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Knowledge Creation in Teachers' Professional Development: Tensions between Standardization and Exploration

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This paper examines processes of knowledge creation among an interdisciplinary group of teachers in a Norwegian upper secondary school who collaborated with university experts in order to develop professional knowledge about writing in and across school subjects. The study, which is based on a sociocultural framework with emphasis on mediated, dialogical interaction, explores the processes of knowledge creation that occurred within this learning community over a two-year period. The main data is drawn from audio-recorded meetings, and the analysis traces the interactions between the participants. Special attention is paid to the teachers' use of student texts and resources related to writing to reveal how professional knowledge emerges over time. Findings show that the enduring talk reflects knowledge creation at the juxtaposition of uncertainty, exploration, and the need for standardization. Such knowledge creation emerges as a result of material, social, and conceptual mediation. Hence, the study contributes to an understanding of how teachers' development of new knowledge can be fostered in a school setting through exploratory talk and different forms of mediation. We argue that the study has implications for professional development, teacher education, and workplace learning.

Key words: Teachers' professional development, knowledge creation, mediation

Introduction

Teachers' professional development in the knowledge society is closely related to what counts as knowledge in educational settings (Kelly, Luke & Green, 2008). School subjects have traditionally been linked to stable and often standardized knowledge, provided by teachers and made publicly accountable through test systems and exams. However, as Edwards, Gilroy and Hartley (2002) show, traditional school disciplines are being challenged by the increasing turnover rate of knowledge production, and the need for teachers to be socialized into future practices and not just current ones. This requires relational expertise (Edwards, 2005), i.e., the capacity to work across knowledge domains and fields of expertise as a key to revitalizing teacher education and teachers' work. Also, reformers have begun to note that a changed curriculum would not directly lead to changed teaching practices (Coburn & Russell, 2008). New expectations of student performance would entail new ways of teaching, not just ambitious policy documents. Similarly, Hargreaves (2003) shows that existing educational models often prevent innovation and, in fact, make innovative teaching communities deteriorate and give up. His response is cultivating teachers' collaborative and collective expertise by engaging them in action research as true learning communities. Hence, professional development in the form of teachers' learning communities is currently seen as a ticket to change; teachers depend on professional development to cope with their challenges as knowledge workers (Vescio, Ross & Adams, 2008; Little, 2011).

As an increasing amount of research shows, professional learning communities have the capacity to promote and sustain the learning of professionals in the school with the collective purpose of enhancing student learning (Stoll, Bolam, McMahon, Wallace & Thomas, 2006). Key conditions are norms of collaboration, focus on students, access to a wide range of learning resources and mutual accountability for student growth (Lieberman & Pointer Mace, 2009; Vescio et al., 2008). These are conditions that afford and constrain interactions among teachers. However, the research to date has made relatively little headway in examining the nature of such interactions by which a professional community is forged, sustained, and made conducive to learning and improvement (Horn & Little, 2010). Even though it is more common that teachers come together to cooperate and share their experiences, norms of privacy often leave the conversation at the level of the superficial (Little, Gearhart, Curry & Kafka, 2003; Coburn & Russell, 2008). However, as recent studies note, schools with norms that enable teachers to share data about their classroom practice

openly, critique one another, or ask challenging questions are more likely to have conversations that delve more deeply into issues of instruction and student learning (Coburn & Turner, 2011; Horn & Little, 2010; Timperley, 2009). These are concerns addressed in this study.

In addition, few studies have addressed the notion of knowledge creation through analysis of interactions in schools. One example, however, is a study by Lund and Hauge (2010) in which they analyzed how a small group of young learners sought to make sense of a seemingly senseless act of terror. The study showed how the group synthesized diverse and often conflicting information from the Internet, developed a poster and a PowerPoint presentation, and staged a TV debate for the rest of the class to watch and thus developed new insights into a phenomenon that was new and bewildering to them as well as to their teachers and not described in traditional textbooks.[1] The teachers we study are engaged in similar, although less dramatic, work as they seek to develop practices related to student writing and, more specifically, common guidelines for learners' use of sources (in literature as well as on the Internet), and to explore different forms of feedback to student texts in a situation where practices differ across teachers and the school subjects they teach.

The present paper aims to show how a group of experienced teachers in a Norwegian upper secondary school expanded their knowledge base about writing in and across school subjects through an enduring dialogue in a learning community. We do this by examining collaborative processes of knowledge creation (Paavola & Hakkarainen, 2005) as a point of departure. This involves mediated processes that rest on the use of conceptual as well as social and material artifacts (see the section on Theoretical framework for an elaboration). Although we draw on longitudinal data to capture development, the empirical focus in this paper is on five selected episodes from five of a total of 13 team meetings during a period of two years. Against this backdrop, we pursue the following research question:

> How does mediated, interdisciplinary talk, supported by university experts, stimulate knowledge creation processes in a team of teachers?

[1] The case referred to is the tragedy at School #1 in Beslan (September 2004) where Chechen rebels took hostages and the Russian troops stormed the school, attacking the rebels. The battle that ensued left 344 dead, among which 188 were children.

In the following we seek to answer this question. First, we present the context of the study before approaching knowledge creation by juxtaposing professional development, mediation, and artifacts within a broader, sociocultural, and activity theoretical perspective. This is followed by a section on our methodological approach and a presentation of the data we analyze. Next, we discuss our findings before concluding with some implications for professional development and education of teachers.

Context of the study

Fagerbakken is a Norwegian upper secondary school with 60 teachers and approximately 600 students. The school enjoys a good reputation, the teachers are highly qualified, and the student results are above national average. Previously, there have been only a few attempts at collaboration across disciplines; generally, teachers have been organized in subject-centered units. However, some of the teachers in this school wanted to learn more about writing in the disciplines, and with support from the principal, they took the initiative to cooperate with two university experts. The experts were invited to engage with and support the team, and to contribute with knowledge whenever requested or they identified a need for it. This resulted in establishing an interdisciplinary writing team consisting of 11 experienced teachers, who all volunteered to the project, and the experts. The writing team met regularly, at least once a month, to discuss students' texts and issues of writing in and across the disciplines. The subject domains of Norwegian as a first language, foreign languages, history, and natural sciences were represented in the teacher team. This local school project, which is both a school development project and a research project, ran for three years (2007–2010) and in close collaboration between the teachers, the experts on writing, and the principal of the school. The purpose of this research project was to identify teachers' emerging knowledge of writing and their discourse strategies when negotiating their perceptions of students' texts, and to explore the ways teachers and experts communicated as they developed their knowledge. According to research on professional learning communities, teachers' learning was assumed, in turn, to increase their repertoire of instructional strategies and to consequently increase student learning (Helstad & Lund, 2012; Vescio et al., 2008).

In the Norwegian Knowledge Promotion Curriculum, K06 (Kunnskapsdepartementet, 2006), writing is defined as one of five basic skills to be

integrated in all disciplines and at all levels.[2] Hence, this curriculum reflects an international trend where writing is regarded as a strategy for domain-specific learning and communication (Newell, 2006). For learners in upper secondary schools in Norway, critical and accountable use of sources has increasingly emerged as a crucial competence within these basic skills. As the participants in the team concentrated their work on writing of argumentative texts in diverse subjects, the use of sources quickly emerged as a common denominator. The reasons are partly found in the fact that argumentative texts in themselves rest on accountable use of sources, partly in the fact that the K06 curriculum and the trend towards exams opening up for the use of available resources emphasize the importance of correct and productive use of such references. Across subjects, teachers also are encouraged to give students qualified and concrete feedback to texts, including their use of sources, in order to improve students' learning and writing skills. Developing criteria for teachers' response and assessment of students' texts is an important aspect in this work. However, as this is a rather new dimension in several school subjects many teachers feel uncertain about how to integrate it in their practices. In such a situation we see how the teachers we study turn to each other for advice and exchange of ideas and experiences, often mediated by learners' texts, expertise within the group or from the university representative, or concepts from their profession.

Theoretical framework

As indicated in the introduction, teachers of the present and future need to increasingly work with knowledge that is not merely given (such as in textbooks) but with knowledge that is continuously developed and renewed as a result of progress made in diverse scientific domains. This is not to say that teachers are expected to take part in scientific breakthroughs or add historically substantial and original contributions to their fields of expertise. However, their role entails making sense of an ever-expanding volume of information and moving across knowledge domains in order to draw on horizontal expertise and co-configuration of work to adapt to changing needs (Engeström, 2004). It also means working at the edge of one's compe-

[2] In the Norwegian Curriculum from 2006, literacy in the broadest sense of the word was made a key part, as writing, reading, arithmetic, oral skills and digital skills were to be integrated in all disciplines from 1st through 13th grade. Each teacher is supposed to work with these skills in ways that are relevant in their own discipline (Øgreid & Hertzberg, 2009).

tence; the sheer turnover rate of available information and what counts as current, relevant, and valid knowledge challenges teachers' capacity to keep up with research and not just what the textbooks have to offer.

Today, teachers are not merely expected to be subject-matter experts (in addition to being expert orchestrators of educational activities, social workers, accountable bureaucrats, and dependable and just assessors). In the context of the knowledge and networked society (Castells, 1996), teachers also need to appropriate and even develop new knowledge; increasingly, they have to work at the periphery of their current horizon of professionalism. This calls for a concept of learning and professional development that goes beyond well-established metaphors such as knowledge acquisition and mere participation in communities of practice (Sfard, 1998).

A vital principle in sociocultural theory is mediation; i.e. that our knowledge of the world emerges, is sustained and further developed as we make use of available social, material, and conceptual artifacts. Mediation is a fundamental concept in the Vygotskyan legacy (Vygotsky, 1986; Wertch, 1998). However, when applied to collaborative efforts of creating new knowledge and not just appropriating given knowledge, we need to look for a slightly expanded conceptualization: Vygotsky developed his concept studying how agents acquired given knowledge or approached a problem with an unambiguous solution. In order to expand the conception of mediation to capture processes of developing new and collective knowledge, we turn to Paavola and Hakkarainen's knowledge creating metaphor (Paavola & Hakkarainen, 2005; Hakkarainen, Palonen, Paavola & Lehtinen, 2004) to theorize what teachers are up against.

In a discussion of Annabelle Sfard's (1998) seminal analysis of the acquisition and the participation metaphors, and with special attention to agency, the authors summarized three approaches to learning:

> Agency appears to be facilitated through learning processes in which there are aspects of all three metaphors of learning (…); acquisition of existing knowledge ("monological", within mind approach), a variety of ways of participating in cultural practices ("dialogical" approach emphasizing interaction between participants), and joint working for advancing collective knowledge ("trialogical" approach […]). (Hakkarainen et al., 2004, p. 10)

In the case of "trialogical" knowledge advancement, the authors elaborate what it entails by pointing to a project plan for a mental health facility as an example of a mediating artifact. This makes the knowledge creation metaphor resonate with fundamental principles in activity theory, e.g.

the notion of expansive learning which involves change and transformation (Engeström, Miettinen, & Punamäki, 1999). According to Paavola & Hakkarainen (2005), influential representatives of the knowledge creation metaphor are Engestrøm's expansive learning theory, Bereiter's knowledge building approach, and Nonaka and Takeuchi's theory of organizational knowledge creation (cf. Engestrøm & Sannino, 2010). Despite differences between these theories, they have many features in common: (1) pursuit of newness, (2) mediating elements, (3) viewing knowledge creation as a social process, (4) individual subjects in collective knowledge creation, (5) going beyond propositional knowledge, (6) recognizing conceptual artifacts as important, and (7) interaction around and through shared objects. In essence, this approach concentrates on collective and mediated processes involving shared artifacts and objects.

In our analysis of how and what teachers try to make sense of in excerpts from meetings in the writing team we find that the knowledge creation metaphor carries explanatory power when facing the phenomenon we study. With its theoretical foundations in the Vygotskyan tradition of language as mediating thinking and activity theory's focus on shared artifacts and objects as vehicles for mental development it functions as an analytical lens when we turn to the empirical material. First, however, we briefly need to present our research design and the methodological approach to knowledge creation.

Research design and methodology

The research design of the present study rests partly on ethnographic fieldwork from 13 meetings of an interdisciplinary team (Silverman, 2006), and partly on interaction analysis (IA) (Jordan & Henderson, 1995) of specific episodes in these meetings. The data corpus, which was conducted from 2007–2009, consists of observations in the form of field notes and audio-recorded data from these meetings, as well as six interviews with participants, logs written by four of the teachers, responses to questionnaires, and document analysis (syllabi and policy documents). The documentation types are mutually constitutive of the object, which is to understand how teachers develop their knowledge in situated activities with shared objects (cf. Paavola & Hakkarainen, 2005).

In order to capture mediated knowledge creation *in situ*, we used interaction analysis as our main methodological approach. In IA, a fundamental assumption is that knowledge emerges in interactions among members of

a particular community, mediated by talk but also mediated by the artifacts they use. IA specifically focuses on how interrelations between talk and the use of artifacts are conducive to professional learning and human development. In this paper, examples of artifacts are the students' written texts (material) and the emerging standards for accountable use of sources (conceptual). Also, IA offers a multi-level approach: how the individual, the social, and the institutional levels aspects of activities converge in such interrelations. Although originally developed with video recordings in mind, we found IA useful for audio-taped recordings as well, since IA allows researchers to capture the complexity and dynamics of interaction.

In order to unpack in some detail what occurred at a specific time, the empirical analysis focuses on the moment-to-moment interaction in five selected episodes from five meetings in the writing team that took place from 2007 to 2009. Thus, while the episodes were selected in order to visualize processes of knowledge creation and to display how these processes stimulate professional development, we also sought to document the possible transformation of teachers' knowledge creation over time. These selections from the data corpus qualify as dialogic episodes understood as a specific type of situated and relational social practice (Helstad & Lund, 2012; Nystrand, 1997). Such episodes constitute the unit of analysis, i.e., the analytic focus that serves to capture seminal moments as well as the temporality of talk.

Furthermore, what delimits the dialogic episodes used in the present study are features that signal emerging knowledge creation through participants' interaction with common objects. Consequently, such episodes are not merely illustrations or examples of a phenomenon, but should be seen as empirical carriers of more general principles. They are not statistically generalizable, but they are arguably analytically generalizable, i.e. in the sense that "the findings from one study can be used as a guide to what might occur in another situation" (Kvale, 1996, p. 233).

Episodes and trajectory

In the episodes that follow, the participants discuss issues related to writing in diverse school subjects. The point of departure for their inquiries is students' texts, which the teachers have brought to the community for discussion. The meetings usually consisted of a discussion of student texts and a session concerning specific issues related to writing competence

where the use of sources emerged as a common problem of inquiry. While teachers of social studies and history have focused on such concerns in their teaching for a while, many of the teachers of other school subjects were quite unfamiliar with these issues. Thus, several teachers expressed uncertainty concerning this matter and the need for common guidelines that would assist them in teaching how to deal with sources. In particular, there was a need to speak unambiguously regarding how to apply in-text references and the literature list following the text. As researchers, we could follow this work over time where drafts of guidelines were negotiated, revised, or rejected before the group settled on a template that could be applied for all subjects at the school.

In episodes 1, 2, 3, and 4, the participants particularly explored if and how developing common standards and guidelines across the subjects is possible, while the last episode (episode 5) shows how the teachers explore new ways of giving feedback to students' texts. In the episodes, we meet 7 of the 11 participating teachers in the writing team and the 2 experts: Frida[3], a professor and an acknowledged authority on writing, and Kurt, a teacher of academic writing at the university. Ragnhild is a teacher of natural science; Tora is a teacher of English and the local project coordinator; Ben, Martin and Edith are social science and history teachers; and Kirsten and Liv are teachers of Norwegian as a first language.

Episode 1: Exploring how to approach the use of sources in student texts

In the first episode, December 2007, the question of how to treat sources in student texts emerged. Addressing the goal for their work ("students have to learn to document their sources"), Ben introduces a "simple way" to handle it:

1. Ben (Social science): I intend to make a couple of examples of how students can provide the sources in a simple way. Students have to learn to document their sources, and although this method may not be formally correct, as teachers we need to see that the students have actually read some material that they reproduce in their texts, right?

[3] All the names are pseudonyms.

2. Martin (History): It is important that students work with sources all the time. They have to learn more about assessing sources critically and identify their bias and credibility.
3. Kirsten (Norwegian): Is it possible to arrange a workshop on this? I mean the sources on the Internet, for instance, because I have very little experience in these matters. If any of you who have worked with this could teach some of us, I think it could be very interesting.
4. Edith (History): I, too, think that it would be interesting.
5. Tora (English): So you wish for a course in the use of sources and how to assess them critically?
6. Kirsten (Norwegian): Yes, for us and for the other teachers. We're going to propagate this in the subject departments, right? But initially, this is something that we need to explore in our own classrooms, don't you agree?

Providing examples of how the students can manage the use of sources in a simple and not too detailed way, and introducing concepts such as critical assessment, bias, and credibility, Ben and Martin demonstrate specific knowledge as well as experience regarding the use of sources. However, not all teachers are familiar with this, as documented when Kirsten and Edith wonder about the possibility of a workshop in order to increase their own knowledge. The requests from these teachers signal that they are at the periphery of their competence when trying to adapt to changing needs (Engeström, 2004). Also, Kirsten states that before disseminating their new knowledge (potentially acquired in such a workshop) in the subject departments, the teachers need to experience what it entails. As Kirsten puts in a reflection log: "We have to experience the writing strategies ourselves to discover how it works".

This episode shows that the teachers face a dual challenge in their professional development: first, learning what accountable use of sources entails when introducing this into their own practices and second, how such practices can be shared with colleagues. One strategy is for teachers to learn from each other, making scientific knowledge transparent in the community of learners. Social mediation in the form of more knowledgeable peers emerges as crucial at the juxtaposition of exploration and the need for standardized practices. As such, teachers learn to teach the strategies they are developing by figuring out how to teach them to fellow teachers. In the process, they learn to talk about teaching rooted in the context of their own classroom (Lieberman et al., 2009). Hence, collaborative work with sources

as well as common standards might function as drivers for knowledge creation. Such concerns are pursued in Episode 2.

Episode 2: Common guidelines as a dilemma

In a meeting five months later, May 2008, one of the experts, Kurt, introduces a material artifact in the shape of a first draft of a template with common guidelines for how to deal with sources (cf. requests for assistance in Episode 1). The teachers want common standards primarily for them to steer the students towards more accountable use of sources in their written texts. In the following episode, the teachers negotiate these guidelines.

7. Kurt (expert): (*distributing a paper with guidelines)* This is a suggestion; a draft. Next, the school has to decide where to go [with it].
8. Ragnhild (Natural science): Let us present this as an example to our colleagues.
9. Tora (English): Yes, a suggestion. That these are tentative guidelines.
10. Frida (expert): (*addressing Tora, the local project coordinator*) The teachers have to comment on this before deciding anything. I suggest you ask the teachers to help us develop these guidelines. Do not state that, "this is the way you have to do it at this school".
11. Kirsten (Norwegian): (*addressing Kurt)* What kind of template is used?
12. Kurt (expert): The guidelines are taken from a book of references which draws on writing practices in the humanities and social sciences.
13. Tora (English): Okay, but what do we do now? Do we need to respond to what might be misunderstood or what is not covered by the template?
14. Kirsten (Norwegian): Was there anything in the student texts I presented that was in disagreement with these principles?
15. Kurt (Expert): A lot. That's the problem. When we approach this [draft] as a formal standard, it must be fairly consistent.
16. Tora (English): We do not have so much time left. Do we have to decide on this prior to the summer vacation?
17. *(silence)*
18. Ragnhild (Natural Science): And it is because of the students we are doing this, right?
19. *(silence)*

The episode demonstrates the risks of introducing common standards: on the one hand, they function as scaffolding for the teachers in their collective zone of proximal development (Vygotsky, 1986); on the other hand, they risk becoming too rigid as indicated by Frida (10). By suggesting to the local project coordinator that she should ask the teachers to help develop these guidelines, Frida advises the group to be careful, recognizing teachers as autonomous professionals as well as the limitations of a structuring artifact. Further, by opening up for advanced expansion, Frida mediates a possible development into new territory. While validating the draft of guidelines in a book of references (12), Kurt is quite normative referring to "formal standards" and "it must be fairly consistent." The dilemma is highlighted when the expert (15) acknowledges that the student text presented by Kirsten is not in accordance with the draft of guidelines he had suggested. This dilemma comes across as a discursive manifestation of tensions between standardization and functionality. Together with the time constraints (16), it brings the process to a temporary standstill. The silence in the group (17, 19) suggests that uncertainty on how to proceed as well as relevance for the students dominates at this point. In activity theoretical terms, we could say that the object, which is to improve students' writing skills, risks slipping away. In episode 3, we see how these problems persist.

Episode 3: Exploring pros and cons of templates and standards

In this meeting, January 2009, the department heads[4] are gathered to discuss experiences from the writing project and further consequences for professional development in the departments. In this episode, they discuss the common standards for sources that have been introduced and that now have reached a stage where considerable detail has been attained. Frida addresses concerns about this template, expressing her worries about the details to be adhered to by all the teachers. Ben follows up this concern (cf. Episode 1), articulating doubts about the level of detail.

20. Frida (expert): I would have made the template far simpler. I've always been afraid of that list because if that is what our project is to people on the outside, such a recipe has no chance to succeed—it is too detailed—and I cannot imagine that teachers will begin to scrutinize [student texts] and say "you have used periods instead of commas there," and so on.

[4] Of the 11 participants in the writing team, 5 are department heads.

21. Ben (social studies): I tell my students that the purpose is not to present the sources formally correct in every detail, but that as a teacher, and as a reader, I find the sources that I know that the students claim they refer to. We have discussed this a lot, it has been a long journey to find something in common with regard to these guidelines. In retrospect, I think that we should have simplified the whole thing.
22. Ragnhild (natural science): Yes, but even for examinations in mathematics, students have to name their sources, and as teachers we actually have the responsibility to teach students how to write more than just content.
23. Frida (expert): Yes, I agree to that.
24. Ragnhild (natural science): But still, the content is the most important thing, I think.
25. Frida (expert): Anyway, the proposed guidelines should be evaluated before the project is complete, or else it could just drift away and result in something that has no impact at all.

This episode shows how the dilemma of standardization and functionality persists. As an expert on writing, Frida intervenes in clear terms (20) and articulates how the conceptual artifact in the form of the guidelines are still tentative and should be made subject to a broader evaluation before being put to use; i.e. she emphasizes the functionality aspect. Hence, Frida shows that the artifact (guidelines) threatens to replace the original object (improving student writing) and thus, threatens the sustainability of their efforts (Engestrøm, 1990; Lund and Hauge, 2010). Ben (21) corroborates Frida's opinion by drawing on his own practices as a teacher and, as in Episode 1, refers to the purpose of their work. Ragnhild, too (22), articulates their dilemma by bringing in the relation between content and accountable use of sources; "to teach students how to write more than just content." Her utterance suggests that the teachers are in the midst of an expanded notion of what writing in the networked society entails.

So far, the episodes we have examined show how teachers, through articulating their insecurity while at the same time drawing on colleagues' and the expert's insights, are caught in a dilemma; while a rigorous template provides a "safe" prop for an emerging practice, it could also represent a straightjacket counterproductive to reflective use of sources in students' texts. In the following episode, we see how the participants through exploration pursue the problem when material artifacts in the form of various student texts reflecting different school subjects are analyzed.

Episode 4: Exploring ways to follow and expand common standards

In this meeting, March 2009, Liv, a teacher of Norwegian language, brought student texts from her class to discuss issues of sources. After presenting one of the texts from her students, Tora points to the way this student had specified the sources:

26. Tora: (English) I just wonder whether the way this student has presented the references is acceptable. Is this the way our template suggests it should be done?
27. Liv (Norwegian): I told the students about our common standard, which prescribes the way to do it, but if they do it in a way that is almost correct, I think it is okay.
28. *(mumbling)*
29. Kurt (expert): There are different scientific fields that have very different standards. I guess you will come across this issue several times.
30. Frida (expert): I think we have to offer the students a variety of opportunities; do we need to be that strict? Nowadays, it is common to use sources from the Internet, and we need to create templates that are in accordance with this trend. If we only do this in the usual way, I do not know, perhaps we need some new tools here.

This episode shows the difficulties of doing things "the right way" – is there one way or many ways to handle sources in written texts? Tora immediately introduces her uncertainty (26) and looks for support in defining what is "accepted" and "the way" the template is meant to work. When Liv responds, she points to the delicate balance between prescribed standards and pragmatism (27), a concern introduced by Ben in previous episodes. Hence, the teachers 'see' two aspects of a phenomenon. This reflects how a professional discipline notices in a particular way and amounts to exercising professional vision, understood as "socially organized ways of seeing and understanding events that are answerable to the distinctive interests of a particular social group" (Goodwin, 1994, p. 606). Kurt develops the point by referring to different standards for diverse scientific domains (29). As Øgreid and Hertzberg (2009) show, different school subjects hold different traditions and standards for writing. At the same time, these are rarely explicitly articulated, resulting in tacit knowledge and vague perceptions of genre differences and conventions.

Further in this episode, Frida expands the topic by referring to the need for "a variety of opportunities" (30) brought about by access to Internet

sources. These require an expanded template artifact that models how such sources can be represented in student texts. The implication is an expansion of the object and a potentially additional element of insecurity.

Episode 4 is an indication that the project team is in the process of collaboratively constructing a more sophisticated and thus uncertain object than when they first set out. Social (experts, colleagues) as well as material (student texts) mediation is at the heart of this process. In the final episode, we see how participants engage in expanding the object by establishing a "research project" while still acknowledging the uncertainty that looms over the project.

Episode 5: Expanding the object: Feedback on student writing

In this meeting, December 2009, Martin elaborates on a "research project," which he developed together with one of his colleagues and which aimed at examining systematic feedback in digital format to student texts. Such feedback involves the use of criteria and standards discussed in the prior episodes. The previous semester, Frida introduced the community to different forms of feedback, which Martin has picked up. Consequently, an additional perspective on the dilemma is articulated:

31. Martin (social studies): As you know, we got some ideas from Frida about how to respond to student texts. I thought about this a lot during the summer and then Kirsti and I started to provide different forms of electronic feedback. We have a lot of varieties that we're testing out in subjects as social studies, history and Norwegian.
32. Ragnhild (natural science): Do you provide specific tasks to the students?
33. Martin (social studies): We make the assignments, but it is the feedback on the texts we work with, which differs depending on the tasks and the subject. We experiment with different types of responses; we just test it and see what happens, Kirsti has opted for a more detailed version than the one I explore right now. You might call it a sort of experiment, we decided to go for it after Frida's contribution. We are not going to do it regularly – all of this – because it is terribly time-consuming.
34. Researcher: Would you tell us a bit more about this project? What do you actually do?
35. Martin (social studies): We try to figure out whether these lists of criteria and standards in use in almost all schools are of any help at all.

> Students are really frustrated about all these lists. They perceive them as meaningless so to speak. We let the students explore different varieties of feedback both with and without criteria, and later, when the students get their texts back with our comments, they reflect on their experiences in written logs. Then they tell us to what extent they used the feedback. It is very exciting when students hand in these logs. But we have to test it further.

This episode shows how at the end of a lengthy project on writing in and across school subjects, experienced teachers explore new practices as they develop material and conceptual artifacts. Their exploratory work is also fuelled by research (introduced by Frida) and experience by engaging in the project. For instance, how the teachers critiqued, negotiated, and developed criteria for the use of sources and how they tested different forms of giving feedback come across as a cyclical encounter with intervention from experts and contributions from peers. This recurring theme reflects the skepticism towards the increasing amount of national and local criteria that may lead to instrumental learning where teachers check off criteria rubrics instead of engaging in true learning processes (Hopfenbeck, Throndsen, Lie & Dale, 2012). On the other hand, many teachers call for criteria because they would then need to spend less time developing tools of feed-back and assessment themselves, a concern which is traced in Martins' statement (33): "We are not going to do it regularly – it is terribly time-consuming." Hence, the episode echoes the tensions between standardization and exploration when working with students' writing.

In Episode 5 the (preliminary) result is a practice which is quite bold and potentially innovative, discursively manifested by the many occurrences of terms such as "test," "experiment," and "explore". The exploratory talk, as well as the exploratory work, emerges as a driver for the teachers' professional development. However, the reactions from the students, as articulated by Martin, indicate that teachers and students perceive and make use of concepts and standards quite differently.

Knowledge creation at the juxtaposition of uncertainty, exploration, and the need for standardization

Developing new knowledge about writing across the disciplines is a complex endeavor because it involves teachers traversing the boundaries between the specific school subjects they teach. However, tra-

versing boundaries is necessary in order to expand the educational object and develop relational expertise and common knowledge needed for 21st century education (Edwards, 2005; Edwards, 2012). In the case of the writing project, the episodes reveal how collaborative interactions as well as conceptual and material artifacts mediate such knowledge and expansion.

Collaborative interactions partly materialized in the form of interventions from experts, partly from teachers who were more knowledgeable about the use of sources assisting colleagues who articulated more uncertainty about source use. Thus, we see how social mediation and "going public" with their thoughts in a community of learners were crucial for expanding a multivoiced, collective zone of proximal development for the participants (Daniels, 2001; Lieberman et al., 2009). However, it is also essential to see how such a zone is constituted not just by talk but by the use of artifacts. As our interaction analysis has shown, we encountered both material and conceptual artifacts. The material artifacts primarily involved texts written by students and used by the project participants to exemplify problems and dilemmas of practice regarding how to handle sources and teachers' feedback to student texts. The evolving template for citing sources is another example. As for conceptual artifacts, we see how guidelines and criteria are at the center of achieving a shared understanding of how different forms of standards balance between the level of detail and pragmatic and more exploratory approaches. This is basically a question of concept validity; the concepts in the shape of criteria to be developed need to match the specific practices that are enacted.

Our analysis of 5 episodes of moment-to-moment interactions from meetings in the writing team shows how teachers slowly move from a situation where the needs for assistance, such as workshops and experts' contribution, dominate to a situation where they systematically test different ways of giving feedback to students' texts, referred to as their "research project". This amounts to a trajectory of knowledge creation in the sense that they pursue and to a certain extent capture and develop their understanding of a phenomenon that is relatively new. This pursuit is driven by tensions between the need for shared standards and flexibility of use and the use of artifacts. It is a joint effort and social process, it definitely goes beyond propositional knowledge ("exploration" is used repeatedly), and it centers on the expansion of a shared object. These are all characteristics of what Paavola and Hakkarainen (2005) identify as knowledge creation.

However, the episodes also show that knowledge creation is a fragile and difficult endeavor. Throughout the episodes, we see how the participants on the one hand move between uncertainty and a realization of the need for

professional development and, on the other hand, express a need to develop templates and standards that can "institutionalize" new practices. The juxtaposition of such diverging aims seems to emerge as a driver of change that goes beyond teachers' "private practices". Yet, this may not suffice to establish new insights and professional development and render them sustainable in a larger community such as a school. The teachers seem to be aware of this as they repeatedly addressed how to involve their colleagues (e.g., Kirsten in Episode 1) and their responsibility towards students (e.g., Ragnhild in episode 3). This institutional aspect is also echoed by the expert Frida when she refers to the draft of guidelines, adding that "the school has to decide what to do [with it]." (Episode 2). Thus, the collegial as well as the institutional aspects of knowledge creation point to challenges of making new insights sustainable beyond the participant level.

Conclusion and implications

In our research question, we asked how mediated interdisciplinary talk supported by university experts stimulated knowledge creation processes in a team of teachers. Analysis of the episodes show how such knowledge creation emerges and expands as a result of material, social, and conceptual mediation. This study has demonstrated the way knowledge creation and, in this case, professional development emerges at the juxtaposition of the need for standardization and the exploration of new practices, an endeavor which entails both risks and uncertainty. Also, the study has shown how longitudinal and artifact-mediated collaborative dialogue promotes professional learning and development.

We argue that the findings in the present study have implications for teacher education, professional development, and workplace learning. In the introduction, we referred to research indicating that teachers need to be prepared for emerging and future practices and not just historically institutionalized core practices. However, such future dimensions do not seem to be systematically cultivated in teacher education or in-service training today (Hargreaves, 2003). One reason might be the persistent element of uncertainty that accompanies these dimensions. As shown, uncertainty is very much visible in the episodes we have analyzed, and has also been the subject of research into what constitute contexts for learning and teaching (Edwards et al, 2002; Morgan, Russell & Ryan, 2002). However, this study has shown how such uncertainty might be productive when teachers face the challenge of working at the edge of one's competence or even going

beyond it. We have seen how uncertainty, in this case, is closely linked to a tension between needs for standardization and further exploration. Such tensions force teachers to use discretion and go beyond groupthink and 'one size fits all' and engage in creative and exploratory activities which, we argue, are conducive to professional development and very much aligned with requirements from the knowledge society.

Regarding professional development and workplace learning, the study has revealed the significance of teachers' collaborative efforts towards increasing their own as well as their students' learning. Cochran-Smith & Lytle (1999) perceived professional learning communities as grounded in knowledge *for* practice, assuming that the knowledge teachers need to teach is generated when teachers treat their own classrooms and schools as sites for investigation; at the same time they treat the knowledge and theory produced by others as material for examination and interpretation. This study has exposed that the recognition of colleagues' and external experts' contributions not only helps teachers become articulate about understanding learning and teaching but it also opens them up to others' ideas, to research and scholarly literature (Lieberman et al., 2009).

In this study, the collaboration in the community of learners has in particular focused on student writing. According to Horn and Little (2010) looking at student data has the potential for bringing students more explicitly into negotiations among teachers, and to expand teachers' opportunity to learn. As work places, schools that support teacher learning and foster a culture of collegiality are better able to support teachers, pursue innovation, respond effectively to external changes and ensure teacher commitment (Little, 2011). Taken together, the writing team in the present study had resources both internally and externally to combine problems of practice with social, conceptual and material tools that supported professional development. However, as Horn and Little (2010) argue, it is the content and the nature of the talk in the community of learners, whether it is superficial or in-depth, that fosters learning and knowledge creation.

As the analysis in the present study has largely built on teachers' talk and their exploratory work with shared objects, we let one of the teachers articulate the essence of the current study. Ragnhild (a science teacher) described it as follows: "There are some tools [referring to mediating concepts and artifacts], and we need to know how to use them (…) The most important part for me has been to learn how to practice writing in a new and expanding manner. Due to the participation in the writing team, I now practice in new ways."

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