Teaching and learning aspects of remote medical consultations
BY SIGMUND AKSELEN AND SVEIN-IVAR LILLEHAUG

Abstract
This paper discusses educational effects of remote medical consultations. First, a definition of telemedicine and a brief overview of some of Norwegian Telecom Research’s remote consultation applications are given from an educational perspective. Some state of the art theories of teaching and learning are presented and discussed. Then, the focus is put on functionalities that can increase the educational outcome from remote consultations. Finally, possible impacts on society from lifelong learning through remote consultations are discussed and thoughts on future work are given.


1 Introduction
In 1988, Norwegian Telecom Research (NTR), in cooperation with the University Hospital of Tromsø (UHT), started a project on telemedicine in North Norway. North Norway is characterised by sparsely populated communities spread over vast distances. Furthermore, the increase in complexity and amount of medical knowledge has caused a demand for specialisation within the health services. As a consequence there is a limited number of qualified personnel within certain sectors of the health services, especially in remote areas. An objective of the project is to use telemedicine to provide equal health care services to each individual in Norway, regardless of geography or economic variation in the population.

Telemedicine is not a new concept. Health care professionals have been using the telephone to carry out their services for years. In addition, research efforts have been put into utilising more of the telecommunication repertoire including speech, text, data, picture and video communication (8). A goal for telemedicine is to eliminate travelling for patients and specialist. Telemedicine may be defined as (2):

The investigation, monitoring and management of patients and the education of patients and staff using systems which allow ready access to expert advice and patient information, no matter where the patient or relevant information is located.

The NTR telemedicine project systematically explores the possibilities provided by new information and communication technologies in improving health care services, and has led to several telemedicine applications. Today, these applications are based on a variety of networks, ranging from the ordinary telephone network to specialised data and videoconferencing networks. The applications may be grouped into four categories (3): remote diagnosis, distance learning, medical information and administrative information.

In this paper we focus on remote diagnosis as collaborative work and discuss the educational effects it has on the health care personnel in remote areas.

2 Remote diagnosis
The term remote diagnosis refers to remote consultations where the diagnosis is based on medical data transmitted over telecommunication networks. Usually there are three persons involved in a remote consultation (see figure 1). The most important is the patient concerned about his disease. There is also the general practitioner who has insufficient knowledge to assess the patient’s problems, and finally there is the specialist who is supposed to diagnose the problems and propose treatment if possible.

Most of NTR’s telediagnosis applications are based on transmitted medical pictures, both live and still. The applications include, among others, remote consultations within: pathology (15), radiology (21), endoscopy (7), dermatology (10,12), cardiology (1) and even psychiatry (9). In addition, trials have been conducted on remote consultations within microbiology, gastroscopy, electrocardiography and electroencephalography. All these applications are similar in many aspects, both in their technological solutions and methods of work, but different in others.

A majority of the applications utilise videoconference equipment over a 2 Mbit/s switched network. Some of the applications include add-on special purpose equipment such as a microscope or endoscope to provide “the necessary pictures”. Most applications demand all involved persons to participate at the same time (synchronous communication). Lately, research and development has begun in order to provide several of the applications on lower transmission capacity and, thereby, cheaper networks. ISDN is, in this respect, seen as an obvi-
ous network solution (3). Terminal equipment used in the ISDN solutions include the Tandberg Vision videophone (14), and NTR’s own system for digitising, storing and transmitting medical stills (pictures) from arbitrary video sources. Further, the applications will also provide for asynchronous communication, (i.e. the participants will not necessarily be present at the same time).

Below, tele-endoscopy, remote diagnosis of skin diseases and remote echocardiology will be described in more detail with focus on the educational aspects. Below, the term practitioner will refer to both general practitioners in primary health care and residents in remote hospitals.

2.1 Tele-endoscopy

An endoscope is a device for guiding a source of light inside the human body and transposing an image of the examined organ on a monitor. Tele-endoscopy refers to the transmission of these images over the telecommunications network to a specialist at the other end. A practitioner is, however, still needed to bring the endoscope inside the patient and adjust the positioning to get the correct images (7). Tele-endoscopy is used in remote consultations and transfer of consultations between the two consultations of each patient. As with tele-endoscopy, a session of remote diagnosis of skin diseases can be divided into examination, diagnosis and compilation of treatment plan. From the educational perspective the service can be described through three phases. First, the practitioner functions as the specialist’s extended arm by providing the specialist with different pictures (by moving and focusing cameras) of the patient, and giving comments about how the skin feels as well as other necessary anamnestic information. This process might also include the practitioner taking a biopsy or performing other tests. Throughout the session the specialist explains the different actions as well as the reasoning behind his diagnosis and the resulting treatment plan. In the second phase the practitioner and the specialist cooperate as colleagues during the consultation. As the practitioner gains the necessary knowledge and skills through collaborative practising, he is ready to move over to the third phase of independent consultation with the patient. Similar to the tele-endoscopy service, the specialist is brought in whenever necessary to help, monitor and evaluate the practitioners’ actions.

2.2 Remote diagnosis of skin diseases

Remote diagnosis of skin diseases is based on technical solutions similar to tele-endoscopy. The only difference is that instead of the endoscope the practitioner has several cameras which are used to transfer still and motion pictures of the patient to the specialist. As with tele-endoscopy, a session of remote diagnosis of skin diseases can be divided into examination, diagnosis and compilation of treatment plan. From the educational perspective the service can be described through three phases. First, the practitioner is, however, still needed to bring the endoscope inside the patient and adjust the positioning to get the correct images (7). Tele-endoscopy is used in remote consultations and transfer of consultations between the two consultations of each patient. As with tele-endoscopy, a session of remote diagnosis of skin diseases can be divided into examination, diagnosis and compilation of treatment plan. From the educational perspective the service can be described through three phases. First, the practitioner functions as the specialist’s extended arm by providing the specialist with different pictures (by moving and focusing cameras) of the patient, and giving comments about how the skin feels as well as other necessary anamnestic information. This process might also include the practitioner taking a biopsy or performing other tests. Throughout the session the specialist explains the different actions as well as the reasoning behind his diagnosis and the resulting treatment plan. In the second phase the practitioner and the specialist cooperate as colleagues during the consultation. As the practitioner gains the necessary knowledge and skills through collaborative practising, he is ready to move over to the third phase of independent consultation with the patient. Similar to the tele-endoscopy service, the specialist is brought in whenever necessary to help, monitor and evaluate the practitioners’ actions.

2.3 Cardiology diagnosis through remote echocardiology

The project of remote diagnosis through echocardiography has taken a somewhat different approach than tele-endoscopy and remote diagnosis of skin diseases. So far the main topic has been to investigate the appropriateness of remote echocardiology as a tool for distance education of physicians with minor practical experience in echocardiology (1). The technical solutions are similar to the other presented projects. In addition to videoconferencing two dimensional, M-mode and doppler echocardiography are transferred.

The practitioner involved in the test trial had no further experience with echocardiology than a five days theoretical introduction course. During the test trial, 38 patients were first examined by the practitioner with the specialist remotely monitoring the practitioner’s performance and giving supervision. Practical instruction in examination techniques, diagnosis and compilation of treatment plans were given by the specialist whenever required. To double-check the practitioner’s performance, and to evaluate the quality of remote echocardiology, the patients were directly examined by the specialist later. Based on a comparison between the two consultations of each patient, Afsæth et. al concludes that remote echocardiology is an efficient and appropriate technique for education in echocardiography.

3 Educational implications of remote consultations

The projects described above have similarities both in technical solutions and phases of execution. A typical session goes through the steps of examination, diagnosis and compilation of a treatment plan. Within each discipline the practitioner evolves from having minor experience in the field to becoming a semi-specialist through three phases: practical demonstrations given by specialist, practising in co-operation with specialist and, practising under supervision of the specialist. This approach of learning is known as the role model within the medical system (13). The role model has its parallel in educational theory in what Collins et. al and Brown et. al (4,5,6) have proposed as the cognitive apprenticeship model for instruction of cognitive skills. Since ancient times apprenticeship has been the most common method to transmit the knowledge from a master to an apprentice in a wide variety of fields, also within medicine. In their argument for cognitive apprenticeship, Brown et. al claim:

“...that knowledge is situated, being in part a product of the activity, context and culture in which it is developed and used ((4), p 32),”
The cognitive apprenticeship model comprises three methods similar to the three phases of the role model: situated modelling, coaching and fading. These are described as follows in (4):

- **Situated modelling:** The teacher/coach promotes learning, first by making explicit their tacit knowledge or by modelling their strategies for students in authentic activity.

- **Coaching:** The teacher/coach supports the student’s attempts at doing the task.

- **Fading:** The teacher/coach empowers the student to continue independently while the support is gradually withdrawn.

Collins et al (6) summarise the benefits of the cognitive apprenticeship model for instruction as follows:

- Learners will more easily understand the purpose and use of knowledge.

- Learners learn by actively using, rather than passively receiving, knowledge.

- Learners learn different conditions under which they can apply their knowledge.

- Learners can generalise the knowledge across meaningful situations (instead of directly acquiring a generalisation without any context).

A good educational outcome of the CA model relies on good and efficient communication between the apprentice and the specialist throughout the different phases of the model. Both the practitioners and the specialists involved in the three projects presented above, report a better educational outcome through remote consultations as compared to the traditional specialist education within the respective disciplines. They explain that the practitioner in a remote consultation receives much more attention and supervision from the specialist than a physician going through his special education at a central hospital. This observation corresponds with the following shortcomings identified in an evaluation of the traditional education in ventilator therapy among nurses and physicians specialising in intensive care and anaesthesiology at UHT (13):

- There are weaknesses in the supervisor’s ability to explain cases/problems and their solutions.

- Feedback on student performance is missing or of varying quality.

- Students are rarely required to explain cases/problems encountered or their own solutions.

- Supervisors are not available when needed, and when available, time limitations prevent the supervisor from demonstrating or giving detailed enough explanations.

A remote consultation provides an environment that, by its characteristics, forces the participants to bypass these possible weaknesses in traditional education. These characteristics can be identified as:

- The specialist needs to involve the practitioner in the procedures in order to carry out the examination/consultation.

- The specialist is dependent on the practitioner doing a good job.

- The practitioner is more frequently required to explain his reasoning and performance.

- The specialist is available during the entire session.

- The specialist saves time as the practitioner begins to work more independently.

- The specialist can use his time on challenging cases, as more patients are treated by the practitioner.

As a result, both the practitioner and the specialist are highly motivated to follow the CA methods of situated modelling, coaching and fading thereby leading to an efficient educational outcome of each session.

A measure of the success of the NTR’s telemedicine project is the high number of requests from remote hospitals and health institutions that want access to the different services. The hospitals want to take advantage of the benefits that telemedicine provides. For example, the patients can receive specialist consultations locally. In a remote consultation, the three participants have the opportunity to discuss the problem at the same time. This has not been the case earlier. The gap in time from the problem’s occurrence, the call of the practitioner’s attention to it, the specialist consultation, and the practitioner being informed of the diagnosis and the treatment plan, is reduced. Same time, same subject and same information available is, according to Jøsendal et al (12), the remote consultations’ greatest pro. The medical personnel (in primary health care) get better opportunities to keep professional contact with other institutions and groups of specialists. This may improve stability, competence and recruiting of medical personnel, thus increasing the possibilities for running a qualitatively good and safe service. Further, through good telecommunications the medical personnel can take part in an exchange of knowledge and professional discussions independent of geographic location. The personnel can raise their competence and get further education without leaving their district and thereby save many and expensive travels. Time saved on travelling can instead be invested as work time. In summary the remote areas can provide a better health care system at a lower cost.

Up until recently, most of the services in the telemedicine project have been performed on a trial basis to a few remote sites. Opening the services for more widespread use will increase the load on the specialists and their departments at the central hospitals. Therefore, the different services need to be investigated for how to most efficiently meet the new demands.

### 4 Increasing the educational outcome

A main focus of the telemedicine project has been to provide remote medical consultations by combining advanced medical technology and telecommunications. The above discussion implies that the educational outcome of remote consultations might be just as important as the service provision. This has lead to applications, such as remote echocardiography, where the main topic has been to investigate the appropriateness of remote consultations as a method for distance education of health care workers.

One way to prevent an increased load on the specialists and their departments might be to make the practitioners more independent. This can be done by providing additional tools for educational purposes and specialist advice. In other words tools that offer the practitioner an efficient learning environment combined with supervision functionalities without necessarily having access to the specialist. Computer applications have the potential to facilitate both learning and assistance during a consultation. By inte-
responding learning theory. Influenced by the development of a core instructional theory will often be related. For instance, the formalisation of learning comes. However, the two are closely related. For instance, the formalisation of learning is an active, constructive, cumulative and goal-oriented process where the learner is required to play an active part. For effective learning to occur, various psychological processes in the learner must be engaged. For example, learning must build upon, and be influenced by, the learner’s prior knowledge, and certain functions integral to the learning process must be performed by the learner or the instructional agent. Shuell has summarised current cognitive research on learning and education in a theory of twelve learning functions (see table 1). Each of these can be accomplished in a variety of effective and appropriate ways. Although the functions can be initiated by either the instructor or the learner, it is actually the learner who must carry them out. The functions are mechanisms to cue different learning processes. Lillehaug (13) argues that Shuell’s theory of learning functions does not only summarise the current cognitive research on learning and education. It can also be used as a reminder scheme when designing learning environments or as a framework for evaluating the effectiveness of different educational settings such as computer-based education, through their support of the functions.

In the following section we will use Shuell’s learning functions as a reminder scheme in proposing additional educational facilities for remote echocardiology in the form of computer-based applications. Also, it will be discussed how such applications can incorporate advisory facilities to help the practitioner.

4.1 Remote echocardiology and additional educational facilities

During remote echocardiology the specialist can trigger different learning functions as follows: focus the practitioner’s attention on the colour and form that characterises regurgitated and stenotic valve lesions; encourage comparison by changing presentation between different modes of echocardiographic signals (e.g. from M-mode to Doppler); make the practitioner generate a hypothesis in the form of a diagnosis (e.g. some cardiology dysfunction) whose investigation is given relevant instructional feedback and cor-

---

Table 1 Shuell’s learning functions with examples (20)

<table>
<thead>
<tr>
<th>Function</th>
<th>Teacher initiated</th>
<th>Learner initiated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expectation</td>
<td>Provide overview (map, diagram); Statement of purpose</td>
<td>Identify purpose for using the program</td>
</tr>
<tr>
<td>Motivation</td>
<td>Opportunities for interaction; Interesting material</td>
<td>Personal interest; Look for ways to make personally relevant; Make it a game</td>
</tr>
<tr>
<td>Prior Knowledge</td>
<td>Remind learner of prerequisite information, etc.</td>
<td>Ask self what is already known about the topic</td>
</tr>
<tr>
<td>Activation</td>
<td>Highlights; Animation; Audio supplements</td>
<td>Identify key features; Record notes</td>
</tr>
<tr>
<td>Attention</td>
<td>Provide diagrams and/or multiple examples/contexts; Suggest mnemonics, etc.</td>
<td>Generate mnemonics, images and/or multiple examples/contexts</td>
</tr>
<tr>
<td>Comparison</td>
<td>Encourage comparison with diagrams/charts/ questions</td>
<td>Look for similarities; Draw diagrams/charts</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>Encourage student to think of and try various alternative courses of action</td>
<td>Generate possible alternatives and corresponding solutions</td>
</tr>
<tr>
<td>Generation</td>
<td>Guided practice and/or reflection; Multiple perspectives/examples</td>
<td>Systematic reviews</td>
</tr>
<tr>
<td>Repetition</td>
<td>Provide instructively relevant feedback and correctives</td>
<td>Seek answers to self-posed questions</td>
</tr>
<tr>
<td>Feedback</td>
<td>Have next action by student based on an evaluation of the feedback received</td>
<td>Ask &quot;What do I currently know?&quot; &quot;What do I need to know?&quot;</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Check for understanding</td>
<td>Monitor Performance; Self testing</td>
</tr>
<tr>
<td>Monitoring</td>
<td>Provide ways to combine and integrate information - e.g. with graphics or multimedia</td>
<td>Establish categories; Construct tables; Seek higher-order relationships</td>
</tr>
</tbody>
</table>

---

45
The practitioner has the opportunity to initiate the different learning functions himself (e.g. comparison by looking for similarities between a particular patient case and previous examined patients). A computer-based application for enhancing learning efficiency needs to support the learning functions in a similar way.

The first thing the practitioner has to learn is how the movements of the probe affect the presentation of echocardiography signals and when to make use of the different modes (good examination techniques). A learning environment can cover these aspects through integration of multimedia where the moves of the probe are shown in one picture frame while the corresponding output of echocardiography is shown in another frame. The movements of the probe can be accompanied by textual information which explains what is done and which effect this has on the output. By including possibilities to show outputs of all three modes at the same time, the relations between these can also be explained.

Typical patient cases with textual information could be stored (also by the specialist and the practitioner) in a database for reviews by the practitioner. Through options for freezing and focusing, the practitioner may freeze a case and focus on details of particular interest. Exclusion/inclusion of textual information can be used by the practitioner to test out his own hypothesis.

A learning environment with the described facilities may give support for Shuell’s learning functions as follows:

- **Expectation and motivation:** Supported through overviews of what needs to be learned, and further, by pointers to the paths for how to learn it.
- **Prior knowledge activation:** In demonstrating techniques for how to use the probe, textual information/explanation reminds the practitioner of prerequisite general knowledge or particular information about the actual patient.
- **Attention:** Supported through visual and textual pointers to details of particular interest in a reviewed patient case. Further, the practitioner is given time to process all available information through speed/pause control. Also, a scratchpad editor might be usable to make notes and save information for future reference.
- **Encoding:** Supported by real-life patient cases examined with the same equipment as by the practitioner.
- **Comparison:** Supported through possibilities for comparing different typical cases stored in a database, or through comparing the practitioner’s hypothesis with the corresponding cases in the database. Further, demonstrations of how to best make use of the different examination modes can be valuable.
- **Hypothesis generation:** Supported through possibilities for the practitioner to make hypothesis on patient cases which can be checked out versus cases in the database.
- **Repetition:** The practitioner can repeat the review of any case available in the database, or he can store own patient cases for later systematic reviews.
- **Feedback:** The practitioner can run a stored case, first without textual explanation, generate hypothesis, and get feedback through reviewing the case with textual explanations.
- **Evaluation:** Supported through feedback that can be applied by the practitioner in future cases.
- **Monitoring:** Supported by having the application check out the practitioner’s suggestions for diagnosis and treatment plans on stored cases. In addition the practitioner can continuously monitor his own performance through the feedback he receives.
- **Combination, integration, synthesis:** Supported through a combination of demonstrations with and without explanations, comparisons between stored cases and practitioner’s cases, and presentation of relations between the output of the different examination modes.

The suggested facilities for a computer application may support some of the practitioner’s educational needs. Further, use of the application may make it possible for the practitioner to train/work without having the specialist available. Thus, the above discussions has implicitly indicated the potential for such an application to function as a kind of job aid (19). However, it is of utmost importance that the specialist still do supervising from time to time through ordinary remote consultations.

We have focused on, and discussed additional educational facilities for one particular remote consultation, namely remote echocardiography. It is a topic for further work to specify our initial suggestions in more detail, and to implement and investigate them. The possible generalisation of facilities for other kinds of remote consultations should also be put on the future agenda.

**5 Conclusions**

A number of services have been investigated and further developed within the NTR’s telemedicine project (16, 17). The use of remote medical consultations has not only been successful in the sense of making specialist medical services available to a larger part of the population, but also in enhancing the competence of the health care personnel in remote areas. Patients, practitioners and specialists are, in general, positive to the use of remote consultations.

The educational success obtained through remote consultations has been discussed and the learning effects have found support in theory of cognitive apprenticeship.

The current organisation of remote consultations has to be revised in order for the different hospitals to provide such services on a larger scale. The load on the specialists and their departments can be reduced by facilitating practitioners with supplementary computer-based applications. The specification of appropriate functionalities will benefit from consulting educational theory, e.g. from having Shuell’s learning functions serve as a reminder scheme.

The consequences on society of offering specialist services based on remote consultations, where the practitioner can learn while performing his job, include among others that the stability, competence and recruiting of medical personnel in the districts may increase.

We have, in fact, discussed a service and an organisational set-up which facilitates on the job training, where learning occurs as you work, and may, thus, make the old vision of life-long learning a reality.
Acknowledgements
The authors thank Per Lunde, Steinar Pedersen, Svein Erik Stenvold for valuable discussions on their participation in the telemedicine projects, and Birger Nymo and Barbara Wasson for useful comments on earlier drafts of this paper.

References
10 Holand, U, Stenvold, S E. Are the patients satisfied with teledermatological consultations? (In Preparation).
17 Nymo, B, Engum, B. Telemedicine to improve the quality, availability and effectiveness of the health service in rural regions. Kjeller, Norwegian Telecom Research, 1990. (TF lecture F10/90.)