Identifying and overcoming tension in interdisciplinary teamwork in professional development: Two cases and a tool for support

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ABSTRACT

A central interest in developing professionalism resides in the potential for practitioners to learn from and with one another in ways that support transformations of their knowledge practices. However, negotiation between multiple perspectives, interests, practices and traditions intertwines cognitive-epistemic with socio-relational and affective aspects, which may lead to tension and conflict. While tension can disable learning, we argue that identifying these tensions should be viewed as a significant source for change and development. We will present two cases, which show similar patterns. Tension in medical teams is a threat to patient safety. However, an uncritical attitude does not foster learning, and instructors at simulation training courses may therefore put focus on tensions through questioning. Eventually learners may develop skills in analysis, which cover explanations and strategies and which provide a fruitful approach to the problems. The second case investigated teacher-researcher collaboration at a secondary school, and focuses on the design of a learning module. Identification of tensions during meetings helped participants to focus their efforts on the root causes of problems, which led to a reconceptualisation of the current work practices. This subsequently helped team members to deviate from established norms and improve their practices. We will present a video annotation tool with which learners can make annotations that serve the role of mirroring material: letting learners use the tool to annotate video recordings of their teamwork can highlight underlying tensions. An advantage is that problems do not risk being overlooked and instead become a starting point for change.

INTRODUCTION

Rapid changes in current networked society present new challenges to human competence and flexibility. Productive participation in knowledge-intensive work requires that individuals, their professional communities, and their organizations develop new practices, advance their knowledge and their understanding as well as produce innovations. This is reflected in developments in professional communities wherein work is increasingly focused on the deliberate advancement of knowledge rather than on the mere production of material objects (Bereiter, 2002; Paavola & Hakkarainen, 2005). In order to cope with the cognitive, social, and motivational challenges of knowledge-based society, tools and pedagogical methods are needed that open up opportunities for enduring and sustained transformation of professionals' knowledge practices.

Based on the works of Engeström (1987), Schatzki (2002) and Reckwitz (2002) we define a knowledge practice as follows: *a social-historically created and shared behavioural pattern consisting of an interconnected and inseparable array of recurrent activities, conventions, rules and norms that play part in the creation of knowledge artefacts.* According to this conceptualization, practices are characterized by their social nature, which means that practices are shaped by and evolve within a knowledge community, ultimately becoming part of the its identity. In addition, the concept of knowledge practice entails stability as well as change. Stability is reflected as routines, procedures, conventions, underlying beliefs and values, epistemological conceptualizations and the set of available tools. At the same time, practices are open to change in that each activity based on this practice is adapted in response to changing contexts and particular circumstances.

The rationale for practice transformations is that newly developed practices and tools aim to overcome the tensions a particular knowledge community identified during certain events in their knowledge work. Practice transformations involve fundamental changes in views, beliefs, ideas and ways of working with knowledge that fulfil a certain need that is relevant for a particular professional

community's knowledge work. These transformations lead towards historically new types of practices based on collaborative, tool-mediated knowledge production that takes place as long-term, sustained processes and which ultimately lead to a reconceptualization of the object and motive of the community's knowledge practices to embrace a more diverse horizon of possibilities than in the previous practice.

However, practices are difficult to change, not only because this would imply a negative evaluation of previous socially grounded practices, but also because such transformation involves a period of disorientation while old practices are gradually unlearned and new practices are gradually developed (Eraut, 2004). During this period professionals feel like novices, but without having the excuses or discounts on performance normally assigned to novices. The pain of transformation lies in the loss of control over one's practice when one's tacit knowledge ceases to provide the necessary support; and the emotional dimension is also of considerable importance. In addition, Little (1990) reports that professionals view transforming practices as involving high transactional costs to participatory work in time. According to Argyris and Schön (1978) the central problem for most professionals is that they are intellectually and emotionally committed to espoused theories which describe the world as they would like it to be, but which do not necessarily accurately describe their own activities and constrain possibilities for transforming their practices. Moreover, practices are similar to physical infrastructures in a sense that when everything is working well one does not pay attention to them. Consequently, professionals rely on them even they are not fully aware what constitutes them. Additionally, the practices have been evolved during a long period. According to these authors, these problems can only be solved when professionals step outside their taken-for-granted world and espoused theories to actively search for genuine feedback which challenge the outcomes of their activities.

Although practices tend to remain stable and to reproduce socially shared knowledge, this stability is altered as internal or external disturbances produce various forms of tensions within activity systems (Engeström, 1987, 2007; Hakkarainen, Palonen, Paavola, & Lehtinen, 2004). The notion of developmental tensions as a driving force of change and development is drawn from the premises of cultural-historical activity theory (CHAT) (Engeström, 1987; 1999). CHAT draws upon the works of Heidegger (1962), Dewey (1968) and Leont' ev (1981) converging on the role of tensions and their resolution as a means of revealing the nature of the world around us. In these socio-historical approaches to learning and knowledge, tensions are conceptualized as the conditions that open up opportunities for creative efforts in activity and communication and are as such the driving force behind innovative knowledge practices.

Changes in practices are due to external as well as internal disturbances. According to Engeström (1999a; 1999b), identification of tensions in an activity system helps learners to focus their efforts on the root causes of problems. Barab et al. (2002) corroborates on this in arguing that tensions and their resolution helps to identify the dynamic forces of change and comprise an important constituent and starting point for investigating such processes. The mechanism behind tensions resolution is that as the tensions of a particular activity system are aggravated, some individual participants begin to question and deviate from its established norms. Learning is accomplished when tensions lead to a reconceptualization of the object and motive of a particular activity to embrace a more diverse horizon of possibilities than in the previous activity. While practices might change when new tools become available or circumstances and contexts shift, they can also be deliberately altered by those carrying out the activities when they invent new strategies of working or activities. In addition, members of a community may experience difficulties in constructing a connection between the goals or their actions and the object and motive of the collective activity, which may give rise to tensions.

For instance, knowledge communities that involve cross boundary practices between different domains of knowledge embody an epistemic collision of activity systems which generates disturbances and conflicts. This involves that in collaborative contexts, negotiation between multiple perspectives, interests, practices and traditions intertwines cognitive-epistemic with socio-relational and affective aspects, which may lead to tension and conflict. As practices inevitably change when concrete activities are carried out, the development and transformations of practices proves to be an ongoing and contingent process. Due to this dynamic nature of practices, the design of a new object might overcome shortcomings of former existing objects, but when they are employed as tools this will restructure the nature of the current practices and will in this manner create new opportunities but also new problems and challenges. According to this line of reasoning, learning or development of practices occurs when members attempt to negotiate about how to adapt their knowledge practices as a results of these disruptions feeding into the shared object.

In general, what is important here is that a group of professionals has to capitalize on the multiple perspectives of its members, that the group creates ownership and commitment towards achieving the common objectives and that members build up on each other willing to learn from tensions. The way to overcome these tensions is to negotiate possible solutions or design hypotheses for new practices or new tools. Eventually these new practices and tools lead to new tensions which leads to an iterative sideways movement. Preconditions for groups to be able to solve tensions to improve their practices are: 1) proactive and continuous creation of common ground, 2) sharing tensions in considerate ways and 3) supporting and recognizing agency (Matusov, 2001). However, what is still lacking in socio-historical accounts and studies of tension resolution as conditions for practice transformations to occur, is a description of patterns of tension resolution that lead to productive changes and development. Moreover, the investigation of trajectories of tension resolution affecting the emergence of new knowledge practices located at several timescales and places has rarely been touched upon in empirical endeavours.

In the present paper, we will present the data of two studies in the fields of medical simulation training and of a school-university partnership at a secondary school, respectively, which show similar patterns in the cognitive-epistemic consequences and resolution of tensions. Tension in medical teams may pose a threat to patient safety. However, for learning to take place during training, uncritical analyses are not productive and some tension may be the result of instructors' questioning about problems. Initially it is common for learners to react by placing blame on themselves. Eventually more mature analyses develop which cover explanations and strategies and which provide more fruitful ways from the tension. The second case investigated the practice changes of an interdisciplinary team which focused on the redesign and implementation of a learning module. Meetings of this team served to reflect upon and analyze teachers' prevailing practices, as well as envision and implement changes to the module.

METHOD

Multiple, intertwined methodological approaches and various approaches to data collection and analysis were combined to elaborate dynamics of incremental changes which reflect practice transformations resulting from patterns of tension resolution. The two cases involved ethnographic studies with participatory observation, developmental intervention approaches interviews and event sampling to follow processes towards new practices. Our analyses took tensions in professionals' activities as a point of departure. We look for episodes in the material that express problems and materializes as developmental tensions. Then we can investigate discursive activities between professionals (micro level), elaborate on episodes of tension resolutions over time (meso-level) and examine how patterns of tension resolution relate to transformations of practices at the level of trajectories (macro-level). This gives to transformation processes as they play as professionals deliberately extending shared knowledge and mobilize knowledge types embedded in the social practice in their problem solving. For framing the analysis we developed the following approach:

1. Description of the knowledge practices of the investigated professional community;
2. Description of the nature of tensions that occur in these practices. Explore resolutions to the tensions, characterize tension-resolutions and analyze how these contribute to transformation towards new practice over time;
3. Examination of practice transformation including emphasizing the vertical (socialization and internalization) and/or horizontal dimension (boundary crossing and externalization).

The cases in this cluster examine the nature of these dilemmas, tensions or tensions that provide an important starting point to explore change and development of knowledge practices.

To assess the knowledge practices of the actors involved both studies, we combined data collected from different instruments, namely:

- Material artefacts, such as reports, concept maps, and written comments;
- Pre- and post questionnaires;
- Semi-structured interviews;
- Transcribed recordings and minutes of the meetings;

These instruments were mainly designed to capture critical events during the meetings and to discern how these events are echoed in the ways professionals adapted their practices. Critical events were conceptualized as articulations of developmental tensions and were posteriori checked with the investigated knowledge communities.

CASE 1: ANALYZING MEDICAL TEAMWORK IN SIMULATION TRAINING COURSE

The performance of medical teams is influenced by social relationships and communication patterns and poor team communication is cited as the primary behavior that increases risk to surgical patients. Health professional scientists and educators have begun to explore relational aspects of team interaction, such as attitudes, communication and decision making and how tension influences team communication and revealed some troubling characteristics of team function (Lingard, Garwood, Poenaru 2004). They describe how 'tension spikes' are particularly common around topics such as the use of time, the distribution of resources, the negotiation of roles and responsibilities, and the teaching of trainees. Furthermore, cross-disciplinary conflicts (e.g. between surgery and nursing, or internal medicine and surgery) can make tensions difficult to resolve and, consequently, impede successful communication and collaboration.

These kinds of tensions need to be addressed because of their serious potential consequences and in fact they are typically explicitly addressed in courses. There is a widespread awareness of these kinds of challenges. For instance, during the simulation training courses that is the topic of this study, the importance of a good team spirit, the use of resources, responsibilities and the assuming of professional roles are regularly discussed in depth.

As discussed above, tensions may also lead to something constructive. The tensions discussed here are of a certain kind which may or may not appear during simulation training courses of medical teams and specifically when the participants discuss and analyze the behavior of the teams during debriefing sessions following the simulations themselves.

Introduction

The aim of this study is to shed light on how groups who have taken part in medical team training exercises in a simulation environment analyze their own behavior and how they develop the capacities for doing such analyses (Karlgren, Dahlström, Lonka, & Ponzer, 2007; Karlgren, Dahlström, & Ponzer, 2008). The participants collaboratively attempt to understand and assess medical teams' performance and this capacity of collaboratively creating teamwork analyses is crucial for the quality of the work of the medical team and in consequence for patient safety.

At the Stockholm South General Hospital simulation courses are organized aimed at training medical teams in neonatal resuscitation. The participants are pediatricians, anesthesiologists, obstetricians, nurses, and midwives. The courses start with lectures and are followed by simulations and debriefing and feedback sessions. The participants work in teams to practice solving complex, authentic cases: the medical teams provide newborns (a small manikin) arriving from the delivery room with intensive care. Emphasis is on learning the medical guidelines, resuscitation procedures, and equipment but also on medical teamwork, leadership and communication skills. During the course the participants take part in several simulations that are recorded on video and watched and analyzed together with instructors in debriefing sessions following each simulation.

The focus of the study here was on the debriefing sessions. Several teams have been observed and video recordings of debriefing sessions have been analyzed using an interaction analysis approach with a specific focus on what the participants discuss (and do not discuss) in the debriefings, their roles in the team (leader or member), professional role (profession) and role in the simulations (participant, observer). Of especial interest have been the kinds of analyses that are created in the debriefing discussions and how these develop during courses.

Empirical Findings

The characteristics of the teams' discussions and analyses vary depending on the teams, its participants and the character of the simulated case. However, some typical recurrent trends have been discerned in the debriefings of the many courses that have been studied. The initial analyses made by the participants are often not so well-structured and instead imprecise, overly critical of themselves as individuals, uncritical towards the rest of the team, and, overly positive about any achievements made by the team. In the beginning of these courses the participants tend to overlook serious mistakes and safety-critical habits revealing unawareness of many critical issues regarding teamwork in critical care. Later in the course, the participants usually begin to agree on a shared conceptual framework and terminology which the team members start using and referring to explicitly. Problematic issues are addressed and less often overlooked.

The quality of the analyzing carried out by the participants develops during the courses. The analysis of this and other teams has shown how the medical teams typically develop through a number of phases. This development is often characterized tension preceding the development through the phases which is often created by instructors or other observers questioning the current practices of a

medical team. Initially (0), the participants often lack awareness of problems occurring in their own teams and sometimes also of the body of research on such medical teamwork. After having taking part in some simulation training and getting feedback from experienced instructors typically leads to (1) course participants becoming aware of and beginning to identify problems that take place. Often these are focused on in a rather unconstructive way and frequently participants will blame themselves for causing them. And while they may be very motivated to perform better and to avoid the problem in new simulations they often do not create sufficient explanations of why the problems occurred in the first place making it difficult to create strategies for avoiding the difficulties. Later on, participants begin (2) constructing explanations to the problems and eventually also (3) suggesting alternative ways of behaving which may resolve or avoid a particular kind of problems. So overall, medical teams taking part in the courses may develop in trajectories going through such phases.

Especially the later phases of constructing explanations and suggesting alternative strategies concern creating knowledge collaboratively using the video recordings and conceptual artifacts. We will present excerpts to exemplify the trajectory and some of these levels presenting how medical teams discussing their performance in debriefing sessions.

The background to the example is that the team has taken part in a simulation where they have for a while lost focus of one of the most important activities during resuscitation, namely ventilating the child properly. Despite this the team displays typical signs of how teams initially interpret their own performance; a positive attitude to the team's performance (Midwife: "Yes, it was good, if not very good". Obstetrician: "Our thinking was good") and especially toward other team members (Pediatrician: "I felt support, because I got so many suggestions"). This positive attitude is common after the first simulations and there is a risk that teams are overly positive and overlook problems and difficulties which actually take place. The analyzing is thus not so productive at this stage but later this team realizes several issues; they are not ventilating the child sufficiently, they should have called for an anesthesiologist earlier (see line 356), they fail to document their work etc. But at this stage there is an unawareness of many of the problems which the team members do not seem to notice. This may be problematic because this attitude will be unlikely to foster further learning and developing the practices of the team. It is not unusual that individuals have a self-critical view of their own performance; when the obstetrician realizes that they should have called for an anesthesiologist she reacts by saying "It is I who should have done that immediately" implying a self-critical and self-blaming attitude. However, if noticing the problems does not lead to a discussion about *why* the problem occurred the team is unlikely to develop new strategies for avoiding the problems in future cases. As long as these attitudes do not lead to coming up with ideas of how to modify the team's behavior, the attitudes will not lead to improvements of the team. In the excerpt below the team takes its first step towards an analysis by identifying a problem after the instructors has asked several questions about their behavior.

Example of a sequence of productive interactions

Excerpt. First debriefing (problem identification)	Categorization / comment
338. Instructor: Much happening now, many of you working intensely. What is most important now? Silence	Question about priorities
339. Instructor: Let us say the following: you are ventilating with the neopuff. You have applied the ecg-electrodes. You are working with the pulse oximeter, apply it. You have blood gas. Only examples of everything that is going on. Which is the most important?	Summarizes (the pulse oximeter (to measure the oxygen saturation in the blood) Priority question, important for team leader
340. Very softly: ventilation	
341. Instructor: Say what?	
342. Ventilation	
343. Instructor: Yes! A and B right?	(A= airways, B= breathing)
344. Instructor: If you have to choose between all the things that you are doing, what would you take away right now? You can not take away the ventilation.	Prioritization
345. I was thinking of these electrodes.	
346. The pulse oximeter, and the electrodes	
347. Instructor. You would remove the electrodes and the pulse oximeter? How about listening with the stethoscope, do you take that away?	Question about behavior
348. Pediatrician: No, you want to be able to check the heart.	

349.	Instructor: You want to be able to check the heart.	
350.	Pediatrician: I was thinking a bit about if we get those electrodes there we do not need to work with there	(with the heart)
351.	Instructor: What are you going to use the intravenous access for?	Questioning about the activities
352.	Pediatrician: When I saw the acid-base. This was before I found out that this child probably was hypovolemic (state of decreased blood volume). When I saw the acid-base I thought we needed to give Tribunat	
353.	Instructor: Mmm	
354.	Pediatrician: I realize that now. The child was blue, should have given more oxygen	Problem identification
355.	Instructor: OK. You could now at the age of 3-4 minutes consider adding some oxygen. You ventilate the child and still have central cyanosis.	
356.	Pediatrician: And at this stage we should have called for an anesthesiologist. (We had) a child which does not react correctly to ventilation	Identification of a problem: lack of resources but no explanation to why the anesthesiologist was not called in.
357.	Instructor. OK!	
358.	Instructor: Someone else that you might want to call?	
359.	Pediatrician: My pediatrician on standby duty.	

In the excerpt above, the instructor summarizes what has been done (lines 338-339) and then repeatedly asks about what should be prioritized in the activities and questions about what the team actually did during the simulation. By such repeated questioning of activities and prioritizing the at this point tensionless attitude eventually leads to noticing problems in what the team had done. The questioning seems to work as a trigger for problem identification and eventually the team members end up with identifying some problems and activities which they feel that they should have carried out ("we should have called for an anesthesiologist") (356). Notable however, is that the teams at this stage do not give any explanations to why they acted as they did and not as they feel that they should have. The instructor's questions led to that some problems were noticed but explanations to these are not presented yet, and the team's learning from the case is still quite limited. Until they have a better idea of why the problems took place it is unlikely that they will come up with constructive ideas about how to avoid the problems from showing up again. Without explanations to the problems there is little chance of the teams suggesting ways of how to transform their practices.

In the excerpt below the instructor continues to question about priorities and prompts for explanations in order to encourage the participants start questioning their behavior and creating explanations and alternative strategies. Such interventions may lead to the team questioning their current view of what happened and in this case eventually gives results; the team begins to suggest explanations to a problem and alternative suggestion for how to behave.

Episode 5 from the last debriefing: (Alternative action)		
209.	Anesthesiologist: yes, the gas is coming and fastening the tube, that's the next step	Question about priorities
210.	Instructor: What is most important right now?	(clear about priorities)
211.	Anesthesiologist: Breathing	(B = breathing)
212.	Pediatrician: 'B'	
213.	Instructor: That the tube is set in place and that its position is checked.	
214.	Obstetrician: mm	(is referring to the design of the difficult case in the simulation)
215.	Instructor: Now we very mean towards you	
216.	Anesthesiologist: The blood gas is coming at the same time	
217.	Instructor: Yes, and exactly in this situation a distraction takes place, we will se what happens. (They watch the video for a few seconds)	
218.	The blood gas, what's with the blood?	
219.	Pediatrician: Yes, there is a delay with the (paper) note and all	Problem identified

220.	Instructor: Ye-es. We see that. And why did this happen then? How can this come to take place? Silence	Prompts for explanations
221.	Pediatrician: Because I was distracted by the paper note of course, otherwise …	Explanation suggested
222.	Instructor: Can this happen in real life do you think?	
223.	Yes	
224.	Absolutely	
225.	Anesthesiologist: the midwife coming in with the paper maybe checks what is going on and does not put it in your fist, it's a bit like that, is this the right occasion?	An alternative action is suggested which would have handled the problem
226.	Pediatrician: ...or I should have said: "Wait a second" and put up my hand to illustrate.	
227.	Anesthesiologist: Yes	

The excerpt is from the last debriefing of a course. Here the instructor continues asking questions about priorities in the teamwork (210) and prompts the team to come up with explanations about why the team behaves in the way it did (220, 222). An explanation is suggested (221) which eventually leads to a suggestion about a concrete alternative behavior (226) which would be a way of avoiding the distraction that disturbed the team and keep the team focused on what they consider most prioritized.

The excerpts above show a trajectory of how the medical teams move from a level of unawareness of problems and possible knowledge to be created concerning their teamwork. The team is initially satisfied with the performance of the team but after some questions from the instructors about priorities and questions about their behavior the team eventually begins identifying problems in their teamwork; imperfections in their collaboration or suboptimal behavior which could be improved. By the questioning the instructor manages to disrupt the contentedness of the team and encourage them to identify potential problems. In the examples of this case, the instructors played an important role. The tension and the continued analyzing that was brought about by their questioning and encouragement can just as well be (and often is) performed by peers or other observers in the courses.

CASE 2: SCHOOL-UNIVERSITY PARTNERSHIP

A central challenge in transforming practices of teachers resides in potentials for teachers to learn from and with each other in the work place as they create and advance shared epistemic artefacts relevant for transforming their knowledge practices. To advance our understanding of such processes in teachers' practices, we must explore how these practices evolve. This case focuses on developmental tensions between members in university-school partnership, and how their resolution points to practice transformations.

The setting and knowledge practice of the investigated knowledge community

This research case investigates developments in teachers' coaching practices (Sins & Andriessen, 2008; Sins, 2009). Such changes result from discursive activities reflecting on tensions in current practice, and the groups attempt to overcome these tensions by creating conditions for and tools that fostered practice transformations. The case study takes place at UniC, a secondary school in Utrecht in The Netherlands. The university-school partnership involved a 2-year collaboration to redesign a learning module aiming at enhancing secondary students' meaningful learning. The design principles of trialogical learning were employed to flesh out the design. The multi-disciplinary team consisting of educational researchers, teachers, students, dean, process coordinator and pedagogical experts was set up. The knowledge creation metaphor matched UniC's general pedagogical approach and objectives.

At UniC, students are coached towards the national school exam, complementing the focus on knowledge acquisition by stressing development of competencies, skills and personal development. Within this pedagogical context, teachers' coaching practices traditionally focus on the development of courses and assignments providing guidance to students' self-directed learning process. For instance, if students require more information in particular knowledge domains they can contact their teachers to provide workshops . There are no fixed testing periods, so students can discuss with their teacher when they have accomplished an assignment and when they can take a test to complete the assignment. The nature and the timing of the end result of assignments are negotiated with the teacher.

By clever organization of compulsory learning materials students are enabled to develop their own talents and interests in a learning module in which they plan and perform projects within or outside of

the school context. This means that every week in the curriculum a half day is reserved for these projects for periods each of which last eight weeks. The school supports the students and offers possibilities to carry out their projects. During each period students negotiate their projects with the teachers. Still, the dean and teachers at UniC expressed the aspiration to challenge their students more towards meaningful learning during their projects. Based on a survey performed at UniC, the dean concluded that students were underachieving during these periods. In addition, both the dean and the teachers' articulated that their role during these projects was unclear and that they needed more scaffolds to structure their coaching.

Therefore, via a project coordinator they contacted educational researchers at Utrecht University working in the KP-Lab project to join forces to redesign, implement and empirically test this learning module. The multidisciplinary team redesigned this learning module based on knowledge creation principles (Paavola & Hakkarainen, 2005). One central feature of the knowledge creation approach that was taken up in the design was the concept of *mediation* which means that students' activities are directed towards the collaborative creation and advancement of shared knowledge objects (e.g., documentaries, research reports or instructional material) mediated by specific supporting technological or conceptual tools.

The collaborative design, implementation and testing of the new learning module implied that new, high demand is placed on coaching practices of the teachers. They had to: (a) comprehend the theoretical principles behind the knowledge creation metaphor, (b) apply these principles in their practice, and (c) reflect on their role as a teacher and transform their practices accordingly to scaffold students' knowledge creation processes.

Empirical findings

To assess the knowledge practices of the actors involved in the multidisciplinary design team at UniC, we combined data collected from different instruments, namely:

- Material artefacts, such as reports, concept maps, and written comments
- Pre- and post questionnaires administered to both students and teachers
- Semi-structured interviews with students and teachers
- Transcribed recordings and minutes of the meetings of the design team
- Transcribed recordings of meetings between students and their teacher

These instruments were mainly designed to capture critical events during the meetings of the project partners and to discern how these events are echoed in the ways teachers adapted their practices and tools. Critical events were conceptualized as articulations of disturbances, conflicts or dilemmas during design team meetings and were posteriori checked with the team members.

Most tensions were observable on the boundary of the intersecting activity systems showing how team members balanced institutionalized or traditional and newly developed practices. One source for tensions involved the specific organization of teachers' coaching practices to be more in line with the new pedagogical approach and at the same time foster students' knowledge construction processes. The following excerpt exemplifies this tension during an interview with one of the participating teachers:

1	Teacher3	I see that an increasing amount of student groups do not have a clear view of what they are doing, that is what I am afraid of, unfortunately
2	Researcher1	How do you coach these students then?
3	T3	Well, you cannot just leave them, than this would lead to chaos. […] You can divide tasks in the group and think of who is going to do what, but then I would be too directive and I am not sure whether that should be our intention, so therefore I give them more freedom […]
4	R1	[…] Well you mean that you are still in search of what is expected of you as a teacher. What do you need in your coaching?
5	T3	First I need to know more about knowledge creation, what the idea and what the pillars are, so I can eventually adapt my coaching to that […] normally I am very clear in my teaching, but in this pilot it seems that you have to discover what the best ways of coaching are

Interview Teacher 3; December 2006

Teacher3 expresses his concern about his impression that students have not been successful in organizing and structuring their work. When prompted for his ways to cope with this impression in his

coaching, he states that he would like to be more directive, saying " .. you can divide tasks in the group" (passage 3). He identifies a tension with what he interprets as the coaching practice which would comply with principles of knowledge creation" but then I would be too directive and I am not sure whether that should be our intention, so therefore I give them more freedom" (passage 3). Eventually, for him to overcome this dilemma, more guidelines for coaching knowledge construction are needed.

   Thus, this episode points to a tension between what can be interpreted as top-down instruction at one hand and social distancing at the other. Teacher3 was reluctant to interfere with students' activities too much, since this would be in conflict with his emergent perspective about what is important when fostering students' knowledge construction. Still, this coaching practice added to the problem of students, who reported that they sometimes experienced their teachers' approach as being disruptive in the context of their activities:

Researcher3	What do you think of your teachers' coaching?
Student1	Well, sometimes teachers ask us just too often what we are doing and what our end product will be; what we want to achieve. But in most cases, we had explained that seven times already and they still want us to explain it even further, while we even do not yet know how far we can go, that is quite annoying

Interview Student group 4; December 2006

In this episode student1 reflects on their teacher's approach, mainly involves asking explanatory questions about the nature and status of the group's activities. This is corroborating on what teacher3 stated in the previous episode. Although teacher3 adopted this coaching practice as his interpretation of what is needed to foster students' knowledge construction processes, this caused a conflict with the observed and experienced processes of teachers and students. This point was explicated during a subsequent plenary meeting of the design group:

1	Teacher3	[…] Well, it seems our students do not have a clear idea of what they have to do
2	D	Students have to know what the assignment entails […]
3	Ped. Expert	[…] So I would suggest that the teachers can focus on helping to students create these structures. […]
4	Researcher3	Students could concretize their ideas in a plan
5	T2	So I would like to coach them to make it clearer like what the object is and its requirements. So far, we have maybe been too reserved.
6	PE	That is very important, and then those group members will follow their own work structure. […]
7	R2	Still, it is not a bad thing that it going like this, if they first muddle a little, […]
8	PE	But you shouldn't let that continue too long
9	T1	But, what you see now. That we should give a little more structure
10	T2	We can ask students to make a so-called Tabasco planning which they are already used to construct. In this planning they have to specify the activities they are going to perform, what the end objectives are. This can serve as a tool for teachers to monitor students' progress without being too directive or strict […]
11	Process coordinator	And you could revise this planning, which makes leaves it more open for students […]
12	T2	Apparently that is needed
13	R3	So, it is our observation that that is needed, yes.
14	T2	Well, that is clear by now. This shows that a good start is necessary. There has to be concrete object and once that it is there, it will go well

Protocol meeting design team; January 2007

This episode shows the identification of the issue that is at hand ".. it seems that our students do not have a clear idea of what they have to do" (passage 1), leading to an expression and framing of the tension between teachers' current approach ".. So I would like to coach them to make it clearer like what the object is and its requirements. So far, we have maybe been too reserved" (passage 3), and the

more directive approach ".. But, what you see now. That we should give a little more structure" (passage 9). The suggestion that is put forward to overcome this tension is to synthesize both perspectives in a concrete manner, ".. We can ask students to make a so-called Tabasco planning which they are already used to construct" (passage 10). This is accepted and taken up by the others ".. apparently that is needed" (passage 12).

Another issue related to teacher's 3 concern regarding the lack of guidelines for coaching students' knowledge construction, and the contribution and roles of the members of the design team in the coaching practices:

1	T3	Nevertheless, it is important get more assistance during work sessions because now we're only with the three of us,. that is my first concern
2	D	It should be fixed then, we need teachers for this class […]
3	T1	Sometimes you [Researchers] are a little blunt It is not criticism but I noticed that you have you own agenda You don't really help us coach, we just have to take care of it. In my opinion that is not really being an actor!
4	R1	Well, the idea was that we didn't want to participate as a teacher because we don't have that expertise though we are here to provide you with some advice and answer your questions, if you have any
5	T1	[…] I am teaching the knowledge creation project on my own which is not an ideal situation, I just want you to think with me. Clearly we don't expect you to teach […]
7	R1	Well, I believe that is a good thing to hear, I am glad that this came forward
8	PE	The researchers are used to stay in the background to be able to observe the process as objectively as possible
9	T2	There is a big culture difference because we are used that everyone is involved You are think as observers
10	PC	It is a type of participation when you are observing […]
11	T2	You could divide one group into two groups so that T1 has to coach his own groups but that T4 and T1 meet each other during class to discuss any problems or to ask each other for advice
12	D	You can then also ask researchers for feedback during coaching […]
13	R1	Yes, that would be perfect [everybody agrees]

Protocol meeting co-design team; January 2007

This episode shows a tension between the work traditions of researchers at the one hand and teachers at the other. The issue that was expressed "..it is important get more assistance during work sessions because now we're only with the three of us" (passage 1), opened up for explicating the underlying conflict between the perspectives of researchers and teachers regarding their role during the coaching of students' knowledge creation processes. Utterance s such as "..You don't really help us coach, we just have to take care of it. In my opinion that is not really being an actor!" (passage 3) versus "Well, the idea was that we didn't want to participate as a teacher" (passage 4) illustrate this tension. Subsequently this resulted in a framing of these conflicting perspectives from the view of the traditional work practices of both groups to create common understanding ".. There is a big culture difference because we are used that everyone is involved You are think as observers" (passage9). Eventually, partners provided suggestions to overcome this tension by a division of labor ".. You could divide one group into two groups […] you can then also ask researchers for feedback during coaching" (passage 11).

The abovementioned developmental tensions set the stage for collaborative analysis and for the creation of a shared understanding to overcome them and change teachers' coaching. Eventually, teachers' coaching transformed towards an increasing emphasis in the collective construction of a planning together with students. This would help students to organize their work and offered teachers a tool that enabled them to monitor students' progress during knowledge construction:

Phase 1 in coaching knowledge creation
- Do students have a clear plan?
- What are they eventually going to show, what is their object?
- The teacher has a specific role in this process

- ‘Go’ or ‘no go’ decision

Slide taken from presentation of Teacher3; March 2007

In this artefact, i.e. presentation provided to other teachers at UniC, teacher3 shows that that the significance of a "planning" is echoed in teachers' coaching practices. This theme can be traced from the tension that team members identified and attempted to overcome earlier. Moreover, teacher3 took up this idea and implemented a 'go-no go' decision in his practice. Then students had to negotiate their planning with their teacher before they were allowed to continue with their knowledge creation projects:

R3   How do you see your role as a teacher now, what is most important?
T3   Well. First that students chose a subject and that they construct a planning. And the task of the teacher is to perform a reality check and argue whether students' planning is a good one or not, to give a 'go' or 'no go' decision at the start. There is where the teacher plays an essential role and this planning gives a good tool for me to observe what is happening and to ensure that students keep in a 'flow' towards the end

Interview Student group 4; December 2006

In this excerpt, teacher3 reports that he had adapted his coaching to such an extent that he now asks his students to construct a planning and that it is the teacher's task to decide whether students can continue in pursuing their knowledge construction according to this plan or that they have to construct a more realistic or challenging planning.

Tension resolution of conflicting perspectives about division of labor between members of the design team resulted in creation of a joint venture agreement:

For Utrecht University this agreement involves:
- To perform research at UniC in collaboration with teachers and students concerning the concept of knowledge creation and support thereof
- To realize a long-term relationship between research and educational practice, in which knowledge, insights and experiences are exchanged with the aim of learning and capitalizing from each other

For UniC this agreement involves:
- To obtain more insight and tools to experiment with possible solutions for the challenges and issues which structurally occur in educational practice
- To realize a long-term relationship between research and educational practice, in which knowledge, insights and experiences are exchanged with the aim of learning and capitalizing from each other

Join venture agreement, first version; April 2007

Transformation and contribution to new practice over time

In this research case, it was illustrated that interaction between different knowledge trajectories occurred on both the individual and collective platform of the design team and how participants stabilized out of flux by changing their practices accordingly. During meetings practical pedagogical enacted knowledge of teachers intersected with social practices of the educational researchers. At this level, developmental tensions surfaced on the nexus of perspectives, agendas and interpretations of the actors involved in the collaborative design in the university-school partnership. The attempts undertaken to overcome the identified tensions involved the creation of artefacts (e.g. the joint venture agreement) that serve to objectify and afford this transformation.

Tacit knowledge (represented as the network of implicit epistemological beliefs, attitudes and knowledge) was explicated during group meetings and ideas expressed were often taken up by the group and integrated within existent practices, or became the driving force behind the development of relatively new pedagogical practices. For instance, the tension between top–down instruction versus social distancing and differentiation of coaching styles was resolved by a collective envisioning and

fleshing out of coaching practices. More specifically, more emphasis was placed on employing students' planning as tools to monitor and to scaffold students' knowledge creation.

In sum, the case shows the transitions observed from identification of tensions, the attempts to overcome them by engaging in transformation of coaching and of social practices towards the creation of artefacts that serve to objectify and afford this transformation.

CONCLUSION

In the present paper we aimed at describing patterns of tension resolution in two research cases from the fields of respectively medical simulation training and pedagogical design in the context of a school-university partnership. Based on socio-historical perspectives on learning and development, we have appropriated the notion of developmental tensions as a driving force of change and development. Although we do not claim that developmental tensions are the sole impetus of transformations of work practices, the investigation of tensions and their resolution helps to identify the dynamic forces of change and comprise an important constituent and starting point for investigating such processes (Barab et al., 2002; Engeström, 1987; Koschmann, Kuutti, & Hickman, 1998; Murphy & Rodriguez-Manzanares, 2008). For the research reported here, the identification of these tensions provides a starting point for investigating and explaining practice transformations in knowledge creation contexts.

In the cases reported in this paper, we have seen similar patterns of managing or resolving tension, namely: identifying, labeling, framing and solving/suggesting:

1. *Labelling the issue:* Often, tensions are not about the issue at hand (e.g., scheduling a meeting) but rather about what it represents, such as the experience of disrespect or the illegitimate exercise of authority. A tension could only arise as the consequence of one of the professionals in the knowledge construction work to describe a particular problem at hand;
2. *Identifying the tension:* as a result of professionals knowing what the issue is at hand, the contradictions in perspectives, knowledge, attitudes or affects come to the fore explicating the problematic features of the practices under scrutiny. These tensions are explicated in the voices of the several professionals in the collaborative knowledge construction work;
3. *Framing the tension:* subsequently, the tension is framed employing the self-created language, norms and rules of the knowledge community. This framing is necessary for creating a shared understanding of the tension and for constructing a representation of the forces acting in preserving and causing the problematic practices at hand. This will eventually enable professionals to adapt their practices to be able to overcome the tension;
4. *Constructing solutions:* Finally, professionals transform their or shared practices, construct new tools and implement them in the ongoing knowledge construction work.

The findings have illustrated that the interaction between different knowledge trajectories occurred on both the individual and collective platform and showed how professionals stabilized out of flux by changing their practices accordingly (cf. Ludvigsen et al., in press). This means that during the meetings of respectively the medical teams and the pedagogical design team, different modes of knowledge intersected and tacit knowledge (represented as the network of implicit epistemological beliefs, attitudes and knowledge) was explicated. We assert that although goals not always converge, productive collaborative work is possible. We observed that the work around shared objectives and the tensions that emerged from this process, served to elaborate and refine existing knowledge practices, and develop new ones.

These observations have been used as input in the design of a video reflection and annotation tool for supporting the identification of tensions in team work[1]. One of the central ideas underlying the Semantic Multimedia Annotation Tool (SMAT) is that users can share, compare and discuss their annotations of video recordings. A challenge is that video recordings can easily be imported into the tool and that it easy to share these as well as to collect annotations from different users and to share these among users (see Figure 1).

The annotation tool is intended for both individual and collaborative annotation and thereby supports this task. When videos are annotated individually, this means that this activity is embedded in collaborative work. Annotated videos can be used as for instance mirroring- or reflective material which provides resources for the main object-oriented activity. For instance, videos that are annotated by others may result in the explication of a particular tensions which may open up opportunities for changing knowledge practices of a particular working community towards more productive ones.

Moreover, SMAT enables users to compare annotations which can potentially be supportive for analyzing trends in the annotations.
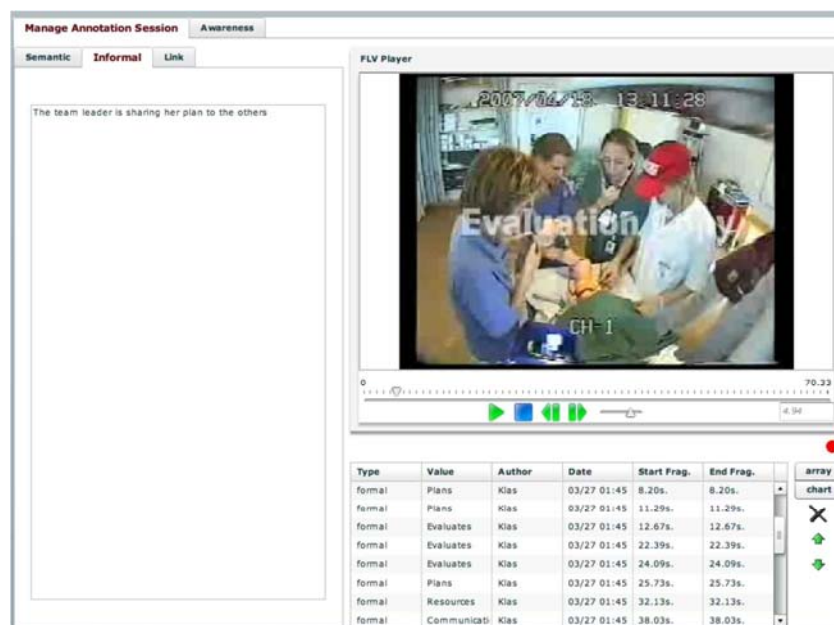

Figure 1. Screenshot of SMAT

The point of the tool is thus to highlight the professionals' different observations which thereby highlight underlying tensions. An advantage is that problems do not risk being overlooked and instead become a starting point for change. SMAT offers knowledge communities to analyze and reflect on current work practices in productive ways by means of the collaborative annotation of videos. It has the potential for users to identify tensions in their current beliefs, understandings and routines to open up opportunities for transforming their practices. As we have seen these tensions set the stage for collaborative analysis and envisioning which proves to be a crucial precondition for the creation of a shared understanding for overcoming these tensions by changing practices. SMAT supports this identification of tensions by having users annotate video recordings of their practices employing shared vocabularies or ontologies. This fosters focusing a particular group's efforts on the root causes of problems.

Research should be conducted on the use of the tool and the practices surrounding this use, e.g., how it is used individually and collaboratively to create annotations and how this use can contribute to patterns of tension resolution and resulting practice transformations. The development of such practices should also be studied as well as how the tools and variants of it can be used to modify, support, augment and improve these practices. Little if any empirical research has been done on the above.

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