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ABSTRACT

This study considers telemedicine as an IT-enabled integrated health care network that supports collaboration and learning for knowledge creation, acquisition, transfer and sharing among health care parties. It employs a case study methodology to investigate the nature of telemedicine network, technology characteristics, use of technology and quality of inter-practitioner interactions in relation to the occurrence, nature and content of learning processes as well as the health care delivery outcomes within a wound care network in a Midwestern USA state. We conducted 12 open-ended interviews with the medical practitioners and administrators who participate in that wound care network. Based on the findings from this study, we build a grounded theory of the learning processes that occur within telemedicine networks. The grounded theory provides understanding about how effective learning can be fostered in a telemedicine network and how it contributes to the high-quality health care and telemedicine effectiveness.

Keywords

Telemedicine network, interaction, learning, quality of healthcare, effectiveness, learning communities.

INTRODUCTION

The recent resurgence of telemedicine has the potential to start a trend toward virtual networking among health care parties. If it develops past isolated applications, telemedicine will tend to evolve from point-to-point connections toward more coordinated, integrated, and interoperable networks. These IT-enabled networks involve collaborations among multiple players across multiple sites and thus provide the foundation for the development of organizational learning communities. These communities can promote the knowledge acquisition, sharing, and creation, which would enable quality improvement and novel insights in the knowledge-based health care delivery industry.

This study adopts a case study methodology to examine the learning processes occurring within a telemedicine-enabled wound care network in a Midwestern US state. We use a grounded theory approach to identify factors and processes that influence the learning processes among medical practitioners through the telemedicine networks. We focus on understanding how effective learning can occur in telemedicine networks as well as how thriving the telemedicine networks can be built on learning. Moreover, our main focus is on micro-level care-giving behavior, because we believe that this is the best way to understand the learning process.

LITERATURE REVIEW

By electronically linking together health care parties (health care professionals, hospitals, researchers, institutions, patients, nurses, etc.) for effective collaboration, and by providing easy access to up-to-date information/knowledge, telemedicine has the potential to create interlinked learning networks. Therefore, telemedicine is defined as an IT-enabled integrated network providing health care services in a single specialty or multiple specialties (Bashshur, 1995). Due to the proliferation of telemedicine in recent years, electronic networks of health care providers and institutions are replacing traditional health care organizations to serve as the focus of health care delivery in some communities and areas.

When telemedicine is defined as an integrated collaborative network for health care delivery, the existing learning literature indicates the potential of telemedicine as an ongoing, interactive learning system for knowledge creation, acquisition, transfer, and sharing. It has been argued that learning is easier and faster when actors form a community that consults about a practice or problem (Brown and Duguid, 1991). Members of learning communities are aware of each other's perspectives and tendencies. They value one another's views and may even implicitly take others' perspectives into account when facing an uncertain situation. A learning community is a public good. Its members know that they obtain value from the community and are willing to contribute their own questions, expertise, and insights in a system of generalized exchange. Once a learning community is recognized as a public good it acquires a momentum of its own. Members are drawn to contribute to the community and interaction within the community is self-sustaining.

Our research questions are: How does learning occur within a telemedicine network? What is the nature of the learning processes? What are the factors and processes influencing learning? What effects will learning processes have?

METHODOLOGY

Due to the lack of research on learning in the telemedicine context, this study employs a case study methodology with an aim of generating, in a grounded and inductive fashion, a descriptive and explanatory theory of the learning processes that occur among medical practitioners through the telemedicine network. So, we draw on the grounded theory approach (Strauss, 1987; Glaser and Strauss, 1967), which is considered appropriate for theory development in IS research (Eisenhardt, 1989; Orlikowski, 1993).

Site Selection

The telemedicine network selected for this study is a wound care network (WCN) established by a major urban medical center in a Midwestern US state. Due to the lack of wound care specialists (WCSs) in the rural areas, the medical center has utilized videophone technology to build a network among doctors, WCSs and nursing staff in the rural clinics and facilities. The videophone is primarily used for wound care consultation, which involves rich interactions among medical practitioners and thus provides opportunities for learning.

Data Collection

The primary method for gathering data was through 12 in-depth semi-structured interviews with a number of medical practitioners (i.e., WCSs and nurses) and administrators who participate in the WCN. The interview subjects were identified based on their participation and involvement in telemedicine activities within the WCN. We sampled subjects to ensure that we interviewed a representative sample of the roles in the network. We interviewed 2 wound care specialists, 6 nurses, the program director and a supervisor of the wound care specialist. The director and one wound care specialist were interviewed twice.

The interview questions focused on the following topics: (a) the nature and history of the WCN, (b) the people and organizations involved in the WCN and their characteristics and relationships, (c) the types of information technology used to deliver wound care services and how they are utilized for the medical interactions, (d) the nature and quality of interactions among the medical practitioners within the network, (e) the nature and contents of various learning processes that occur through the WCN, (f) the learning effects of the WCN, (g) the outcomes of wound care delivery after the telemedicine implementation, (h) other changes and improvements experienced after the telemedicine implementation, (i) challenges or difficulties encountered during the telemedicine implementation, (j) the organizational climate for learning and collaboration, and (k) future directions for the development of WCN. The interview reports were also supplemented by documents and archival sources, such as telemedicine protocols, telemedicine policies and procedures, wound consultation logs, etc., which provide additional information about the characteristics and development of the WCN as well as inter-practitioner interactions within the WCN.

CASE DESCRIPTION

The wound care network (WCN) in this case study was developed to deliver wound care to rural areas where there is a severe shortage of local wound care specialists. The WCN has two wound care specialists (WCSs), who provide telehealth consultation services to the rural care facilities (e.g., home health care, clinics and nursing homes) throughout the whole service system. During consultations, they utilize videophones that can connect them through the telephone lines to the patients, nurses and other practitioners from in the rural areas. The videophone is simple, cheap and easy-to-use equipment. It transmits at acceptable speeds on normal phone lines. It also allows people to attach and employ different peripherals, such as removable or additional remote cameras for capturing and transmitting wound images. Both WCSs usually have 4 or 5 home telehealth consultations per week, each lasts 20-30 minutes. The video-mediated medical encounters mainly involve assessment and treatment of the patients' wounds.

Using videophone, the medical practitioners interact differently than in traditional face-to-face medical encounters. Firstly, during the telemedicine session, the nurses do the wound care by themselves while being talked through a treatment procedure by the WCS. Traditionally, however, when the WCS is present on-site, the nurses can only observe the WCS doing the wound care instead of doing it themselves. The WCN director and nurse said, "*She (the WCS) watches them (the nurses) do the care and gives them feedback....*" "*She (the WCS) instructs us by watching us on how to perform whatever the care it is we need to do for the patient.*" Secondly, because the nursing staff actually do the wound care during the medical encounter, they seem to be more involved in care-giving. The WCN director and nurse said, "*…Having the local nurse do the care results in a greater focus and more attention to why they are doing so and what they are doing.* "*I (the nurse) find it a lot more interesting and fascinating. The more I am involved, the more interest I have in the work.*" Therefore, by doing the care themselves, the nurses have greater engagement in the interactions with the WCSs and patients and paying more attention to the tasks at hand.

Thirdly, the video-mediated medical encounter involves greater interaction interdependency between the WCSs and the nursing staff. The nurses become the hands and eyes of the WCSs during the telemedicine sessions. They do the physical exam of the patient, provide in-person medical observations to the WCS, follow the WCSs' instructions, and apply treatment to the patient. And the WCSs rely on the nurses' observation and information to make diagnoses and recommend treatment. The nurse said, "*I (the nurse) tell her (the WCS) about things that we are trying on it (the wound). I describe how it looks like that way? Make sure she gets a full view of what the wound looks like.*" The greater interdependency between the nurses and WCSs during the telemedicine session builds trustful, peer relationships among them, which then promote effective collaboration among them. The nurse and WCS said, "*I (the nurse) got a closer bond with her (the WCS). ... It seems that we're in the same group instead of being specialist and nurse. We are like colleagues.*" "*…Staff feels more of a team and more collaborative and less likely to go out and jump out on their own.*"

Fourthly, the use of telemedicine increases the opportunity for more frequent and timely feedback on the wound care practice. One nurse said, *"(Using telemedicine), I got faster feedback on how I execute the treatment. (That) makes the treatment and application more precise and accurate."* Finally, the interaction between the WCSs and nurses are reflective in nature. The WCSs attempt to evaluate, explain, and justify diagnoses and treatments while she is instructing the nurses on wound care during the video-mediated medical encounter. The WCN director said, "*She (the WCS) watches them (the nurses) do the care and gives them feedback. Here is why you are doing this. Here is why you don't change dressing each day. Here is the type of bandage to use.*" "*... They (the WCSs and nurses) can try a new wound care procedure or protocol, and then evaluate that wound daily or weekly to see if it's progressing or not progressing.*"

Considerable learning occurs within the WCN among medical practitioners who communicate/interact on wound care using the videophone. Nurses learn specific medical knowledge, such as wound assessment, new procedures of applying medication to a wound, etc. The nurses said, "*She (the WCS) has taught me much about wounds… We're learning how to work on the bad wounds.*" "*From her, we learn a lot about different wounds, and care we need to do for that. ... So we learn a lot about wound care and about what we were seeing as far as the wound condition.*" Both the WCSs and nurses also learn how to use the technology for effective collaborative interaction. For example, specialists learn how to best use the technology to instruct nurses on wound care, such as learning to use more verbal confirmations to make up for the loss of visual cues. One WCS said, "*With telemedicine I (the WCS) have to get more verbal confirmation of understanding... I ask them to confirm orders, have them read back to me. I also send notes to them in writing to make sure that there is understanding.*" The nurses learn how to use camera to transmit images, learn to focus on the wound so that both parties have a shared view of the wound, and learn to switch between the views of the wound and the specialist's face to facilitate communication, etc.

As a result of on-going interaction and learning among practitioners through the WCN, the quality of wound care is getting better even without specialists being physically present. One nurse said, "*We have faster wound healing and lower cost*

related to a chronic wound in the form of dressing and in the form of nursing time required to heal a wound." Firstly, nurses learn better in a telemedicine session than in a traditional mode. Learning by doing allows nurses to quickly and efficiently acquire medical expertise and skills through their direct experience with actual wound care practice. The nurses said, "*I've been able to judge wound better.*" "*... It helps me to be able to have a better knowledge of what I am looking at as a nurse.*" Secondly, the use of telemedicine greatly expands the opportunities for nurses to access the WCSs. This may lead to better compliance with the specialist's treatment orders. One WCS said, "*Because of the ongoing availability and follow-up with nursing staff they are feeling better ownership of process, so they are compliant and more knowledgeable.*" Furthermore, using telemedicine, the nurses are able to receive more immediate and frequent feedbacks on their execution of a treatment procedure. This ensures the nurses accurately follow the wound protocols and make precise treatment. And the high availability of WCSs through telemedicine also enables the nurses to try and change the treatment order a lot more quickly when it's not working for the patient. One nurse said, "*By using telemedicine, we can change the wound care quicker if it's not working.... She (the WCS) would see it quicker than she would come herself.*" Therefore, the nurses are more open to new ideas and are willing to try different treatments to improve the wound care practice. The nurses said, "*We found that wound healing a lot faster with telemedicine than the old ways... Because using telemedicine we can try something new everyday on the patient while at the same time being able to communicate with the doctor in time and frequently to see what things are working better.*" In addition, through their frequent consultations with the specialist, the nurses become aware of the complexity of wound care system and come to realize that they know less than they thought they did before. Therefore, they consult more with the specialists and follow the specialist's clinical judgment instead of relying on their own judgment call. One WCS said, "*Now they (the nurses) realize they know less than they thought they did before. ... They understand the implications of making a wrong judgment call their own, so they consult more...*"

As the practitioners see the benefit of telemedicine to achieve high quality care, they rely more on the technology to work with each other for wound care delivery. They are willing to use telemedicine more frequently and more effectively. The nurses said, "*We want to improve the wound care practice by using the telemedicine more and getting her (the WCS) more involved*" "*We hope to expand and get it (the telemedicine) out more. We're going to get in with the doctors so that they can take care of the patients more and make things better.*"

CASE ANALYSIS AND DISCUSSION

The learning processes that occur among medical practitioners through the telemedicine network and their influencing factors and consequences are shown in Figure 1. It indicates the key categories and concepts that emerged from the data analysis as well as the relationships among those categories and concepts.

The adoption and use of telemedicine create a new environment for interaction among medical practitioners. The telemedicine network has the potential to provide and sustain the proper context for learning by facilitating and enhancing inter-practitioner interactions. The properties afforded by the telemedicine technology and the way the technology is appropriated for medical interaction shape the way the medical practitioners interact with each other to deliver health care. And learning occurs through the interactions among medical practitioners, which involves the exchange, transfer, distribution and creation of medical information/knowledge, the generation and dissemination of new knowledge about how to collaborate effectively via telemedicine, and the application of this knowledge in telemedicine practice. In turn, learning to use telemedicine for collaboration on health care also influences the way practitioners use the technology and the way they interact with each other to deliver health care. Learning processes –learning about medical knowledge and learning about using telemedicine for medical collaboration—generate telemedicine collaborative knowledge and shared medical knowledge, both of which contribute to high quality healthcare. Then, encouraged by the fact that the use of telemedicine can actually improve the quality of care, the medical practitioners are motivated to use technology more frequently and more productively for care delivery. And finally, productive learning through the telemedicine network also promotes the effectiveness of telemedicine network by improving healthcare quality and facilitating the adoption and appropriate use of technology. (See Figure 1)

Properties of Telemedicine Technology

The WCN employs videophone with attachable or remote camera for telemedicine. According to Daft and Lengel's media richness theory (MRT) (1986), the telemedicine system can be classified as a moderately rich medium, which will enable real-time, interactive face-to-face communication/interaction among medical practitioners. As the telemedicine technology enables and mediates the long-distance communication among medical practitioners, the properties of technology determine how the practitioners can interact/communicate with each other to deliver health care.
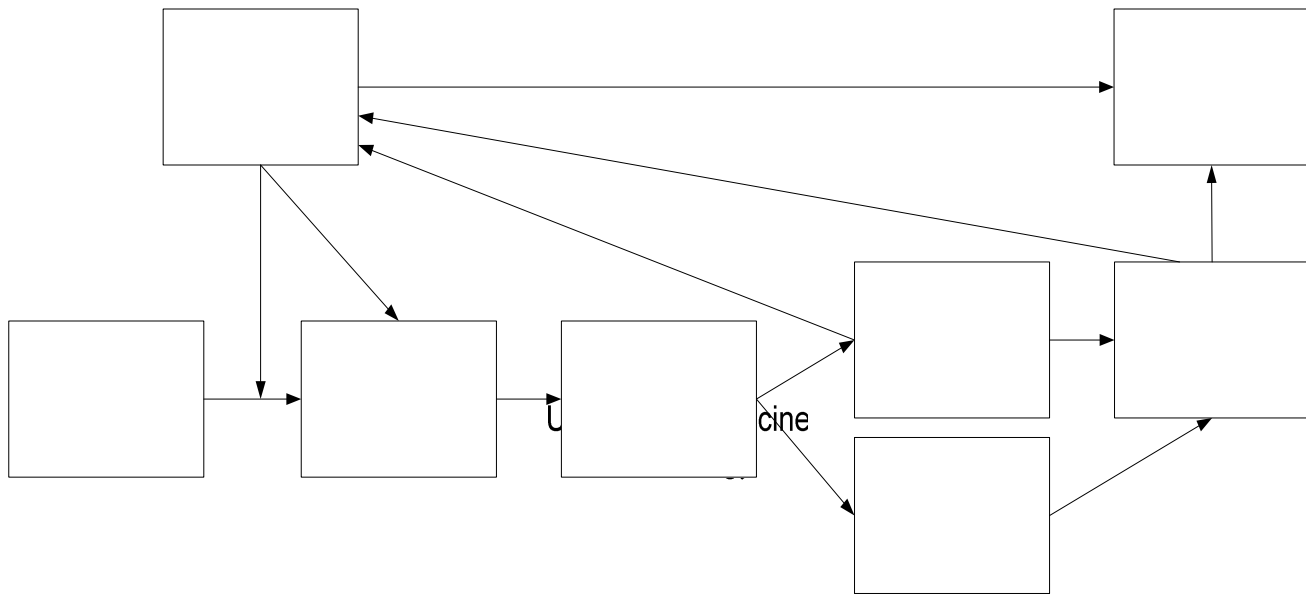
Figure 1. Learning Through Telemedicine Networks

Use of Telemedicine Technology

In the WCN, the videophone is used to provide wound care consultation. When a nurse is treating a patient, she/he can call in the WCS at a distant site so that the WCS can look at a patient's wound, assess the wound condition, communicate with the nurse on patient information, make diagnoses, recommend treatment, and instruct the nurse on different wound techniques and treatment procedures. However, although the videophone allows both voice and video communications, it does not provide as many visual cues as being present in a traditional in-person consultation. The video-mediated communication may reduce the visual cues that are important for effective inter-practitioner communication during the wound care process. Over time, as the medical practitioners learn to use the videophone for face-to-face medical encounters, they come up with different ways to overcome the communication problems during the telemedicine sessions. They carefully set up and deploy the videophone and camera to achieve the optimal level of social presence that can be afforded by the technology, such as manipulating the lens and focus of camera to get a best picture of wounds so that the on-site nurse and the remote WCS can have a shared view of the wounds, adjusting the size of video windows to capture important visual cues, switching between different windows to facilitate smooth communication and knowledge transfer, etc. One WCS commented that they were experimenting with higher quality audio so that they could listen to the wound, since some wounds make different sounds than others when palpated. Practitioners also learn to modify their communicative behaviors to overcome the communication deficit in the technology ability, such as using more verbal expression for confirmation, sending notes to develop shared understanding, etc. Therefore, the way that telemedicine technology is used for medical interaction not only determines the way that practitioners are allowed to interact, but also moderates the effects of technology properties on inter-practitioner interactions by enhancing or reducing the social presence and information cues that can be afforded by the technology.

Interactions among Medical Practitioners through the Telemedicine Network

The interactions among medical practitioners through the WCN mainly involve the interdependent message exchange during the video-mediated wound care consultation. Compared to the traditional face-to-face interaction, the telemedicine-enabled interaction is characterized by higher interdependency among medical practitioners, more frequent and timely feedbacks, greater task participation, more emotional involvement, and higher reflectiveness.

During the telemedicine sessions, the nurse and WCS develop higher interdependency among themselves due to the fact that they greatly rely on each other to accomplish wound care. Instead of examining and treating the patient by herself, the WCS

must instruct the nurse to examine and treat the patient and rely on the information provided by the nurse to make diagnosis and recommend treatment. And the nurse must seek the WCS's advice and follow her instructions to deliver care. Using telemedicine for interaction, the nurses and WCSs are also able to obtain more frequent and timely feedback on wound care practice. The WCS and nurse can interact more frequently over the videophone. The WCS provides immediate feedback to the nurse on how to execute the treatment and the nurse gives timely feedbacks on patient situation for WCS to determine treatment. Telemedicine also enables the nurses to have higher levels of participation in wound care practice. During the video-mediated encounter, the nurses, under the instructions of the WCS, do the care by examining the patient, looking for symptoms, and applying treatment. As a result of higher interdependency and greater participation, the medical practitioners become more emotionally involved in the medical encounter. The nurses devote more attention and interest to the interactions. They also develop a trustful, peer relationship with the WCSs that are critical for effective collaboration. The video-mediated interaction is also highly reflective in a sense that the medical practitioners actively engage in reflective activities during the medical interaction, i.e., explaining, justifying and evaluating the treatment procedures.

As shown by the case data, the medical interactions through the WCN generate considerable learning among medical practitioners, i.e., the transfer of medical knowledge and development of knowledge about how to use the videophone for productive collaboration. As learning occurs in and requires social interactions, the interactions among medical practitioners influence the occurrence and nature of learning through the telemedicine network.

Learning Processes in the Telemedicine Network

In the WCN, the nursing staffs get better learning during the telemedicine session than in a traditional face-to-face encounter. Firstly, the video-mediated medical interaction provides the opportunity for the nurses to learn by doing, while traditionally nurses often learn by observing the expert doing the wound care instead of doing it by themselves. We know that people learn best by doing (Dale, 1969). Learning by doing enables direct input from the nurses and is likely to make a lasting impression on the nurses of why they are doing and what they are doing for wound care. Secondly, as the medical practitioners are more interdependent in performing the care practice, they will develop trustful collaborative relationships that greatly enhance the interchanges of ideas, information, and knowledge. Thirdly, due to the practitioners' greater emotional involvement in the medical encounter, the nurses assume more active roles and devote more attentions and greater interests in their work, which would promote better learning. Fourthly, in a telemedicine session, the nurses learn better also because the WCSs explain why and how a treatment procedure should be carried out as well as the principles to be used for that treatment while they are instructing the nurses on the videophone. In this way, the nurses learn how to approach similar problems in the future. The evaluation of a treatment based on the patient outcome is also critical for effective learning to occur for both the nurses and the WCSs. The evaluation stimulates both of them to reflect on the current treatment procedures. This may lead to the reinforcement or change of the current treatment for desirable results, from which the practitioners learn how to deliver better wound care. Finally, learning through the WCN is of higher quality than the learning in a traditional medical encounter because telemedicine enables more frequent and timely feedback. Learning can be described as a closed loop in the corrective feedback process, alternating among action, feedback and reflection (Argyris and Schon, 1978). Therefore, faster and more frequent feedbacks on wound care practice stimulate quicker and better learning for the medical practitioners.

While the interactions among medical practitioners through the WCN involve considerable learning about medical knowledge, they also entail the practitioners' learning about how to use the telemedicine systems (videophone and camera) for effective medical collaboration. The practitioners learn how to set up the equipment, how to focus and give a clear shot of the wounds, and how to modify their communicative behaviors to overcome the technology limitations.

Telemedicine Collaborative Knowledge, Shared Medical Knowledge, and Quality of Wound Care

As discussed before, there are two types of knowledge learned by the medical practitioners through the videophone-mediated interaction/communication – shared medical knowledge and telemedicine collaborative knowledge. The video-mediated consultation involves practitioners having knowledge gaps for wound care, and hence there will be knowledge transfer from the WCSs to nurses. During the consultation, the nurse, as the receiver of wound care knowledge, attempts to follow the WCS's treatment orders and understand why and how they are working responding to patients' symptoms. While both the nurses and WCSs learn how to use the technology for effective interaction/communication, the WCSs tend to focus on the way that the technology can be used to transfer medical knowledge to the nurse, to obtain different perspectives or experience from the nurse, and to ensure the delivery of best care possible. Therefore, the nurses usually perceive telemedicine as providing a learning opportunity for them to acquire specific medical knowledge, and the WCSs focus on acquiring the knowledge about how to effectively work with nurses via telemedicine in delivering wound care.

Both shared medical knowledge and telemedicine collaborative knowledge contribute to high quality care delivery. The fast and wide sharing of medical knowledge make possible the best medical practices. Telemedicine collaborative knowledge pertains to the productive application of telemedicine technologies for effective medical collaboration. On one hand, the medical practitioners develop greater confidence and adeptness in using telemedicine applications, ultimately leading to a quicker and wider adoption and effective use of technology; and on the other hand, telemedicine collaborative knowledge also helps to improve healthcare quality by enhancing the inter-practitioners collaborations and providing the frequent, in-time access to the wound care expertise. In addition, the improvement in the quality of wound care due to the use of telemedicine adds to the practitioner's good experience with telemedicine. Being aware of the importance and necessity of using telemedicine for high quality care, the medical practitioners become more reliant on the telehealth consultations and are greatly motivated to use the technology more frequently and effectively to deliver wound care.

Media richness theory would predict that telemedicine mediated care would be less effective than face-to-face care, because it is conducted through a less rich medium. However, our results run counter to this expectation: telemedicine mediated wound care can be more effective than face-to-face care. While the telemedicine medium was poorer than face-to-face media, it provided greater focus on the wound than direct vision would have. Having to work harder to understand the patient's condition led to a better understanding on the part of both caregivers of the patient's condition. Moreover, the involvement of both caregivers rather than just the main provider (the WCS) led to a better collaborative understanding of the patient's condition than would obtain in direct face-to-face consultation. That care for the patient was distributed among multiple caregivers made a medium that involved all of them in care more effective, even though it was less rich than immediate contact.

CONCLUSIONS

This case study of WCN investigates the factors and processes that influence learning processes through the telemedicine network and their effects on the effectiveness of telemedicine network. We believe that our study can make the following contributions to the telemedicine research. Firstly, it contributes to the understanding of how the properties of the technology used for telemedicine and the way the technology is used influence the occurrence and nature of learning processes through their effects on medical interaction/collaboration within a telemedicine network. Secondly, it demonstrates the importance of various learning processes related to the effectiveness of telemedicine networks. The micro-level focus of this study is somewhat unusual for case studies of telemedicine and is well suited to illuminating the interaction processes that undergird learning. Thirdly, this study extends previous work on learning by examining the relationship between the nature of interaction and quality of learning. Finally, the findings will also provide the practitioners with implications and guidelines for designing and developing effective telemedicine networks.

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