems and change behavior.[35] In step 3, new understanding was deliberately rebuilt. This is consistent with Coles's[44] description of critical reconstruction of practice, which provides a new understanding and a foundation for further knowledge construction. Information that was built and shared throughout the team structure provided some answers and understanding. This collective reflection requires established social relationships and communication skills.[45] A spirit of inquiry was also noted at tumor boards, which have been found to be a source of practice-based learning, as well as quality improvement.[29] The learning that occurred was again context-specific and situated in the workplace, especially within the cancer-site-based teams.

Informal learning activities were also identified. Staff learned from each other as they "talked shop" informally to exchange ideas and consolidate knowledge. This use of narrative, usually laden with local jargon, is said to help people bond and share a common outlook and create communities of practice.[46–48] Hematopathologists, for instance, have been found to construct new knowledge by building on the experience and conversation of colleagues.[31]

Step 4 advances the understanding that was developed in step 3 to build new knowledge, participate in further research, and develop new applications. Refinement of new knowledge and its confirmation are the final stages of other theories,[7,36,37] and the term *legitimation* has been used to describe the process of sharing and transmitting new knowledge in practice.[9] Legitimation also occurs when professional knowledge is assessed and approved in a peer review process, such as publication in respected journals and inclusion in academic curricula. These activities add status to both the individual and the program in academic settings.[47]

The end result in this study is a formalized body of new knowledge that is practice-based and spans the spectrum from tacit to explicit knowledge. It informs everyday procedures and process, as well as larger conceptual issues and new scientific discoveries. Formal activities, including CME as a traditional venue for dissemination, play an important role in legitimation.

Limitations

The investigator is a radiation oncologist working in the program and at that time was also an active participant in the change process. While this insider perspective inevitably influences the data generation and analysis, it also provides access to data, including comprehension of the dense technical jargon used. The study was qualitative and thus

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Lessons for Practice

- The implementation of several new technologies in a large multiprofessional radiation oncology practice changed not only the treatments that it provided, but also the practice-based knowledge and competencies and the organization of the practice.
- A four-step model suggests different educational activities for each step in the learning process to facilitate implementation of the innovations.

exploratory in nature and was conducted in a very specific practice setting; thus the findings are not generalizable. It generated a model that is currently being applied to new learning opportunities within the same practice. How well this model applies to other practices is yet to be determined, but it may well provide guidance in situations where the nature of the learning is technical, the knowledge is still evolving, and the practice is team-based and part of a multiprofessional organization, such as histopathology, radiology, and minimally invasive surgery practices. Furthermore, it has the potential to inform how technology vendors can support their customers through different forms of educational activities.

Conclusion

The learning described during this period of change was complex, but once the four different steps were identified, it was possible to identify quite different learning activities. Skills training facilitated the use of the new technology and systems. Once people had the skills to use the new technology and were learning how to interpret their new findings, they benefited from self-directed learning opportunities to develop experience and familiarity. As they were developing new understanding and going through a process of critically reconstructing practice, learning was more social and occurred mostly in team-based activities that were deeply embedded in clinical practice, such as QA rounds, or less formally, in the conversations that they had with colleagues. Once this new understanding was used to develop new knowledge, people learned as they formalized the knowledge through documentation and research and as they participated in CME. It was only in this final step that learning occurred outside the practice, especially at CME events, when practitioners could compare their findings and learn from others. Thus these health professionals identified an array of diverse learning activities matched to different stages of the learning process. As future waves of new technology are introduced into practice, this model may guide learning activities to fit specific needs in ongoing professional development.

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