Synchronous and Asynchrounous Medical Problem Solving

"The use of videoconference and a discussion forum for collaboration among health care professionals in Norway"

Line Lundvoll Warth and Rigmor Furu

Norwegian Centre for Integrated Care and Telemedicine
University Hospital of North Norway
Tromsø, Norway

line.lundvoll.warth@telemed.no and rigmor.furu@telemed.no

Abstract—**The use of synchronous and asynchronous telemedicine technology for medical probl]em solving is often treated as a question of functionality. The objective of this paper is to explore how the use of synchronous videoconference (VC) and asynchronous discussion forums for medical problem solving in Norway contributes to sharing knowledge in order to solve medical problems. A secondary use of qualitative data is analyzed in order to explore interactions over a period of time. The results illustrate, by in-depth analysis of interactions, the importance of the interface between questions and answers, when seeking to expand knowledge and learning. Hence, synchronous and asynchronous collaboration represent different opportunities for expanding knowledge. Even though they both can facilitate regularly use, and continuing problem solving, synchronous collaboration is an engagement for here and now problem solving, which affect the regularity and the types of medical problems discussed. The paper is relevant for the topic of the conference, discussing social relations and processes in telemedicine practice. When considering implementing technology for knowledge sharing, it's a need to keep in mind that the practice affects the learning opportunities, and the knowledge shared.**

Keywords—aysncronous; syncronous; medical problem solving; videoconference; discussion forum.

I. INTRODUCTION

Using different telemedicine tools for collaboration allows for both synchronous and asynchronous access to distributed knowledge. Synchronous tools allow professionals to collaborate instantly from different places, requiring same-time participation. Asynchronous tools enable collaboration whenever wanted, capturing the history of interaction, to be shared and distributed to a greater number of professionals. Diverse synchronous and asynchronous use of telemedicine tools has been investigated extensively. In the 90tees the research outlined i.e., the differences between telemedicine applications in terms of their synchronous or asynchronous nature [1], becoming more related to specific services, i.e. wound treatment [2],

audiology [3] and, more specifically, how feasible, cost-effective and reliable asynchronous monitoring and synchronous videoconference (VC) are when compared with one another [4]. The discussion of synchronous and asynchronous use of telemedicine is often treated as a question of comparison to traditional care, and further as a comparison to each other by its functionality. Hence, often with the focus on its capacity, and not on how the social processes is an outcome of the way they are organized.

Knowledge sharing and medical problem solving studies compare face-to-face, synchronous, and asynchronous learning, and have deemed the face-to-face format as a more valuable form of interaction [5]. Asynchronous participants have rated their experience more positively overall [6], as supporting successful distance education, providing access to learning materials from any place at any time [7], and have claimed that asynchronous applications are most likely to provide real change in the practice of medicine [1]. Discussing asynchronous and synchronous medical problem solving is most often attached to education settings, and not as a part of daily practice. These discussions compare which of the two approaches is more suitable for collaboration and knowledge sharing, not focusing on the content in the interaction using the tools, or affecting the outcome of the medical problem.

The manner in which professionals interact while collaborating is of great importance when exploring medical problem solving. Often, when considering different types of technology for learning and knowledge sharing the functionality of the technology are evaluated as important. Here, we explore medical problem solving, and how professionals in daily practice share knowledge in order to solve medical problems using synchronous VC and an asynchronous discussion forum among health care professionals in Norway. Instead of focusing on the functionality, we emphasize the importance of the organization and the social processes of collaboration. The research question is: how does the organization of the collaborative work affect the learning opportunities and what characterize collaboration adjusted for knowledge sharing?

Section two presents the theoretical approach which constitutes the framework for the paper, as the perspectives create premises for understanding medical problem solving in practice. Section 3 describes the method, illuminating the utilization of the data and how the data was collected for the purposes of the original work. In section 4, the results are discussed in accordance with a focus on interactions when health care professionals use synchronous and asynchronous technology. Section 5 is the discussion and the paper concludes in section 6 with suggestions for future research.

II. FRAMEWORK AND MATERIALS

The empirical field is framed by analyzing the activity in the context in which it occurs [8], namely the VC meetings and the discussion forums, and exploring the ways in which professionals together create meaning through mutual interaction.

A. Videoconference as a tool

VC realizes synchronous "here and now" pictures. Four times a week, the GPs in a local medical centre and the specialists at a hospital discussed and exchanged information and knowledge about patients under treatment. As the VC was a part of the morning meeting in a medical department, all the health professionals who participated in the morning meeting also participated in the VC. The GP on duty participated, sometimes with a nurse as observer in the local medical centre in which the patient was staying.

B. Discussion forum as a tool

In the discussion forum, the health professionals were able to post questions (regarding rehabilitation of the elderly), answer questions, exchange experiences at work and reflect together, independent of time and place. The discussion forum enables writing and asynchronous cooperation. Interdisciplinary health professionals from both primary health care and specialist health care participated.

Both methods of collaboration, synchronous and asynchronous, make it possible to transform culture into a common activity. In IV Results, the collaboration is analyzed according to how problems are handled. Dilemmas in the conversation, expressed as choices [9], may either lead to a break down of the conversation [10] or may close the gap in the conversation [11]. When closing the gap, a common meaning of the activity is created. If the gap is not closed, the conversation breaks down. The written text in the discussion forum will be treated and analyzed as written expressions, and dilemmas will be made visible in the conversations. These analytic tools constitute the framework for the empirical analyses.

III. METHODS

In 2014, we gathered materials from two larger studies conducted in Norway in the period from 2006-2010 [12] and 2007-2009 [13], with the purpose of focusing on the interaction during problem solving using VC and a discussion forum. The study discussing *VC as a tool* are based on an analysis of observations of 42 meetings, held during a five-month period. All meetings were video recorded, transcribed, and analyzed. The findings were discussed in eight semi-structured interviews with the participants in the recorded meetings.

The study of the *discussions forum* is based on periods of weekly observations in the discussion forum stretched out over one year. During this period, 35 written posts and 43 answers were registered. The posts were organized thematically from the text-based material. All the text in the discussion forum was copied and stored. The main focus of the observations of the discussion forum was to gain insight into how participants presented a theme to discuss and how they concluded or ended the discussion.

Traffic data revealed 20 visitors in the discussion forum, 7 of whom also participated in the discussion forum. All 7 persons were interviewed in a semi-structured interview. The purpose of the interviews was to map health professionals' experiences in participating in the discussion forum and how they made use of the forum.

Here, the focus is on the interaction between participants; the materials in this article thus do not include statements from the interviews. The excerpts are chosen because they represent issues in which dilemmas and experiences are exchanged. Contradictions in the conversations constitute a potential to develop knowledge [14].

IV. RESULTS

A. Syncronous medical collaboration

This medical conversation takes place over a period of three days. The three episodes presented here constitute each day of the consultations. The GP works together with a nurse at the local medical center. The synchronous VC is part of the morning meeting at the medical department at a hospital nearby. Several specialists participate, and two of them are involved in the conversation. The result is an analysis of how the problems are handled.

GP- General Practitioner, N- Nurse, SP1- Specialist 1, SP2- Specialist 2.

1st consultation

1. GP. "His name is xxx, he came from you, completed the treatment with clostridium. Infection, diarrhea, infection of the intestinal… eh…I haven`t spoken with him, but… eh… I don`t know when he arrived".
2. GP. "He has been here for several days"?
3. N. "He has been here for several days"?
4. GP. "He arrived on the 3rd, yes, from the medical department in your hospital. And here it is… He has completed the treatment. He is not into antibiotics now, but he has experienced a

recurrence of his diarrhea, has bouts of fever of higher than 39°c in the evening. No fever this morning. He hasn`t had a fever this weekend either…So I don`t know if he will stay or not, or what …".

5.   SP1. "I can`t remember him right now…".
6.   SP2. "Give him a new treatment with Flagyl for 10 days".
7.   GP. "Yes…".
8.   SP2. "Give him a new treatment with Flagyl for 10 days".
9.   GP. "Okay, how much"?
10. SP2. "One tablet, 400 mg, 3 times a day, over a period of 10 days".
11. GP. "Okay, is this per os"?
12. SP2. "Per os, yes".
13. GP. "Per os, yes".
14. SP2. "Tell me if this doesn`t have any effect in a couple of days".
15. GP. "Okay, in 10 days"?
16. SP2. "Yes".
17. GP. "Yes, ok. We'll do that".

The consultation begins by presenting the patient, a man who had completed the treatment of an intestinal infection, and was transferred from the hospital to the local medical center (1). The GP caters to the nurse (2), who informs him that the patient arrived one week ago (3) and completed treatment from the medical department (4). The GP shares that no antibiotic was given due to the recurrence of diarrhea and fever (4). The GP describes the situation that arose this weekend, and proceeds to seek out advice as to how to face this development (4). SP1 cannot remember the actual patient (5); SP2 follows up by recommending a treatment of antibiotics for the recurrence of the infection (6). The GP confirms this (7), and SP2 specifies that the treatment is to continue to be administered over 10 days (8). The GP requests information about the dose (9), and the specialist suggests the amount (10). The GP then proceeds to ask whether the treatment is to be given orally (11), which the specialist (13) and the GP confirm (13). In light of his expectation of the immediate effect of the treatment, SP2 recommends that the GP contact him again if the patient does not respond to treatment within a couple of days (14). The GP asks for new information and confirmation that the treatment should be administered for a total of 10 days (15) in spite of the fact that the effects should be apparent after only a couple of days. SP2 confirms this (16), and the GP agrees to follow these recommendations (17).

2nd consultation

18. GP. "Xxx, who saw you with a chlostridium infection after treatment with antibiotics, infection after treatment with antibiotics, experienced a recurrence. We started with 400 mg of Flagyl x 3 after advice from xx (SP2), which was very

successful. After 2 days, the recurrence subsided, and… he is now functioning normally".
19. SP1. "Seven days, xx (SP2), or 10"?
20. SP2. "Since this is the second time, 10 days".
21. GP. "10 days then? I was about to ask about that. Then we will do so! It turned when we started up again…".
22. SP1. "That`s great! It is always good to receive information about how things turn out".

The GP reports that the patient they discussed two days ago has responded positively to the treatment, and that the patient has now regained normal functions (18). SP1 asks if they decided to proceed with the treatment for seven or ten days (19). SP2 justifies his earlier recommendation of ten days thus: since this is the second time, 10 days is necessary (20). The GP confirms that the treatment will continue for a total of 10 days (21) and that this statement is based on the fact that the patient improved immediately after the treatment began. SP1 confirms the development and the fact that it is good to be informed about this development and the effect of treatment on patients whom they have discussed and treated (22).

3rd consultation

23. GP. "He has improved considerably. I believe that we will send him home over the weekend".
24. SP1. "Has he been using Flagyl for another week or something in addition to the primary treatment or..."?
25. GP. "Yes, he received Flagyl for a total of 10 days, 400 mg x 3. He will finish the treatment during the next week. He is completely free of symptoms at the moment. This turned out very well so we'll send him home next week".
26. SP2. "Yes, yes".

Three days later, the GP reports that the patient whom they had discussed previously and who was being treated was now cured (23). SP1 asks for information: whether this was the patient who got received extra doses of antibiotics (24). The GP confirms this and the fact that the cure was administered over a period of 10 days (25). In addition, he shares the most recent plan for the patient, namely, to send him home next week (25). The SP2 agrees with this course of action (26).

The tree consultations illustrate how the problems are handled, using the analytic tools for our framework. In the first episode, the GP identifies two dilemmas. The first is related to the treatment of the patient (1,4) and the second to medical information tools (1), when he is uncertain about which day the patient arrived. The GP is the individual who conveys the medical problem and identifies the dilemma. The specialists use their knowledge and experience (6) from similar cases to recommend further treatment, and to share how quickly the patient should respond (14).

In the second episode, the GP responds to the recommendations from the specialist from two days earlier; and shares that the patient responded as desired and expected (18), and the specialist is pleased to receive feedback on his ratings (22). The specialists also discuss the course of action with one another and explain that normally, a 7-day treatment may be prolonged until 10 days if the patient has a back flipping infection (19,20). In the third episode, the GP follows up on the two past consultations by sharing that the patient has responded well to the treatment (23, 25), and that the patient is ready for discharge. Here, the collaboration adjusted for learning and knowledge sharing is characterized by engaging here and now, identifying and solving dilemmas during the conversation.

B.   Asyncronous medical collaboration

Excerpt A is a text from the discussion forum, in which three participants have written one post each, regarding persons with dementia and in pain. The participants in the discussion forum have a common base; a post from a health professional regarding pain assessment.

A1 Excerpt A, informant 1
A2 Excerpt A, informant 2, etc.
B1 Excerpt B, informant 1, etc.
(…) Text left out

Excerpt A

16.02 : 12:21. A1. "I know that several of you have met persons with dementia and you have not been sure about how to complete a pain assessment. Was the rule of thumb for xx (name) useful? (facial expressions/sounds/defense mechanisms)".

06.03 : 07:53. A2. "About 12 forms of pain assessment exist for persons with dementia, no single method has been validated. They are under development, and none of them are recommended in international literature. That is why we are working on this case – but it will take time! You can read more about it in xx (reference)".

23:03 : 18:51. A3. "We have a type of pain assessment scale for the elderly called the "observation based scale of pain for the elderly". I believe that this type of pain assessment is a good method by which to assess pain among the elderly. If you have trouble finding this pain assessment scale, you may contact me at xx (name) hospital, and I will have it sent/faxed over to you".

This excerpt begins with a dilemma among the participants, about how to complete a pain assessment for persons with dementia. A1 asks about a general rule of thumb. Facial expressions/sounds/defense mechanisms are useful rules for handling pain assessments. A2 answers that several different forms of pain assessment exist with different qualities. The dilemma is that none of these forms of pain assessment has been validated, and A2 refers to

knowledge in the international literature. A third participant, A3, has had some experience in the workplace with using forms of pain assessment, and will share this with the other participants.

This asynchronous excerpt demonstrates how the participants gave their input to an issue in the period of February 16th until March 23rd. The written text allows the participants to discuss issues independent of time, but it results in no immediate follow up, nor does it address the need for knowledge in the moment. The feedback given is anchored in written knowledge to which the participants refer.

Excerpt (B) presents posts on the theme of nutritional status and discussions on using the diet registration form.

Excerpt B

08.02: 13:20. B1. I wonder if there are many (…) who use this method of analyzing nutritional status in the hospital, who performs this analysis and how it is followed up.

08.02: 13:29. B2. In the report (name), the "food card" is a document used to describe the nutrition of the elderly, which gives an indication of the actual problem. Another form of documentation is a nutrition protocol related to the ADL form. I would like to come into contact with someone who has experience using this.

09.02: 13:28. B3. xx (name and title) presented the form of diet record used at xx (hospital). It can be found in archive xx (name).

22.02: 08:40. B4. "In the presentation given by xx (name and position), she gave an overview of the use of PEG-probes/tubes in different countries. In Norway, it has been used very rarely, which I interpret as good news. From personal experience, I know that it is not unusual for patients in nursing homes to be malnourished. Could this be because of the underuse of PEG-probes?"

06.03: 07:52. B5. "The question as to the use of nutrition tubes in different countries is debated and difficult to answer. (…); nevertheless, this question is crucially important to discuss! There may very well be patients in nursing homes who are not adequately nourished, which is not desirable! There are several reasons for this circumstance (…): certain diseases can make meeting nutritional needs difficult (apoplexia, fungia infections in the mouth, cancer, and ulcus, among other things); patients may give up on eating and may refuse to eat because of the limits of age, including weakness, dementia, depression, and psychiatric disease; or health personnel may not follow up enough due to bad food routines, bad food offerings, insufficient vitamins, and the like or a lack of staff and thus not enough time to feed the patients or to sit down with them.

It is not appropriate to deny the use of a nutrition tube that might be useful for the patient. (...) On the other hand, it is extremely important to seek out the cause of the patient's poor nutrition (...). A PEG probe is not always the right solution. A study of pathology in Oslo (...) shows that a relatively large number of the elderly who were dying were malnourished because as life was ebbing out, eating became less important, which is a natural response (…). Other countries face the challenge that (…) there are not enough staff/health personnel. (...) Nutrition tubes may be a cheap solution compared to paying for educated healthcare personnel. In Norway, twice as many healthcare personnel work in health institutions compared to Germany and Austria, and in the USA, over 80% of employed nursing assistants have an education of over 75 hours. They often must consider other decisions compared to those faced by nurses in Norway".

Excerpt B extends over a period from the 8th of February until the 6th of March. The discussion begins when B1 discusses a certain method by which to assess nutritional status, and asks whether any of the other participants suggest using another method, who uses this method and how. Another participant (B2) follows up on the question by referring to a report that describes the "food card", which may be the answer to B1's dilemma. Another possible form of documentation is also mentioned, namely, the use of a nutrition protocol related to an ADL form. The participant who brings up this method asks for a response from anyone with experience in using this specific form. Participant B3 doesn`t answer the questions directly but refers to a form that registers diet that is used by others and that is stored in an archive.

After several weeks, the topic of diet is returned to in the discussion forum because of a presentation about the use of a specific type of tube (PEG) used as a tool for eating (B4). This tube is rarely used in Norway, which the participant regards as a positive thing. Health personnel have a lot of experience with patients suffering from malnutrition, which gives rise to the following dilemma: In which cases is it correct to deny patients the use of a tube as a means of assistance with eating when the patient is malnourished? After several weeks, B5, who held the presentation, addresses the problem. B5 believes this to be a good question, one that leads to several dilemmas that are difficult to resolve. B5 offers several explanations as to why patients are often not well nourished: due to different diagnoses, the patient may have different incentives to deny eating or there may be a lack of follow-up from health personnel.

B4 relates the question to the fact that feeding tubes are rarely are used in Norway, and B5 relates the answer to national and international experiences. First, B5 refers to research-based knowledge from Norway, and states that patients in the last phase of life eat less. Second, B5 refers to economic aspects in international health care, including the fact that using feeding tubes may be a cheaper solution than hiring employees with education. Third, nursing staff in other countries may less education compared to nurses in Norway, which may be one of the reasons why feeding tubes

are used more frequently in other countries compared to Norway. Here, the dilemma is presented, and the knowledge gap is tried to be solved by one way transmission of knowledge. According to our analytic tools, this collaborative work breaks down, as there are no follows up-either by questions or by confirmation on how this knowledge fitted into practice.

V. DISCUSSION

Both synchronous and asynchronous tools represent possibilities for sharing and discussing medical problems. Compared to previous literature, we do not valuable the form of interaction [5] or their positivity [6]. As the results illustrate, the oral (VC) and the written (discussion forum) communication exemplifies that the organization of tools and the tools itself contribute to different patterns of interaction.

In the *VC collaboration*, the GP has questions about patients under treatment as the consultations are running. In the conversation, dilemmas arise about treatment choices. The GP has questions and informs about the patient's condition, while the specialists recommend treatment and explain their treatment suggestions. The GP follows up by asking whether more knowledge is needed. Hence, the medical problem is solved rather than staying unsolved. The consultation takes place over several days, during which the same patient's recovery is discussed through new questions or information as to how the treatment is progressing. The specialists are informed of how their recommendations work in practice.

The *discussion forum* also presents questions related to patient treatment in practice. As illustrated in the excerpts, a question is raised by one participant, and other participants follow up on these questions. The questions are of a more general form, rather than seeking out knowledge to be put into practice in the moment. Follow up questions are generally not posed in the discussion forum. Members in the forum who wish to do so may participate. In principle, the questions are not posed to a specific member. The members refer to their own experience justified by written resources, i.e., international literature and the elaboration of a scheme for registration. The communication does not continue (excerpt A), so we do not know how this knowledge is experienced by the participants at work. Excerpt 5 is an example of one participant (which included a speech about the theme of B4's question) reflecting on a dilemma about the use of a probe.

The written contribution has similarities with the medical conversation, as the health care workers explain and argue on the basis of their experience and knowledge. The discussion forum gives participants the opportunity to catch up on the knowledge exchanged, based on referenced literature, whenever they wish to do so. This procedure differs from the use of VC, in which the journal at the GPs is used as a basis for knowledge exchange.

B5 exchanges knowledge related to solving the medical dilemma, reflecting different treatment options. No concrete treatment suggestions are made, and if the knowledge exchanged is put into practice, the results are not shared afterwards. There is thus no feedback as to whether or not the dilemma is, in fact, solved in practice.

The episodes and excerpts analysed illustrate oral and written communication over the course of several days. The conversation includes the same participants over several days, while the written forum enables several participants to join the conversation. In the written discussion forum presented here, the participants make one contribution each, over an indefinite amount of time. VC is an interface between questions and answers, in a pre-booked period of time. The participants have a common point of reference in a specific problem in the VC meetings. The discussion forum has a mutual theme of reference, which was previously raised as a result of a joint meeting.

VI. CONCLUSION AND FUTURE RESEARCH

In this paper, we have presented several interactions among professionals sharing knowledge in order to solve medical problems. Early literature in the field claimed that asynchronous applications are most likely to provide real change in the practice of medicine [1]. The results illustrate that in-depth analysis of such interactions gives insight into this type of collaboration in new ways. This article illustrates the importance of the interface between questions and answers, when seeking to expand knowledge and learning. The organization of the collaborative work affects the learning opportunities as asynchronous discussions include several participants and allow for collaboration over time whenever wanted. Meanwhile, in-moment interactions enable information and knowledge sharing that can prompt changes in treatment, illustrating the opposite of Alleley's [1] findings, who account for real change in the practice of medicine using asynchronous applications.

Asynchronous discussion forums are often non-authorized according to data protection, so discussions where biographical data appears cannot be discussed, as discussed in VC meetings. This also excludes the use of journals during the collaboration. Non-commitment to be available in the moment, also exclude discussions of acute medical problems.

When considering implementing technology for knowledge sharing, it's a need to keep in mind that the practice affects the learning opportunities, and the knowledge shared. Synchronous and asynchronous collaboration have a tremendous capacity for information exchange and knowledge sharing. Research is needed to gain a better understanding of how healthcare professionals can work together in everyday practice and how the organization of their collaborative work affects their own engagement.

REFERENCES

[1] E. B. Allely, "Synchronous and asynchronous telemedicine", J Med Syst, 19(3): p. 207-12, 1995.

[2] R. K. Chittoria, "Telemedicine for wound management", Indian J Plast Surg, 45(2): p. 412-7, 2012.

[3] W. Swanepoel de and J.W. Hall, 3rd, "A systematic review of telehealth applications in audiology", Telemed J E Health, 16(2): p. 181-200, 2010.

[4] F. Verhoeven, et al., "Asynchronous and synchronous teleconsultation for diabetes care: a systematic literature review", J Diabetes Sci Technol, **4**(3): p. 666-84, 2010.

[5] M. Kunin, K.N. Julliard, and T.E. Rodriguez, "Comparing face-to-face, synchronous, and asynchronous learning: postgraduate dental resident preferences", J Dent Educ, 78(6): p. 856-66, 2014.

[6] E. C. Buxton, "Pharmacists' perception of synchronous versus asynchronous distance learning for continuoing education programs", Am J Pharm Educ, **78**(1): p. 8, 2014.

[7] N. Stergiou, et al., "Using a web-based system for the continuous distance education in cytopathology", Int J Med Inform, 78(12): p. 827-38, 2009.

[8] A. I. Mørch, K.A. Nygård, and S.R. Ludvigsen, "Adaption and generalisation in software product development, in Activity Theory in Practice. Promoting learning across boundaries and agencies", H. Daniels, et al., Editors, Routledge: New York. p. 184-206, 2010.

[9] M. Billig, et al., "Ideological Dilemmas. A Social Psychology of Everyday Thinking", London: Sage Publications Inc., 1988.

[10] S. Bødker, "Applying activity theory to video analysis: how to make sence of video data in human-computer interaction, in Context and Consciousness. Activity Theory and Human-Computer Interaction", B. Nardi, Editor, The MIT Press: London, England. p. 147-174, 1996.

[11] S. R. Ludvigsen, et al., "Intersecting trajectories of participation: Temporality and learning, in Learning across sites: new tools, infrastructures and practices", S. Ludvigsen, Editor, Pergamon Press: Oxford. p. 105-122, 2010.

[12] L.L. Nilsen, "Læring og utvikling av kunnskap i medisinske samtaler. Bruk av videokonferanse mellom allmennleger og spesialister" [Learning and development of knowledge in medical talk. The use of videoconferencing between GPs and specialists], in Fakultet for humaniora, samfunnsvitenskap og lærerutdanning, Institutt for lærerutdanning og pedagogikk [Faculty of Humanities, Social Sciences and Education, Department of Education], Universitetet i Tromsø [University of Tromsø], Tromsø. p. 107, 2011.

[13] R. Furu, "Helsearbeideres deltakelse i virtuelle fagnettverk; et instrument for faglig refleksjon" [Health professionals participates in virtual communities; a tool for reflection], University of Bergen, 2009.

[14] Y. Engeström, "Expansive Learning at Work: toward an activity- theoretical reconceptualization", Journal of Education and Work, 14(1): p. 129-152, 2001.