Introduction
The purpose of this chapter is to examine an elementary-school teacher’s practices of supporting collaborative inquiry. In many present-day classrooms teachers are trying to create collaborative student-centred learning culture with students who are used to follow teacher-centred schooling activities. Therefore, instead of portraying the classroom teacher either as a transmitter of knowledge or a facilitator of learning, it is essential to understand in detail the diversity of roles that a teacher may enact and consider appropriate within the diversity of day-to-day classroom-based activities. We argue that whilst the teacher has a crucial role to play in inducting students into collaborative inquiry learning practices; the significance of teacher guidance has often remained unexplained (Hakkarainen, 2009). Even when the pedagogical setting is organized towards collaboration and student-driven inquiry, it does not mean that students will, as a matter of course, collaborate and take collective responsibility for their own learning. Deliberate guiding efforts, on the part of the teacher, oriented toward establishing, cultivating, and sustaining corresponding classroom practices, are needed. Thus, getting teachers more effectively involved in designing their own inquiry-oriented curriculum would better capitalize on their creative potential as well as facilitate deeper engagement in developing their own teaching and pedagogy (Sawyer, 2004).

In this chapter, we will examine how classroom teacher organized and promoted the computer-supported collaborative inquiry in her classroom. We will, firstly, describe the salient pedagogical infrastructure framework (Lakkala et al., 2008) and the pedagogical model of progressive inquiry that informed her work. We continue by addressing the role of teacher guidance in collaborative inquiry project. By using the teacher’s reflective project diaries we will describe how she organized and supported the collective work by aligning community effort and collaborative tools in the pursuit of shared objects of inquiry. We will also describe how the teacher in her diaries first considered and reflected on what was going on in the classroom and then used these reflections to re-design and re-organize the subsequent activities. Productive pursuit of collective inquiry requires orchestration of technology-mediated learning environments, enacted classroom practices support, with the participating students’ characteristics and dispositions emerged through earlier inquiry-learning efforts. Simultaneously, creative pursuit of a collaborative inquiry project requires real-time orchestration of present activities that allow capitalizing on earlier built knowledge and lessons learned for finding possibilities for meeting higher-level inquiry objectives. The teacher’s efforts of orchestrating the subsequent inquiry process will be illustrated by presenting excerpts of a videotaped “heated moment” and associated teacher-students interaction regarding one particular collective classroom situation. Finally, implications for teacher guidance and cultivation of inquiry practices will be discussed.
Towards Collaborative Inquiry Learning

Studies of successful knowledge building classrooms have been reporting promising results regarding engaging students in collaborative inquiry learning (Hmelo-Silver, Duncan, & Chinn, 2007; Hakkarainen, 2004; Scardamalia & Bereiter, 2006). Such classrooms are oriented toward putting the students’ own questions and ideas at the heart of their working practices, treating ideas and knowledge generated as continually improvable objects of collaborative inquiry efforts (Scardamalia, 2002; Zhang, & al. 2009). The aim is that students would set their own learning goals and assume collective cognitive responsibility for the advancement of collective inquiry under teacher guidance. A teacher is a part of inquiry community learning and building knowledge together with students; simultaneously, he or she has a crucial strategic guiding role without which students’ inquiry would not be successful (Hakkarainen, 2009).

In the settings where the process and the object of inquiry are designed in collaboration with students, the outcomes of the inquiry cannot be fully known in advance – neither the phases of the process nor the content to be studied. In order to prevent novice performers’ frustration, the students should be provided with sufficient support (Hmelo-Silver et al., 2007). That said, there are also serious concerns that too rigid a structure undermines higher-level inquiry learning objectives, because it makes peripheral the pursuit of advancing students’ own ideas (Scardamalia & Bereiter, 2006; Lakkala et al., 2008). However, many knowledge-building studies have focused particularly students’ accomplishments and left aside teacher’s guiding role or the value of particular classroom practices (Hakkarainen, 2009). When novice teachers try to implement knowledge-building culture in their classrooms, they may become discouraged when students initially fail to pose meaningful questions, generate relevant intuitive theories, or engage in productive discourse interaction. The advancement of knowledge-building communities can be attributed to the ways the teachers iteratively develop methods of socializing students to the evolving inquiry culture (Hakkarainen, 2004; 2009). In order to expand and scale up advanced inquiry practices, the teacher’s invisible work in guiding classroom practices has to be rendered visible and analyzed in detail. Consequently, there are clear needs for research focusing on productive pedagogical practices in collaborative inquiry settings.

Supporting technology-enhanced collaborative progressive inquiry

When directing the classroom practices towards knowledge-creation processes, the educators in the field need to consider what kind of practical elements it might contain and how to support them. The CSCL setting has been approached with the notion of pedagogical infrastructure (Lakkala et al., 2008), i.e., a descriptive characterization of social practices. Lakkala and her colleagues (2008) proposed that the fostering of technology-enhanced collaborative learning should rely on deliberately designed technical, social, epistemic, and cognitive support structures. Successful implementation of CSCL appears to require the building of an appropriate social infrastructure around the technical one (Bielaczyc, 2006). Educators need to provide purposeful technological learning tools for supporting inquiry, embedding these as instruments through which to develop shared practices (technological infrastructure). Technical arrangements include both the affordances of the tools that promote inquiry activity, and the arrangements for providing students with access to and guidance for using the technology. The social arrangements should entice the participants to collaborate and create the common ground (social infrastructure). Productive collaboration may require, for example, explicit rules, agreements, and organisational structures (Lakkala & al., 2008). In the spirit of knowledge building (Bereiter, 2002), educators also need to encourage learners to treat the knowledge as something that can be shared and jointly
developed (*epistemological infrastructure*). In addition, educators should facilitate the participants’ understanding and reflection on practices and processes so that they are able to organize their own inquiry process (*cognitive infrastructure*). Students’ self-regulative competencies and meta-skills for planning, monitoring, and reflecting on their work should be supported; this could take place through providing concrete conceptual tools, such as guidelines, models, or templates. The aim of the pedagogical infrastructure framework is to highlight, for educators, the fundamental factors that need to be designed and taken care of, although the perspectives may overlap in providing the same affordances.

Hakkarainen and colleagues have developed a pedagogical model of progressive-inquiry learning (called the ‘Progressive Inquiry’ model as detailed in, Hakkarainen, 2004 and inspired by Scardamalia and Bereiter’s (2006) knowledge-building framework). The progressive inquiry model is a tool that assists teachers in engaging their students in expert-like creative knowledge practices (see Figure 1).

**Figure 1. Progressive-inquiry model**

The idea is that the teachers should guide students to assume responsibility for all aspects of inquiry, such as goal-setting, questioning, explaining, and evaluating and crucially, they must guide students’ process of inquiry through their own example. The model consists of several elements of the inquiry that constitute essential aspects of a cyclic process of solving problems and advancing local, collective knowledge. *Shared expertise* means that the participants of knowledge-creating inquiry are not isolated individuals but a classroom community that pursues joint investigation by sharing all elements of a progressive inquiry. The starting point for the process of inquiry is the creating of a context for the project; engaging participants in pursuing a challenging project that supports the development of their understanding of complex real-world problems and deep principles of knowledge. The
participants are guided to *set up their own research problems and questions* oriented toward explaining the objects being investigated. The *construction of working theories* guides the participants to stretch their knowledge and understanding for creating shared epistemic artefacts for supporting subsequent inquiry efforts. By *critically evaluating* their advancement, individuals, teams, and the whole inquiry community are able to focus their subsequent inquiry efforts in promising directions. The question-driven process of inquiry provides heuristic guidance in the *search for new information* for directions and sources not determined by the teachers or initially anticipated by the participants. The process of inquiry starts with initially very general, unspecified and “fuzzy” questions and tentative working theories; advancement of inquiry entails that the participants focus on improving their ideas by *generating more specific questions* and searching for new information for directing further investigations (Hakkarainen & Sintonen, 2002).

The desired classroom culture that sustains collaborative learning practices would not appear without the intensive practical work of the teacher or whole learning community (Hakkarainen, 2009; Roth, 1998). The teacher’s active role is highlighted in the ways in which she or he facilitates and guides the students’ activities of questioning, explaining, and giving feedback to each other. In an inquiry classroom with two or three dozen students and a single teacher, the teachers have to base their guidance, not only on what any individual or team requires at the moment, but also what they believe the advancement of collective inquiry project and attaining its higher-level objectives require to be successful (Puntambekar & Kolodner, 2005; Mercer & Littleton, 2007). Hence, orchestration of serious technology-mediated inquiry learning is not only focused on real-time improvisational efforts of supporting productive participation in discourse interaction (important as such) but sustained and long-standing efforts stretched across many sessions for creating conditions for advancement of the inquiry (guiding participants to documenting advancement of inquiry, organizing and structuring evolving epistemic resources, and planning and envisioning further pursuit of inquiry). Such expanded approach on orchestration creates opportunities for collaboration and sustain progressive discourse focused on attaining the higher-level objectives.

Sawyer (2004) emphasized that classroom collaboration requires the teacher to manage the participatory aspects of social interaction – for example, turn taking, the timing and sequencing of turns, participant roles and relationships, and rights to speak. The teacher should observe, reflect, and comment on students’ reciprocal inter-linkages as well as their relations to the materials and objects of inquiry. The most effective classroom interaction balances structure with flexibility and improvisation. Sawyer (2004) particularly emphasizes the value of ‘improvisational’ teaching, where learning is shared social activity, where all participants are participating and managing collective process, not only the teacher. In this kind of instruction, the teacher tries to give students freedom to construct their own knowledge, while providing the elements of structure that effectively scaffold the co-constructive process. Improvisation can work only, if all participants have internalized many joint conventions and appropriated shared practices.

**Context for Collaborative Learning Settings**

In the section that follows, the role of teacher guidance in orchestrating inquiry learning will be examined by presenting a case study of our own. “The Artefact Project: Past, Present and Future” was designed together with the class teacher and took place in her classroom in Laajasalo Elementary School, Helsinki, Finland (see Seitamaa-Hakkarainen, Viilo, &
Hakkarainen, 2010 for detailed descriptions of the project). The Artefact project started with 32 participating ten to eleven years old elementary students at the beginning of their second term of fourth grade and continued across 13 months until the end of their fifth grade. The technical infrastructure of the projects was provided by Knowledge Forum (KF, Scardamalia & Bereiter, 2006) that allows visual organization in terms of creating interlinked series of views (background pictures with interlinked computer notes). The project was based on the following commitments: 1) intensive collaboration between the teacher and researchers; 2) integrating many school subjects for solving real-world problems; 3) engaging in extended technology-mediated inquiry across a long period of time; 4) breaking the boundaries of traditional schoolwork by engaging a professional designer to support students’ inquiry that involved designing artefacts.

Figure 2. Phases of the Artefact Project

The aim of the Artefact project was to support students understanding of the diversity and development of artefacts in their cultural context. In the first phase - The Past - the actual historical investigation of artefacts and their functionalities were carried out. Each student team chose the history of on one type of handheld artefact, i.e., ball, clock, jewellery, lamp, lock & key, money, and spoon, for investigation; the students’ ideas drove the historical investigation. In the second phase of the Artefact Project – The Present – the students investigated physical phenomena of artefacts, such as movement of a ball, functioning of a lamp, light, and characteristic of metals. They were guided to ask questions and carry out their own scientific experiments as well as those based on pre-given science tool kits. The third phase of the project – The Future – took ten weeks. Under leadership of a professional designer and teacher, the participants designed a lamp and future artefacts in teams.
In total, the Artefact project took 139 lessons (each lesson takes 45 minutes) over three terms. The teams were main actors in about half of the overall project time. About half of the time, the participants worked with KF (Seitamaa-Hakkarainen et. al. 2010). In the first phase of the project, the students worked in the heterogeneous “home teams” (about 4 students per group consisting of boys and girls, as well as less and more advanced students), which investigated the chosen artefacts and produced knowledge to their own team-based views in KF (i.e., views created and organized by each team). During the second phase of the project, all students worked with topics shared by the whole classroom and created collective KF views (i.e., views shared by the whole classroom). In the last phase, the students returned to their original home teams (formed in the beginning of the project) and the whole class community worked in the collective views. In the last phase, notes were mainly written in teams rather than individually; i.e., all team members participated in creating the content of their note. The classroom activities were organized during the project so that there were a) joint classroom sessions, b) team-based KF activities, c) conducting of experiments, and d) participation in excursions (e.g., museum visits). The joint session took place in front of a shared screen (video projector showing KF views or notes); sometimes these were a short meeting assisting in organizing activities whereas other occasions involved extensive knowledge-building discussions.

Our research relies on extensive ethnographic data collected during the longitudinal study project. During the process, the teacher wrote weekly in a reflective, project diary. The template of the diary guided the teacher to reflect on the issues that she considered important at the moment of writing: 1) how were practices organized; 2) what themes and contents were addressed and how was the inquiry developing; 3) how did the community function; and 4) what was the role of technology supporting the process. The teacher filled one project diary template several times during the weeks that involved participation in shared project activities. This method of repeatedly collecting teachers’ contextual reflections regarding the inquiry corresponds to the method of event sampling (Bolger, Davis, & Rafaeli, 2003). The diaries were analyzed with qualitative content analysis using Atlas.Ti software (Viilo, Seitamaa-Hakkarainen & Hakkarainen, 2011). The video recordings captured the overall classroom setting and activities. The aim was to ensure that the teacher’s role in the process was included. The diary-based method provided us an access to the teacher’s orchestration in the background of the project within conjunction of observational work of video data. For this study, we concentrated on the collaborative whole class sessions. In what follows we give an overview of the teacher’s reflections on the actualized process drawing on the contents of her reflective project diaries. In addition, we illustrate the nature of the teacher’s presence in the classroom by selecting one representative example of her practice and the guidance pattern in the longitudinal project.

**Teacher’s reflections in the diary**

The reflective diary entries underscored the teacher’s own active role in organizing and guiding the students’ inquiry practices. She appeared to be committed to teaching and contributed a great deal of her own time and effort. Her activities relied on the continuous assessing of the students’ ongoing inquiry processes. She emphasized that the learning community should decide in joint knowledge-building sessions collectively how to pursue further inquiries. After the community had planned how to advance, she proceeded to consider from her part how to implement the practical support required for attaining the project objectives. The teacher described in her diary her real-time support and concerns during the unfolding practice. As the students’ work unfolded, she needed to rely on her own guiding principles based on the higher-level objectives (i.e., facilitation of progressive
inquiry) of the project, the pedagogical infrastructure created, as well as her subject domain knowledge and skills.

The reflections indicated how the teacher instructed, reminded, and continuously gave supportive feedback in order to guide students to participate in inquiry activities. When necessary she also structured activities and tasks at the background so as to assist students in performing inquiry activities needed for advancement of the project; such orchestrating activity taking place at background appeared to be complemented real-time guidance. Simultaneously, she tried to support students’ own thinking and their assuming of responsibility for the development of the project. Diaries revealed that her main concerns regarding student guidance related to progressive questioning, eliciting searches for deepening information, the production of written notes for knowledge advancement, and organizing KF views for mediating inquiry efforts.

The higher-level objective of the project was to investigate cultural artefacts; the exact nature of activities to be conducted were not determined beforehand beyond the main stages of the project, but emerged collaboratively across the project (i.e., ideas of studying light or designing lamps). The teacher emphasized that the students should create their own questions or problems within the overall frames of the project. Simultaneously, she was, however, concerned that the participants’ initial personal theories and questions tended, frequently, to be superficial rather than explanation-seeking in nature. Her solution was to require a reiteration of the questioning and encourage students to provide deeper-level explanations. Sometimes she provided supporting questions herself in order to foster the investigative orientation of the students. Continually she faced the contradiction: too much guiding could lead in too teacher-centred activities and too little guiding could leave the students without direction.

They needed to be urged to wonder and make more in-depth how- and why-questions. PR:339-341

Evaluating the process: Should I have given the questions literally? It could have made the pupils’ focus clearer. On the other hand in this phase it is good to see where the students are spontaneously focusing their attention. The students themselves are creating questions which are better than the advising questions. We are again facing the situation where we are forced to evaluate what is too much guidance and how much guidance is needed. F:195-202

The teacher paid considerable attention to guiding students to search for further information to deepen their partial explanations considering their inquiry topics. The teacher often guided students to use information sources which she herself considered useful so as to prevent students from getting lost whilst using the Internet. In addition, she tried to ensure that the student teams were aware of each other’s information sources and shared their achievements. She focused the students’ attention on the significance of collaborative efforts so that the products of team-based activity would be shared by the whole community. According to the reflective diary, the teacher coached the students in making notes and expressing ideas in their own words so as to make their own thinking processes visible and the subject of collective evaluation. The note making was supported with mind maps or sometimes with a structured form, which guided students to write down specific aspects of the phenomena under investigation. The reflections also indicated that the teacher emphasized the usage of subject domain tools, (e.g., cables and light bulbs, or prisms and glass sticks, when doing experiments, or just their earlier notes and summaries) to facilitate inquiry process and mutual sharing of it.

When students were doing their experiments, I said again and again, to write down as much as possible, write down how you are doing the experiment, and what is happening, and what you
observed. I spent my time shepherding the children in different rooms. I had to make sure that everyone had good place to work. PR:269-276

While monitoring the students’ inquiry, the teacher followed students’ development in sharing responsibilities and working, and made remarks concerning the emergence of the student community; these reflections addressed group structures, division of work, and commitment to the collaborative work. She has organized the group to be as heterogeneous as possible. The students’ own interests or research questions and, in some cases, their relations with others, especially friends, affected the composition of teams. The teacher remarked in her diary how the organization of team processes or the division of labour were managed and sometimes she mentioned that her own presence was needed so as to get everyone involved. She felt that through the course of pursuing a successful project and accumulating experiences, the commitment to inquiry increased. She was also pleased when the students assumed responsibility for the whole community - taking care of their team members by guiding them and offering help.

The students are working a lot in teams or in pairs. They are pleased to advice each other and other teams as well in using new tools. They are eager in writing notes and raising questions about artefacts. P:929-932

Underpinning the enacted classroom situations were teacher-made plans and the arrangements needed for building a supportive basis for the students’ working, even though the teacher could not predict how events would develop within the learning community. Her organizational processes concentrated on managing the timetable and the process of inquiry, eliciting searches for background information, and fostering the continuous documentation of knowledge-building processes. The teacher gave much thought to what the students had achieved and how the deepening of inquiry could be facilitated. By following the students’ process, she was able to pre-figure the forthcoming discussions, assist students in the completion of tasks, and prepare them for emerging inquiry challenges. The teacher linked the activities with their past achievements and grounded the forthcoming events with the current tasks. She took care that the various activities were completed. She considered, when it was time to discuss and make decisions collaboratively, furthermore, how and when to support individual teams in the collaborative discussions. In addition, student teams were guided to pursue parallel lines of activities in conjunction with assisting them to inter-link diverging lines of inquiry. However, all the time she needed to consider how to avoid being too directive but still provide the required assistance.

I let the teams choose their topics by themselves, which was a little risky in my opinion, because I was a bit bothered about whether or not the students would choose the kind of questions that would help them to learn the essential aspects from physics. I don’t really know, what I would have done, if the students’ decisions had been completely “off”. PR:246-252

The teacher estimated that the KF database integrated different aspects and levels of the inquiry process; it mediated the teacher’s general efforts in terms of her organisational processes, with her real-time hands-on guidance activity. Moreover it structured the social responsibilities in respect of the activities and assisted in interlinking personal efforts toward collaborative aims. The KF database was both the tool which organized inquiry and the object of the participants’ knowledge-building activity. It stored all the inquiry efforts and represented gradually accumulating bodies of information as well as associated Internet links. The notes constructed during the process constituted a rich collective memory of the community. One crucial element in the teachers’ background orchestration was to prepare support for externalization of the process by organizing the database, creating new views to work with, and saving the information sources, notes and results of the collaborative discussions in the database. She emphasized that the process should be documented
continuously. She herself often prepared the following collaborative whole class discussions by collecting the students’ writings for example from their own theories, wonderings and questions on the new KF view:

In the next collaborative session I will try to get the students to make observations from everybody’s achievements. But for that, I have to put everybody’s work into the same view, where the notes can be compared, opened and handled easily. P:490-494

The different computer views from Knowledge Forum and the Internet were typically reflected on the shared screen for collective examination. When the class was collaboratively talking and generating ideas, the teacher collected the emerging ideas and process organizing plans using the computer, and displayed these on the wall using the data projector. The collaborative results were then saved to the KF-environment. Instead of herself having the whole responsibility for the development of the collaborative session, it was shared with the classroom community.

**The teacher practice in the collective classroom situation - the heat of the moment**

The following project session shows the continuity of the teacher’s reflections. The excerpts that follow each other are also exemplifying the teacher’s typical practices. The students had earlier constructed their initial working theories and questions regarding the main question “What the light is and how the lamp produces the light?” that the teacher and researchers had jointly agreed. By relying on her evaluation of knowledge produced by students, the teacher guided the participants in this session, to participate in “strategic planning” regarding how to make Light View more comprehensive and how to continue collaborative inquiry regarding light. The teacher wrote in her diary:

I decided to do new view named lamp and related phenomena for the purpose [i.e., make specific theories and questions for answering the main question “What the light is and how the lamp produces the light?”].

Theories were written. I don’t remember the date.

I read the theories. I was thinking, that they should somehow be organized, because the view seemed to be rather chaotic. The theories were still quite superficial. PR: 110-119.

In the classroom, her direction was needed for the students to be able participate using their own initiative. The community was collectively discussing the plan how to proceed. The plan was created by developing their collective objective at the same time. When they had created together an understanding as to how to proceed, they continued in smaller groups whilst the others were reading further information about electricity. The teacher could not know beforehand, how this would be done.

Excerpt 1. Episode 1, “Discussing about previous task”

**Teacher:** ... Well, I put our main page on display and we'll look at what you've done during last week. I think that, we really need to think about how we're going to proceed from this, but you might have some previous experience of dealing with situations like this, and I think that now we should think together as a group, how to go forward from here as you have put up your theories on the view from the lamp and the phenomena related to it. This is the kind of work we have ahead of us. What does this look like? What does it look like? When there is so many of them, they are coming forth little by little. What do you kind of first impressions does this give you? Michael?

**Michael:** It's quite confusing.

**Teacher:** So it appears to be.

**Tom:** There is now a big pile of work

First the teacher tried to orientate the students to the strategic activity and planning what to do next. She started by reminding their previous phase. The students were pointing to the same
chaos, that the teacher referred in her diary. During discussing of the previous task, the class was following the current situation from the shared screen.

Excerpt 2. Episode 2: “Discussing about strategy and deepening inquiry, Connection to past events, Collecting rising ideas”

Teacher: Previously we have had these kind of big projects, if you remember anything about the Pohjola (Nordic) project, or from the early phases of the Artefact project where we had this kind of large amount of information in front of us. What did we do then? And what can we do now? With this kind of pile of data? Suggest something.

I'm going to put up some ideas that come to mind. Ethan?

Ethan: To sort them.

Teacher: Ah. Sorting is a good start. Other ideas? Theo?

Theo: Sorting them in rows.

Teacher: Sorting them in rows. Anything else? Anna?

Anna: Mind map.

Teacher: You were thinking of some kind of mind map of this. How did you expect to organize it on a mind map? We have used mind maps to organize our previous work.

The students remained quite passive in the first episode, so the teacher opens the discussion about inquiry in the second episode. The content of the episode has changed from the previous task to strategy. First, the teacher helped the students and connected the situation to their past activity by reminding them of the previous phases. Then, the teacher collected and wrote up ideas emerging in discussion. Such orchestrating epistemic activity that appeared to assist the community in advancement of inquiry often took place in the background.

Excerpt 3, episode 2: “Discussing about strategy and deepening inquiry”

Teacher: Well, organization is our goal, surely. And sorting them in rows. Actually, there were two parts to this question, what were the two parts when I asked the question? Tom?

Tom: How to get the lamp to light and I don’t remember the other one.

Teacher: Let's look at the topic, someone else. Lara?

Lara: What the light is.

Teacher: Yes, that's where we'll find both of these answers. We could start from just one, right? Well then? If we look at one or the other first. Yea, what should we do with the notes where there is already a subject in the info screen because you've already made, Mike, has already made it a light, so we can just pick up from there. What should we do to it? Nina?

Nina: Put them together?

Teacher: Yea. But, in order to know what to put into one group. Tom?

Tom: If we make two mind maps, where one would have what light is and the other how to get a lamp to be alight.

Teacher: Yea we have to probably group it like that. But I don't know if we'll be able to get it into a mind map right away. Ethan?

Ethan: Well, that we could put, put some subtitles from the essence of light.

The students are a bit passive and the mutual collaboration has not been started; the teacher needs again to urge and help students further. First she connects the situation to the previous task, their subject of wonder, very mechanically using the ”initiation-response-evaluation” – pattern (Mehan, 1979). It helps students to start discussing the inquiry strategy in more equal manner. In the end of exchange, Ethan rises up “subtitles from the essence of light”. The situation continued with a short discussion regarding what Ethan meant with “essence” and it became evident that Ethan meant to search for qualities or core characteristics. To continue,
the teacher also asked them to remember what kind of phenomena they had been considering in the earlier, historical phase of the Artefact project that could be useful in the present organizing and rising-above effort. The students gave ideas about “utility” and “purpose”. The teacher concluded that: “Will we be fine with these ideas? Well let's look as we open these, what else will come out and we need to get it up there to the title so they'd differ.”

Excerpt 4, episode 2: “Discussing about strategy and deepening inquiry”

**Lara:** I was just thinking that, we could probably get it organized easier if we hold the shift key and press activate everything in the other area and move them somewhere lower.

**Teacher:** Ah, yea.

**Lara:** Then it would be easier to organize.

---Skipped: searching volunteer (Lara) for mechanic organizing. Students are pointing and telling to Lara where the right notes are. ---

**Teacher:** Thank you, Lara. Great! And what about next? Well, there is nothing for it but to open them and look what we find.

**Tom:** Let's start with the upper one.

**Teacher:** Okay, good; let's start with the upper one.

The discussion about inquiry continued and students started to participate. They were suggesting what to do. One student organized some notes about light in the front computer with the help of others. The teacher had urged and engaged students to participate in creating plans as to how to proceed together. The teacher concludes and continues that now they need to open the notes. The following last excerpt (excerpt 5) is a sample of from the long episode where they were discussing about content of the inquiry. In that episode, they were opening the notes and examining them.

Excerpt 5, episode 3: “Discussing about content”

**Teacher:** [concluding the previous wonders]: In the dark you can't see anything. What about in the light. That's the meaning. We can't see without light. We need light to see. [commenting again the issue from the note reflected on the shared screen, reading the new issue]: Well this is all well said, light lights the darkness. You can move it from place to place. [commenting the student note]: Well, that is those lamp businesses. [reading partly and commenting the next issue from the note]: But light can be... what does it depend on or does what determines if a light is bright or dim? What causes it? What causes it children? Michael, what do you think?

**Michael:** (unclear) Fire requires oxygen which it then burns and then requires more energy. The less it's in use the dimmer it is.

**Teacher:** yea but what question does that answer? Now it's so that, we need to think up new questions. Who hasn't said anything yet? Everybody with raised hands has already said something. Tom?

**Tom:** Well, it answers the question that what a lamp needs to be.

**Teacher:** Well, now we need to do so that, I'm going to put a new subject there, so what kind of light there is. Good. There. Was it John also? Yea it was that, let's put that there too. This is pretty slow work, but let's look at a few more if we can get this kind, where does this belong, does it belong to either group?"

The excerpt 5 shows how they were opening the notes one at the time, raising the students own wonderings at the centre of discussion and analyzing them further, and categorizing the notes under self-made subtitles. They were able to participate in the creation of the organizing procedure; even the teacher directed and mediated the discussion. After they had modelled the organizing procedure together, the students were able to continue it one team at the time. The teacher wrote in her diary afterwards addressing a number of questions generated by students and emerging through interaction with the teacher.
30.9. We were examining what kind of notes had been done. We were organizing notes under the headings that we had created together. At the same time, we were considering what kinds of questions the notes were answering: Where does the light come from? What is producing the light? The source of light. What is light? How can the light be used? What is light like? Burning.

PR: 221-229

Later on she also reflected advancement of collective inquiry in her diary. These reflections indicate that she still was not satisfied for progress of the project thus far. She wanted the students to continue and re-iterate the question-explanation process in teams:

2.10. I urged them to wonder and make more in-depth why-questions. I remember explaining that the theories were not yet detailed and deeper-level enough.

More wonderings, questions and deepening questions were collected and commented in teams.

Now we were getting deeper into things. The questions started to become more detailed and focus on some specific phenomena related to light. In fact we discovered many-sided things about light, and the groups chose themselves a topic that they wanted to start to study. PR: 231-244

After the re-iteration of the question-explanation process, she was satisfied and let the students choose their research topics themselves. While the present investigative project involved pursuit of genuine inquiry with emergent problems and directions, it was not open-ended in terms of allowing spontaneous and free production of ideas; there were higher-level objectives of learning to understand cultural artefacts are multiple levels that guided the teacher’s efforts of orchestrating collective inquiry activities.

Concluding remarks

This study depicts elementary-school teacher’s practices, her efforts to promote pupils’ cognitive responsibility for advancing their collaborative object-oriented inquiry process themselves. The teacher assumed the role of organizer concerning collaborative progressive inquiry and designing activities. This was based on the continuous monitoring of the pupils’ current state within the inquiry process. The aim of the pedagogical infrastructure framework was to highlight, for educators, the fundamental factors of inquiry learning that need to be designed and taken care of. The teacher diary revealed the epistemic infrastructure when she is concerned with how to guide and support students’ deepening inquiry; how to encourage them to propose ‘why’ questions without guiding them too much. In the social infrastructure she considered the students’ team activities and their interaction, although the decision in respect of grouping had been made at the beginning of project. During the project she reflected on individual student’s roles, highlighted their special area of expertise, supported the creation of collaborative culture, how to behave and so on. In terms of the development of ways of using Knowledge Forum, creating and sharing views and making collective discussion notes during the process, she constructed a technological infrastructure of inquiry use. Knowledge Forum structured the process and mediated activities, and rendered their objects visible and accessible to the whole learning collective. The video excerpt highlighted our interpretation of the cognitive infrastructure regarding how the teacher tried to encourage students to take responsibility for the organisation of the inquiry process. These efforts involve a creative and situationally varying combination improvising structuring. In the background, the teacher evaluated the enacted classroom situations and created aims and plans to guide and scaffold the students’ process. In the enacted classroom situations, the teacher’s aim was to support students own ideas and responsibility of the process, and lean on the emerging classroom situations.

While discourse interaction between the teacher and the students reported by the present investigation may appear as teacher-centered for Anglo-American readers, it is, however,
pretty typical for Finnish school in which students are not oriented toward sharing their spontaneously generated ideas at a social space in the same way than American students do (Hakkarainen et al., 1998). On the other hand, the nature of discourse interaction may reflect the very nature of the inquiry project in question that was not oriented toward free and spontaneous production of ideas, as sometimes seen desirable in student-centred pedagogy, but was driven by disciplined pursuit of shared higher-level objectives of the inquiry project. The present investigation report a collective inquiry project carried out at elementary-level focused on investigating cultural artefacts across one and half year. The present teacher has perfected a practice of pursuing such challenging projects in which she is learning together with the students. Her efforts of orchestrating inquiry learning were oriented to strategically guiding the classroom learning community for pursuing higher-level objective of the project at multiple levels, i.e., a) providing real-time guidance in classroom discussions (micro-level), b) doing background work between sessions for creating conditions for advancement of the project (meso-level), and c) using lessons learned in earlier inquiry project for finding fresh perspectives for advancement of the project in hand (macro-level). Hence, serious inquiry is object-oriented rather than totally open-ended in nature, and this state of affairs affects also the nature of teacher guidance.

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References
Hakkarainen and his colleagues (1998)


