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PORTFOLIOS AS BOUNDARY OBJECT: LEARNING AND CHANGE IN TEACHER EDUCATION

CECILIE FLO JAHREIE

InterMedia, University of Oslo, Norway
P.O. Box 1161, Blindern, N-0318 Oslo Norway
c.f.jahreie@intermedia.uio.no
http://www.intermedia.uio.no

STEN R. LUDVIGSEN

InterMedia, University of Oslo, Norway
P.O. Box 1161, Blindern, N-0318 Oslo Norway
sten.ludvigsen@intermedia.uio.no

Transformation in teacher education is seen as crucial for creating change within the educational system. In this article, we explore how members in a teacher education program interpret new ideas and tools such as portfolio assessment, case-based methods, and ICT. These ideas and tools are important conditions for the collective change of the institution, where portfolio assessment emerges as a new object between the subject-oriented communities. In activity theoretical terms, we suggest that learning is a matter of acting on and talking about the object within and between communities. These sideways movements lead to transformations on the object. This conception also gives us an alternative perspective on the classical theory/practice problem.

Keywords: Cultural-historical activity theory; teacher education; boundary zone; boundary-crossing place; boundary object; portfolio assessment.

1. Introduction

In discussions about teaching and learning in teacher education, the distinction between theory and practice often becomes the focus of attention. How one understands this distinction is closely related to how one understands learning and change. In the research literature, different conceptualizations of this problem can be identified, but they have in common that theory and practice are set up as different concerns (Smagorinsky, Cook, & Johnson, 2003). Theory is understood as the opposite of practice, something that can be put into practice (Kearsley, 1994–2001) or can have an effect on practice (Association for Computing and Machinery, 1997). Different suggestions to the problems are that these two realms may be *linked* (Grisham & Brink, 2000), *bridged* (Akmal & Miller, 2003) or *integrated* (Beyer, 1996; Korthagen, 2001). All of these postulations have in common a hierarchical conception of theory as more authoritative and practice as more protean and

pragmatic (Smagorinsky *et al.*, 2003). We argue that the dualism analytically is problematic in itself and propose a different approach in which theory and practice are conceptualized as different types of cultural practices. We study how learning and change were developed at the Department for Teacher Education and School Development at the University of Oslo. The reform effort is based on four pillars: ICT as social and technological infrastructure, case-based methods, portfolio assessment, and partnership schools. The focus for our empirical analysis is how portfolios, case-based methods, and ICT are objects for negotiation among the teachers. Within cultural-historical activity theory (CHAT), we argue that individual learning and collective learning stand in a dialectical relationship. Learning is a matter of acting on and talking about the object within and between communities. These actions entail ongoing transformation of the activity (Edwards & D'Arcy, 2004). CHAT is an expanding perspective within educational and psychological research, but has not been used extensively in research on teacher education (Roth, 2004).

After a brief discussion of CHAT, we will review how learning and change are conceptualized in different approaches in teacher education and how CHAT could be an important additional approach. In our empirical analysis, we raise two research questions: (1) How were the new artifacts introduced in the reform effort interpreted by the participants and which of the artifacts introduced have become the most significant ones? (2) How can the focus on interaction and negotiation between communities be a fruitful approach for understanding and explaining learning and change in teacher education?

Empirical analysis provides us with conceptual tools for understanding how theory and practice can be seen as different cultural practices.

2. Cultural-Historical Activity Theory (CHAT)

In the middle of the 1980s, a reaction against the dominating cognitive approach to teaching and learning developed in many research communities. This paradigm shift has to be understood as part of a general shift toward language and social practice in different social scientific communities (Bourdieu, 1977; Giddens, 1984; Habermas, 1984; Ludvigsen & Hoel, 2002; Pickering, 1992). The reaction toward the cognitive approach is based on a totally different ontological and epistemological understanding (Packer & Goicoechea, 2000). One of the approaches that are part of the shift toward practice is CHAT.

One important historical source can be identified in Hegel's work in his notion of activity. For Hegel, the self is constituted in the activity, in the social practice of labor. The subjective and the objective worlds are interdependent. One other line of thinking that is important is Marx's elaboration of Hegel's idea of activity. Marx stresses that activity and the mind are social as they contribute to our formation as human beings. Any activity has a specific historical function and is a representation of human actions (Wartofsky, 1979). Consequently, historicity has to be recognized as an essential part of a person's way of being. Leont'ev (1981) shows how individual

actions are part of a larger community and that activity as a concept is needed to understand the formation of collective aspects in our lives.

Engeström (1987) takes the ideas on activity one step further and creates a graphical representation and model of an activity system.[1] In this model, artifacts mediate the activity between the subject and the object. This means that the subjects, artifacts, and objects have to be part of the unit of analysis when we try to understand human learning. The activity system unveils how individual actions are part of the collective activities that are mediated by rules, the division of labor, and the community where the activities take place (Engeström, 1987). Rules could be understood as norms and values in the system, while the division of labor is concerned with how participants and activity systems divide work between them. The community is composed of all those individuals or groups that share the same object and that construct themselves as distinct from other communities.

An activity, such as learning, consists of several short-termed learning actions, i.e. writing an essay, going to classes, passing an exam. To understand the collective activity, it is important to analyze how the individuals use and produce artifacts. Every activity is object-oriented; it is shaped and directed by an object. Objects exist only by means of other objects. This means that they have two fundamentally different roles: as objects and as mediating artifacts or tools. The place and the meaning of the object are decided by the constellation of the activity (Engeström & Escalante, 1996). It is constructed in a dialogical process between the subject and his or her community. An individual's construction of an object is therefore both facilitated and constrained by historically accumulated constructions of the object (Foot, 2002). Since transformation of objects is a very important aspect and premise for change in CHAT, it provides an adequate framework for describing and understanding change in complex social systems.

As most institutions today consist of networks of activity systems where multiple activities seem to be a key issue, it is important to investigate the negotiations and contradictions not only within but also between interacting activity systems. In teacher education, the subject-oriented communities are historically directed toward different objects for their activities, e.g. understanding of assessment or use of ICT. This means that even if teachers from subject-oriented communities in a teacher education department are part of the same institution, they could be defined as members of different activity systems within this institution. It is necessary to examine what happens in the interaction between the different activity systems. To be able to do this, we need some conceptual tools to understand learning across and between boundaries. The area between the activity systems has no established

[1]By community of practice or activity system we do not refer to a specific organization. These concepts could be used to understand a single organization or subsystems in an organization, but as concepts they are not concerned with borders in the same way as in organizational theory (Scott, 1992). Communities of practice could be related, for example, to an academic community or a community of general practitioners in medicine. Organizational borders are thus no longer the most interesting feature of such communities.

practice but reflects the attitudes, norms, and roles of the present systems. The concept of a boundary zone is used to describe and explore the place where participants from different activities meet, interact, and form new meanings (Konkola, Lambert, Tuomi-Gröhn, & Ludvigsen, in press). This is considered a multivoiced place where it is possible to negotiate a shared understanding of the objects. In this way, the activity itself is reorganized, resulting in new opportunities for learning (Engeström, 2001).

3. Learning and Change in Teacher Education

Teacher education has been extensively researched from a variety of different approaches (Cochran-Smith & Fries, 2005; Coolahan, 2002; Houston, 1990; Sikula, Buttery, & Guyton, 1996). Cochran-Smith and Fries (2005) identify three shifts in how research on teacher education is conceptualized and studied as a training problem, learning problem, and policy problem. Since the mid-1990s, there has been an emphasis on policy with a cycle of critique and calls for reform in teacher education (Cochran-Smith & Fries, 2005; Edwards, Gilroy, & Hartley, 2002). Policy studies will not be the focus of our review. Instead, we will present two versions of the research on the training of teachers and teaching as a learning problem so that each enlightens different aspects of learning and change. We will argue that CHAT could be an additional approach with its focus on interaction within and between activity systems.

From the late 1950s to the early 1980s, teacher education was mainly seen as a training problem. The early versions of these studies typically looked at teacher behavior and pupils' learning as a one-to-one relationship. Identification and verification of instructional methods used in teacher-training programs are major topics in this approach (Cochran-Smith & Fries, 2005). A more contemporary version of teaching as a training problem builds on Schön's concept of reflective practitioner. The concept involves considering one's own experiences in applying knowledge to practice while being coached by professionals in the discipline (Schön, 1988). Schön's concept can be seen as a way of bridging the dichotomy between a positivist epistemology and an epistemology of a more subjective or tacit character (Edwards *et al.*, 2002).

Edwards *et al.* (2002) argue that Schön's work has been the prevailing orthodoxy in teacher education. The concept of reflection in teacher education is concerned with how educators make sense of the phenomena of experience and can be divided into three broad categories (Grimmett, 1988). The first category represents research that thinks educational theory can be applied to practice. The second category is training students as, e.g. good teachers. Contributions look at competing versions of teaching and examine their consequences for classroom practice (Korthagen, 2004). The third category draws, in many cases, on a constructivist approach and views reflection as the reorganization or reconstruction of experience that leads to new understandings of action situations or self-as-teacher (Grimmett,

1988). In understanding teaching as training, change is related to how individual behavior is understood as dispositions inside individuals (Bereiter, 1995, 1997). This approach is based on the idea that a teacher's knowledge can be transferred from one setting to another based on these dispositions. This approach must be connected to how knowledge is produced and rises out of activities. In this perspective, learning will evolve and change during the flow of activity.

Since the 1980s, there has been a change in teacher education research focusing more on teaching as a learning problem. The theoretical orientation within this approach varies, but most often, studies are positioned within a cognitive tradition focusing on how "knowledge is developed, used and organized by individuals" (Cochran-Smith & Fries, 2005). Learning to teach is mainly seen as a process of beginning teachers becoming acquainted with the best available knowledge about teaching. This universal body of knowledge is by many seen as the basis for reform in teacher education (Edwards *et al.*, 2002; Wideen, 1995). Within this approach, learning and change depend on whether the learner is able to use his or her mental model to recognize a new problem and identify the knowledge and skills necessary for a solution (Bassok & Holyoak, 1993; Reed, 1993).

At the end of the 1990s, a different epistemological and ontological assumption in cognitive science attempted to work out whether and how distributed cognition and situated cognition are viable concepts in research on education (Roth, 2001). Within this approach, it is argued that knowledge is developed and understood within specific contexts. In contrast to the individual assumptions in cognitive studies, learning entails transformation of the person and of the social world. Within teacher education, the notion of communities of practice (Lave & Wenger, 1991; Wenger, 1998) has inspired research on how student teachers participate in the community of practice of teachers and move from being peripheral to more legitimate participators (Ottesen, 2006; Sutherland, Scanlon, & Sperring, 2005).

Situated learning offers a promising perspective since the focus of learning is no longer inside the individual but on members participating in a community. This means that cultural practices cannot be seen as separate identities but as a dialectical relationship. However, there are some conceptual issues that are underdeveloped in the approach. There are different understandings of how homogeneous a community has to be to be seen as a community of practice (Handley, Sturdy, Finchman, & Clark, 2006). Wenger (1998) characterizes a community as a "shared repertoire" but acknowledges the possibility of tensions and conflicts within individuals and within a community of practice. However, how different practices interact is not well explained by the situated perspective. No concepts are offered to explain tensions within and between practices, and one is unable to grasp how different communities, or sub-communities in teacher education, have different orientations for their activities. These sub-communities are based on subject domains such as mathematics, natural sciences, language, etc. We argue that the site for learning and change is not just within a community of practice but between multiple communities. Learning in professional domains should involve more than just participation; learning has

to take into account how the participants cross boundaries and expand the object in question (Engeström, 2001, 2004). In CHAT, learning is conceptualized on the collective level, where the unit of analysis is interaction and negotiation within and between activity systems. This implies that learning is seen as a dialogical process that creates new knowledge and new practices within and between activity systems. Learning is, in other words, embedded in and constitutive of the qualitative transformation of the activity systems, which is also called expansive learning (Engeström, 1987, 2004).

In the empirical analysis, we explore how teachers from different subject domains create a new structure for the teacher education program. The focus is on the learning activities that take place between these activity systems. This gives us some conceptual tools to explain the interaction between different cultural practices. The analytic concepts central to explaining our understanding of the theory/practice problem will develop from our empirical analysis presented in the next part of the article.

4. The Study

Engeström and Middleton (1996) argue that to understand learning and change we need to understand the complexity between social structures and participants' actions and activities. In our study, the central question is how the reform in teacher education is constituted and constructed. In activity systems, there are potential tensions, breakdowns, and contradictions between all components of the system, which is the key source for change. Empirical analysis based on CHAT involves investigating these tensions and contradictions. This can give us insights to differentiate how we can understand change when new divisions of labor and new artifacts, such as portfolio assessment and learning management system (LMS), are used in teacher education.

Our empirical point of departure is a reform effort at the Department for Teacher Education and School Development at the University of Oslo. The students have either a bachelor's or master's degree, in specific subject domains, before they start this nine-month intensive program. During these two semesters, they study pedagogy and two subject matters, such as social science and history or physics and biology, and are educated to work in either secondary or upper secondary school. The reform phase started as a pilot project with some of the subject communities involved in the fall of 2000. Beginning in 2003, the innovation was expanded to include all the communities. The sociocultural perspective used as an inspiration for the design principle in which they combine a problem-oriented, or case-based, method, portfolio as a new form of assessment[2] and interdisciplinary teams

[2]The portfolio consists of a selection the student's cases in the different subjects. The portfolio can be either paper-based, net-based or on a CD. The students have an interdisciplinary oral exam at the end of the year based on their portfolio.

of teachers. LMS was used to create an infrastructure for coordinating, planning, and structuring learning resources and as a communication platform for interaction among the students, teachers, and partnership schools. The students were also expected to use ICT in their learning activities on campus and to practice teaching with ICT during their internships.

This study is based on observations and interviews from the first year of the reform. Our focus is on the project group's conception of the reform effort. To understand learning and change as a collective activity, we have to analyze how the participants take part in different activities and activity systems over a period of time (Miettinen, 2002). We followed all the meetings in the project group in the fall of 2000 and spring of 2001, approximately seventy-five hours of observations. The second author, who was an external member of the project group, conducted these observations. We had access to all the reports from the meetings. The first author conducted observations from the first semester of different classroom activities in pedagogy, the natural sciences (biology and physics), English, and German. The duration of these observations was twenty-four hours. Within these corpora of data, nine hours were videotaped, and there are thirty-six pages of field notes.

These ethnographic observations and the reports from the project group provide an opening to a description of the empirical context and created the background and the focus for developing an interview scheme. The first author interviewed the academic members of the project group, four teachers, the project leader, and the elected leader for the institute. The interviews lasted ninety minutes and were transcribed by a graduate student. The analysis of the interviews was presented to the informants. The observations and the interviews were analyzed together, but we prefer to present the interviews since they give voice to the participants.

In the analysis, the scientific software HyperResearch was used as a workbench to transcribe the audiotapes and code the raw data according to topics. The analytic work was performed in several steps (Kvale, 1996) as a collaboration between the authors. We analyzed the whole corpus of data to get a substantial understanding of the significant changes in the reform. Then the interviews were systematized according to the themes that were the most frequent and significant among the participants. Relevant themes were, for instance, integration of subject domains, division of labor, ICT, problem-based learning, curriculum, and assessment. These themes were then systematized to illustrate change processes in an institution as part of the formation of new artifacts (division of labor, portfolio assessment, case-based methods, and ICT). Finally, we linked the themes to our theoretical framework. This could be described firstly as an inductive approach in which the empirical data are systematized and analyzed. These analyses were then connected to the overall theoretical framework and review, which could be described as the deductive part. The analysis was presented and discussed in internal research meetings and international conferences.

With ethnographic observations, we can capture how concepts, procedures, and tools are employed and accumulated in the teacher education program (Engeström, 2001). The heterogeneity and the diversity of orientations in the activity system(s) are manifested in the participants' talk, thoughts, and action. Based on the participants' talk and observations, these multiple perspectives are revealed. This analytic approach gives variation and depth to our material. Based on the ethnographic data, thematic interviews, and our theoretical framework, we will argue that we achieved a substantial understanding of the processes of change that actually took place.

5. Empirical Analysis

We will describe and analyze the change processes that were created with emphasis on the following themes: change in the teachers' division of labor, portfolio as an emerging object for change, and ICT as an infrastructure for change.

5.1. *Change in the teachers' division of labor*

The teachers responsible for the teacher education program can be described as members of subject-oriented communities with a high degree of division of labor, and also a high degree of autonomy in their work. The relationships between these subject-oriented communities can be characterized as loosely connected. These communities have boundaries established by the organization and, equally important, by communities of subject specialists in other organizations. This means that their communities do not conform to the order of the organization. The different subject domains usually have tensions and contradictions built into them in relation to coordination and collaboration internally, and in their external relations and networks (Engeström, 2001; Jahreie & Ludvigsen, 2003). As a strategic intervention, the participants responsible for the reform organized an interdisciplinary project group in which the participants had to collaborate more across the boundaries of the different subject domains. As the project leader notes, *"We bring together different groups who are used to working separately. And then you are a bit skeptical of the others. In my experience we have been skeptical, but I think that we finally are getting closer to something we can work together on."* The project leader emphasizes how the different communities are challenged by the project's interdisciplinary approach. He also emphasizes that all the members of the project group are working for an institutional change:

> We have institutionalized the project. It is not just something in a corner. It is a project with importance, and it has been a central part of the progress of the institution. If the project had not been deeply ingrained in the institution from the beginning, I am afraid it would have been an unimportant project with just a few enthusiastic people (Interview, project leader).

This reform project is not led by a few enthusiasts, but by many of the significant members of the organization who want some kind of innovation. Several of the important agents of change in the institution are involved. Even though the members share the idea of change, communication and interdisciplinary work are challenges for implementation.

> We struggle to find the integration between pedagogy and the other subject domains. We started with a desire to find some common elements, but we found out that we were not able to do so because we have a different understanding of the concrete content regarding, for example, case-based methods and the tasks the students are supposed to do (Interview, project leader).

The project leader notes that there are tensions between the different communities regarding interpretation of the different activities. They have to negotiate to find new ways to integrate the relationship between theoretical ideas and practice. This applies equally to finding new classification standards for practical problems, as much as focusing on a mutual understanding of the categories that are chosen. Meetings in the project group, meetings in smaller working units, and informal conversations seem to provide important connections between the subject communities, which give opportunities to reconstruct knowledge and skills. In these activities, the members negotiate how the historically new infrastructure is to be designed. These meetings can be described as a boundary-crossing place where they discuss and expand objects strategic for the change (Lambert, 2003a, 2003b). In the teachers' experience the status of their respective subjects become an object of negotiation (Kerosuo, 2001). The boundaries between the subjects have, of course, been discussed before, but this time the discussion lead to new relationships and implications for practice (see the next section for explanation). Most members in the project group want to negotiate the artifacts that are required to meet the goals for the project (i.e. portfolio assessment, case-based method, and ICT). In this process, they have to find ways to talk together to reach a reasonable level of shared understanding. In this process of negotiation, one learns how to use and talk about the new artifacts (Mercer, 2000).

In the following section, we will show how new understandings of assessment structure, case-based method, and use of ICT is negotiated. The evolution of the objects shapes the activity; structures, attitudes, beliefs, norms, and roles are put under pressure at the collective level and thereby create conditions for change (Konkola *et al.*, in press). These processes demonstrate how the teachers, by means of their work, participates in a transformation of the object through acting on it and seeing it differently (Edwards & D'Arcy, 2004). One important result has been a higher degree of collective effort, which also implies a lower degree of autonomy. These collective efforts in the project group create opportunities for portfolio assessment to emerge as an object between the different communities.

5.2. *Portfolio as an emerging object for change*

The members of the project group agree on case-based methods, portfolio assessment, and use of ICT as the most important aspects in the new structure for the program. Each of these methods have been used elsewhere, but few have integrated these methods into one educational program. A member of the project group says that they now have the opportunity to make teaching more interesting, *"This project has been the tool for changing teacher education, and it's now more interesting for both the students and the teachers. Teaching has been more interesting because we use new technology and new pedagogical methods, especially assessment strategies"* (Interview, member of the project group).

These opportunities create a high degree of motivation for change. A project group member emphasizes assessment strategies in particular as the most important aspect of the new educational practice. One of the other members thinks the use of portfolio assessment initiates a joint exploitation of other tasks as well:

> We are going to keep the characteristics of the traditional curriculum subjects, but at the same time there are topic areas that have to be more integrated. We are getting there with the assessment strategies; the portfolio is used both in pedagogy and the curriculum subjects. With this assessment strategy we will have to collaborate to a higher extent. We have to be willing to do that (Interview, member of the project group).

The teacher stresses that the project's innovation is a new organizational structure in which one maintains the characteristics of pedagogy and the subject domains, but simultaneously finds a way to integrate the domains of knowledge involved. He emphasizes that it has to be a collective effort between the communities. In this process, the teachers' different points of view intersect, and the different voices create new conditions on how the teachers perceive each other and how they can work together (Gutiérrez, Rymes, & Larson, 1995). The head of the department points out in the interview that they have achieved a new and higher degree of coherence in the study because of the new assessment strategies. The discussions of how to design the portfolio system are tense, especially when the overall structure for the system is developed. The tensions are related to how the students should present their work, what kind of cases and tasks, and how much content from the different subjects should be part of the students' portfolios. In addition to these aspects, the members are concerned with the need for students to update their work and how to select students' work for the integrated oral exam, which is based on the portfolio. After several breakdowns, the project group is able to agree on some common elements concerning the structure. The students deliver their portfolio at the end of the year, which form the basis for the assessment. The portfolio consists of works from pedagogy and one of the two subject matters. Two of the works are interdisciplinary: a case based on their own teaching from their

internships and a document in which they reflect on their own learning trajectory. These works form the basis for an interdisciplinary oral exam with an examiner from each of the subjects.

This agreement creates conditions for more detailed work with the portfolio system. Teachers in the different subject matters cannot make decisions alone because the end product should be a representation of work from the different subject matters, as well as interdisciplinary cases. The project meeting creates opportunities for sharing ideas and thoughts about teaching practices, as well as for discussing how they can relate the subjects to each other in the portfolio. A member of the project group says:

> In this project, we have worked through some fundamental pedagogical ideas which we have agreed upon. That is problem-based learning; it is to make situations related to practical experiences with the use of cases. (. . .). We have agreed that the portfolios are an assessment strategy, but we are not done with the discussions concerning what it is supposed to be, the concrete content of the portfolios (Interview, member of the project group).

The member of the project group says that they have been developing some pedagogical ideas central to teacher education. They all agree on portfolio assessment, but they have not come to an agreement on the content of the portfolios. They agree that a case-based method is the right direction to go, but how the method is understood and worked varies. In some communities, small theoretical tasks (such as commenting on another student's 'lab' work) are seen as cases. In pedagogy, they work systematically with cases as a method for creating a better relationship between abstract concepts and practical action and for improving the continuity of the student's learning trajectory. The students write a case study about a specific classroom, pupil, etc. The task presupposes that the students find relevant theory and use the theory to expand their view (Jahreie & Ludvigsen, 2003). Even though the different communities do not agree on the concrete content of the portfolio, all the members in the project group agree at a more general level that they want to try out new forms of assessment, and that portfolios represent the right direction to proceed.

From the teachers' perspective the portfolio system can be interpreted as a boundary object[3] in which the activity systems collaboratively construct a new understanding of the portfolio system. With the notion of boundary object (Star & Griesemer, 1989), the negotiations of new ways for collaborating become more

[3]The notion of boundary object is understood both as a historical-empirical construction, which is the original understanding from Star and Griesemer (Star & Griesemer, 1989), and as an artifact that can be designed as a boundary object, like Wenger's understanding (1998). We argue that it is not possible to design a boundary object; rather we have to observe how it unfolds in a concrete activity.

transparent. Boundary objects are objects that serve to coordinate different perspectives, but do not necessarily create a bridge between divergent viewpoints. When a boundary object serves multiple communities, each has only partial control over the interpretation of the object. The content that the different subject communities in the teacher education program will have as their part of the portfolio is not clear, but they agree on some common elements, enough to work together toward a new joint object. The portfolios become an object to which they orient their actions and activities.

For the change effort to be a collective activity in the institution, individuals who can act as brokers between the different activity systems are needed. Brokers are able to make new connections across the activity systems, and therefore enable negotiations of meaning (Wenger, 1998). For Wenger, the broker is not accepted as a full member of the community or rejected as an intruder. According to our understanding, one must have the legitimacy to question the existing practices of the system to be able to act as a broker (Konkola *et al.*, in press). As a consequence, the broker is interested in the whole activity system and its change, and is therefore a bona fide member of the community. In this view, the members in the project group all have roles as brokers. Both in the project group as such, and in relation to their subject-based community, they have the legitimacy to negotiate the meaning of the portfolio. In the project meetings, they all have to argue for and negotiate how their subject should be represented in the student portfolio. In addition, in their own community, they have to defend the results of the negotiations within the project group. Even if there are existing rules for how each subject should be represented in the portfolio system, the status of subjects, the traditions in the institution, and the teachers' goals and strengths influence the results of the negotiations. Changing the relative balance among the different subject matters creates strong tensions among the teachers.

In the project group's negotiations of the portfolio assessment, we have shown how they manage to develop a joint construction of the tool. The portfolio emerges as an object at the boundary zones between the activity systems where the participants meet and develop new understandings. However, how the concrete content should be understood is still under negotiation.

5.3. *ICT as an infrastructure and new tool in the reform*

All members of the project group have used ICT before the reform was initiated. In pedagogy, they used a groupware system to structure parts of the program and for teacher-student interaction. In natural science and language subjects, they used the web for handing out information and learning resources. They also had some experience with web-based, teacher-learner interaction. With the reform, the project group agreed to implement a learning management system (LMS). They found a solution that was supposed to support a minimum of standardization for dissemination of information and learning resources, for communication, and for the design

of their web pages, but there is no general agreement on how to use the system. One of the members in the project group describes what the disagreement is about:

> In a way we have kept the old organizational structure and added something new. And that is very demanding. The relationship to the students also becomes very demanding if we don't use the virtual room to a greater extent than we have done until now. I am willing to have a discussion about that. I think we will have to. But we disagree on this. Some think they have the answer; I don't think we have, and I actually think there is disagreement (Interview, member of the project group).

As the member points out, the use of LMS is only an add-on in the activity system, and they have not negotiated a common understanding of the role and use of the system. Because of this, he does not think they have reached any of their goals. The tension is first and foremost related to where different activities are to be performed, in a distributed or co-located learning environment. This is discussed in a natural science class with three of the teachers present, whereby one is a member of the project group. Here we draw directly on the observational data. In this discussion, it is easy to see the disagreement:

> Member of the project group: I think we have to ask when it is appropriate to use ICT and when it is not. It is absolutely clear that we can use the opportunities ICT gives to a greater extent than we do. Sometimes physical meetings are necessary, but we can, and we have to, make the most of the C in ICT. The C, the communication between the students, has to be present. Now we use ICT for information, and we lose the C.
>
> Teacher: We disagree on this point. I think that physical meetings are necessary in much of what we do in biology. How are we supposed to complete the curriculum if we cut more classes? We have too few as it is. And laboratory experiments cannot be done on the web! It is better to use ICT in the arena around us, but we cannot cut classes.
>
> Member of the project group: It has always been a fact that that we do not have time to complete the curriculum in classes. But I want to create good net-meetings for what we are not able to complete. That has to be better than saying to the students that they have to read all by themselves?

In these segments, two interrelated themes were discussed: which and what kind of activities should take place within different settings and how the concept of curriculum can be understood. Let us first focus on the function of ICT.

We think that this segment of a discussion shows that how ICT is to be included in the students' learning progress is not a straightforward issue, and it will therefore

constitute a set of tensions between the participants in the activity systems. The ideas that are reflected upon are about what type of knowledge can be obtained in physical meetings and what kind of knowledge can be obtained in virtual meetings. Furthermore, it is stressed that some types of knowledge, such as science experiments, have to be accomplished in physical meetings, and the time they have for lecturing is already at a minimum. As the segment shows, the participants have different opinions about how the LMS should shape the different learning contexts. The discussion relates to how they understand and talk about aspects of ICT and learning, how they should understand specific knowledge domains, and how they should teach in specific domains.

The second theme in this segment is concerned with assumptions related to coverage of curriculum. One of the teachers argues "how are we supposed to complete the curriculum in classes when we already have so few physical meetings." The member of the project group argue that the number of meetings is not the important issue, but how the participants view their field of knowledge and how they think the teaching should be structured. The fact that the curriculum is partly taken for granted by one of the teachers could be regarded as part of the problem. Curriculum is a social and cultural construct, which carries forms of knowledge, assumptions, values, and attitudes. The discussion is related to ideas that are based upon traditions, experiences, and normative assumptions. Without actually testing new teaching methods, the teachers will be caught in dogmatic positions. In a discussion of the differences between physical and virtual meetings, one loses, from an analytical point of view, the possibility of testing how different tools can complement one another. The disagreement about the use of distributed and co-located learning environments shows that the participants have to explore and form new meanings of the object.

ICT can be understood as a set of artifacts and has to be seen as an interrelated part of the activity system. Changes in one part of the system, such as the implementation of an LMS, have effects on the other aspects as well. The implication of this is that ICT is an integrated part of how the teacher education program could be structured and an integrated part of the content in the concrete activities. The idea of how LMS is used in specific activities creates tensions on different levels, such as the relation between co-located and distributed settings, between what types of knowledge could be taught and learned in such settings, and how the curriculum could be interpreted. In the tensions presented in the segment above, the use of the artifacts was connected on how to teach within a specific domain. The interdependency between the different aspects is what needs to be negotiated.

6. Discussion and Conclusion

In the introduction, we raised two questions related to theoretical and empirical issues. We will first offer some conclusions for the empirical question. It is in the relation to practical solutions that we can best identify sets of tensions in and

between activity systems. These tensions become visible in the reform effort analyzed in this article, when the artifacts were introduced, picked up, and interpreted by the participants. Both the historical experiences, which the participants are part of, and the actual implementation of artifacts, create the sources for the tensions described. It was not clear to the participants which aspect of the reform would meet with the strongest approval. Case-based methods, portfolio assessment, and parts of the curriculum had to be negotiated.

The learning challenge in this reform was to acquire a new way of working in which teachers from different subject domains have to collaboratively plan the assessment system and the construction of the curriculum. The tensions and contradictions have created efforts to restructure the division of labor toward a more interdisciplinary way of organizing the community of teachers involved. The teachers had to negotiate and create a new form of social order between the different subject-oriented communities. The consequences of the reform effort are steps toward a new activity system that is built on a higher degree of shared knowledge about each other's practice, and which implies more collective work and a lesser degree of autonomy. The individuals have to be concrete in their collective efforts and accept their colleagues' criticisms of their teaching practice. The fact that the participants in teacher education emphasize different aspects in the change process has to be understood based not only on their history in the institution but also from their position in their disciplinary communities.

We argue that the problem is not resistance to change, which usually is seen as the main problem when trying to create educational reforms, but the direction and the depths of the actual change. All the members of the project group can be seen as brokers in that they all want an institutional change and have the position to question the existing practices of the system (Konkola *et al.*, in press). The participants negotiate how the historically new infrastructure among them is to be designed and the boundaries in the subject themselves become objects of negotiation. The project group creates a boundary-crossing place between the different activity systems where they co-construct their activities (Engeström, 2001; Lambert, 2003a, 2003b). This collective engagement was vitally important for the institutional development.

At the boundary-crossing place, the portfolio assessment becomes a boundary object (Lambert, 2003a, 2003b; Star & Griesemer, 1989). The portfolio is part of a collective effort that bridges the disciplinary communities. The assessment system is an institutional responsibility, and changes in this system have to cut across institutionalized boundaries. In this way, the portfolio assessment system becomes the most powerful object in the reform effort. The group members had to talk and discuss within and between the communities, and the different subject-oriented communities had to configure themselves in relation to each other and to the students. There were different orientations within the project group in how to understand and organize the concrete content of the portfolios, but they agreed on the general structure, enough to work together toward a new joint object.

From a descriptive point of view, ICT has created a new infrastructure. The participants can agree on the importance of ICT in the process of change, but at the visionary level and related to abstract goals. They are not able to develop a shared understanding of how to integrate ICT in teaching and learning. This contradiction points to a basic structural problem, that is, where different activities are to be performed. Whether ICT makes an impact or not is not related to ICT itself, but how it is assimilated as an integrated aspect of the activity system. We argue that the ideas and practices between teaching and learning in co-located and distributed settings have to be put under pressure and reorganized.

When the artifacts were collectively constructed and interpreted, a set of structural tensions within and between the activity systems accumulated. The objects were re-conceptualized and embraced wider possibilities than in the previous mode of the activity. The relevant elements for this conclusion are the change in division of labor, the new meaning attributed to the portfolio as a boundary object, and how the use of ICT creates a set of tensions concerning how to teach and organize the knowledge in the specific subject domains. These contradictions are central sources for learning and change in the entire activity system and produce new cultural patterns of activity. In activity theoretical terms, the reform effort could therefore be described as expansive learning (Engeström, 1987).

The theoretical problem raised in the introduction is related to how we understand theory and practice. The overall argument in this article involves a view of learning and change that goes beyond the leading approaches in teacher education. In the different positions of teacher education we have reviewed in this article, learning and change are understood as reasoning based on dispositions, mental models, and participation. From our point of view, the basic problem with the study of reflective practice in teacher education is that change is understood and explained with new experiences within each individual. The community the learner is a part of and the dynamic development of the environmental structures are not taken into account. Within the situated perspective, change is seen as participation in communities. To understand the hybrid character of teacher education, taking part in several distinct practices, it is not enough to study the individuals' participation within a community. We need to explore and grasp how they participate in their own community as well as across boundaries. New objects could emerge as part of the negotiation in the boundary zones between the activity systems. We will argue that CHAT is an appropriate approach for understanding learning and change in teacher education because CHAT creates sensitivity to the structural features of the activity systems and how they are interconnected at the meaning-making level (Ludvigsen & Rasmussen, 2006).

In this view, theory and practice are understood as different types of cultural practices. Theory is a type of knowledge, which is talked about in specific ways in an activity in institutional settings. We argue that with CHAT we are able to understand how individuals construct new knowledge and new patterns of collective activity. The empirical analysis shows how central concepts from CHAT help to

explain how new forms of practices are created and how organizations are changing. The concepts explored in this article, i.e. boundary zone, boundary-crossing place, and boundary objects, provide us with some conceptual tools for understanding how a basic theoretical problem such as the dualism between theory and practice can be seen as different cultural practices. The perspective and the concepts that CHAT provides us offer possibilities for understanding how learning and change occur in an activity system and at the boundaries between activity systems. Theoretical knowledge is not a given authoritative status, but needs to be understood as embedded in the activities that form the social practice the teachers and the students are part of, whether the activities take place on campus where the intention is learning theory or in schools where the purpose of the activity is teaching students in a specific knowledge domain.

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