Patterns of Guidance in Inquiry Learning

ABSTRACT. The purpose of this case study was to examine a teacher’s guidance of an inquiry learning project in an ordinary elementary-school classroom. The participants in the study were 21 Finnish, grade 4 students (10 years old), from which four students were selected for intensive observation. The technical infrastructure of the study was Computer Supported Intentional Learning Environments (CSILE). The project consisted of a series of 21 lessons. Each lesson was videotaped, and the contents of transcribed videotapes were analyzed by qualitative content analysis. The analysis revealed that although the teacher was able to straightforwardly guide the three, more advanced students through the progressive-inquiry cycle, she had a great deal of difficulty in the case of the less advanced student. Effective teacher guidance appears to be a mediated process in respect of requiring an externalized record of students’ inquiry, e.g., their postings, or at least a verbalized account of it to help the teacher ground her efforts to guide the deepening inquiry.
Introduction

Inquiry learning is a common approach in science education. It has also been applied in a number of other educational programs, and, lately, those assisted by modern collaborative technology (for a review, see Lehtinen, Hakkarainen, Lipponen, Rahikainen, & Muukkonen, 1999); positive results of have been reported, such as enhanced individual learning outcomes, overall more positive attitudes towards learning, students’ increased interest in and motivation for learning, and a higher quality of social interaction (e.g., Goldman, Mayfield-Stewart, Bateman, Pellegrino, & Cognition and Technology Group at Vanderbilt, 1998; Koschmann, 1996; Scardamalia, Bereiter, & Lamon, 1994).

Inquiry learning, however, has also received criticisms, such as inefficiency of the method, difficulty of justifying the amount of time needed to conduct genuine inquiry, and the paucity of knowledge gained from that process (e.g., Kuhn, Black, Keselman, & Kaplan, 2000). Another claim is inquiry learning has shortcomings because there is insufficient research about students’ and teachers’ actual experiences in regular science classrooms to properly understand the inquiry process (Krajcik, Blumenfield, Marx, Bass, & Fredricks, 1998), and, especially, to know how to support and guide inquiry learning activities (Kolodner, 2001). Technological solutions can help the process of guidance by providing tutoring tools, built-in support and scaffolds, or even entire learning environments (e.g., Ainsworth, Wood, & O’Malley, 1998; Davis & Linn, 2000; Fretz, et al., 2002; Goldman, Zech, Biswas, Noser, & CTGV, 1999; Guzdial & Turns, 2000;
Muukkonen, Lakkala, & Hakkarainen, 2001; Scardamalia & Bereiter, 1994; White, 1993). Yet technological guidance does not, by itself, create a genuine inquiry culture; a supporting social infrastructure is needed as well (Bielaczyc, 2001). In creation of the social infrastructure, the teacher’s personal guidance and coaching has a crucial role. Advancement of inquiry is dependent on the teacher’s timely efforts to guide each student’s and the whole community’s process of inquiry, efforts that have to be carefully tailored to each student’s specific needs without being intrusive (Winn, 2002).

In inquiry learning, students are required to engage in more intensive self-regulative efforts than in traditional teacher-directed classroom situations. The teacher does not usually supply or even determine clear, concrete learning goals, but provides context and starting points for the students’ own inquiries; the students are themselves responsible for generating their specific learning agenda and setting up their learning goals. Further, learning tasks are often more open-ended and ill-defined, and thus more complicated to work with than those of conventional learning situations. Inquiry learning is also often collaborative in nature; this collaboration poses challenges for students who are accustomed to individual approaches to learning. Therefore, teachers should not rely too much on students’ unguided creativity, but should intervene by providing pedagogical guidance and an expert model if students are not able to make progress themselves. In order to productively participate in the process of inquiry, in each pedagogical situation, a balance should be found between teacher-controlled and student-controlled aspects of inquiry (Brown, Ash, Rutherford, Nakagawa, Gordon, & Campione, 1993; Brown & Campione, 1996; Hakkarainen, Lipponen, & Järvelä, 2002).
The present study relies on a pedagogical approach called Progressive Inquiry (hereafter, PI, Hakkarainen, 2003; Hakkarainen & Sintonen, 2002), intended to facilitate expert-like question-driven and explanation-oriented working with knowledge at the elementary level of education. Characteristic of PI is to guide young students to a) systematically generate their own research questions, b) construct their own intuitive working theories, c) critically evaluate and assess the various intuitive conceptions generated, d) search for new scientific information, e) engage in progressive generation of subordinate questions and f) build new working theories as the process continues. All aspects of inquiry, from setting up research questions and information search to advancement of communal knowledge, may be shared between students through the Computer-supported Intentional Learning Environment (see, for instance, Scardamalia & Bereiter, 1994), which was also used in the present study as a technical infrastructure. Figure 1 presents a pedagogical model of PI.
Figure 1. Elements of Progressive Inquiry

Progressive inquiry may be regarded as consisting of phases, each of which has its own particular epistemic objective as well as specific challenges for the teacher and requirements concerning her or his guidance. A starting point for the process of inquiry is creating context for a study project in order to help students understand why the issues in question are important and worthwhile to investigate. During this stage, the teacher creates a motivational basis for the progressive inquiry process and helps students to make cognitive commitments to pursue their personal (or team-based) inquiries. A crucial aspect of any inquiry whatsoever is to guide the students to pose questions or problems that direct their subsequent process of inquiry. It appears that explanation-seeking questions and questions that arise from the students’ own need to understand have a special value in inquiry. By encouraging students to systematically create and build their
own tentative working theories for problems being investigated, the participants can be
guided to trust their own voices rather than merely rely on the teacher’s cognitive
authority (Scardamalia, 2002). In this process of self-development, students may be
helped to deepen their understanding by guiding them to explain the investigated issues
to their fellow inquirers (Hatano & Inagaki, 1992). Advancement of inquiry requires,
however, that these working theories be critically evaluated and that the participants
search for and share new scientific information in various ways. A critical condition for
progress is that the teacher deliberately guides students in improving their conceptions by
pursuing subordinate questions in depth (Hakkarainen & Sintonen, 2002). All of these
aspects of inquiry can be shared between the participants. The challenge of teacher
guidance is to anchor all classroom undertakings around these activities so as to channel
students’ cognitive resources according to the progressive-inquiry process (Hakkarainen,
2003; see also Kolodner & Crey, 2002).

As described above, progressive inquiry posses new challenges for learning.
There is a need for more information about how students and teachers are facing the
challenges of inquiry, and more specifically, how the teacher’s guidance is carried out in
inquiry learning. The goal of the present investigation is to analyze patterns of the
teacher’s guidance across the phases of the progressive-inquiry process. The specific
purpose of the study is to examine how guidance in inquiry learning is actualized towards
students characterized as representing varying academic achievements, measured in a
conventional learning setting. In the present study, the focus is on face-to-face guidance
rather than computer-mediated guidance since the particular teacher does not guide the students via network but face-to-face.

**Method**

**Participants and Settings**

The present study is a part of a four-year follow-up series concerning motivational and cognitive effects of Computer-supported inquiry learning in Finnish elementary and secondary schools (see Järvelä, Hakkarainen, Lehtinen, & Lipponen, 2001). The focus of these studies is to describe accurately how different students and teachers cope with challenges faced while conducting inquiry learning in authentic, regular classrooms without extensive support by resources from outside. The data presented here were collected during the second year of the series. The school was an ordinary Finnish elementary school located on an area that represented an average socioeconomic status in an urban district. The participants (11 boys and 10 girls) were 21 elementary school students (age, approximately 10), who conducted a four-week progressive inquiry project, from which four students were selected for observation. The domain of the study was biology, and the topic was adaptation. Students worked individually, in pairs, or in groups of three, based on their own choice. The researchers were not setting up an experimental design, but observing classroom activities as they naturally occurred. The students spent half of the 21-hour project in the computer-class, where they shared their knowledge through the CSILE environment. They spent the other half in the classroom or
in the school-library, seeking more information relevant to their research questions, from books and the Internet. The teacher (age 31) had four years’ experience as an elementary school teacher. She had some experience of inquiry learning from the previous year, but the progressive inquiry model had not been systematically applied before.

At the beginning of the project, the topic for the inquiry was introduced and anchored by telling a story of a mammal that lives in a forest. Next, the students generated research questions about the domain. The teacher asked them to select biology topics in which they were interested, for further inquiry. The teacher helped the students to identify unclear, misleading, or unsolvable questions (e.g., questions with wrong presuppositions) in such a way that it allowed the students themselves to modify them and assume the responsibility of pursuing their inquiry. After this, the students started to search for new information in order to answer their research problems. Towards the end-stage of the first cycle of inquiry, which was conducted by some of the students in the first eleven lessons, the students presented the results of their inquiry to each other. The teacher subsequently guided the students to apply new information and ideas from other students’ presentations that would help them to advance their own inquiry.

Data of the Study

In the present study, teacher guidance of progressive inquiry was investigated by two cases (a group of three, and a single student; altogether, four) of such guidance were qualitatively analyzed, based on the videotaped processes of teacher-student interaction.
In addition, contents of students’ postings to CSILE’s database were analyzed qualitatively in order to illustrate students' activity in the database, which was the main vehicle in inquiry. Two video cameras were used to collect data, one focusing on the group of three students, the other on the one student working individually. The students were selected for intensive observation according to the teacher's suggestion, representing the well- and less-advanced levels of school achievements as measured in a traditional classroom setting. The reason for selecting students with varying levels of academic achievement was to obtain detailed information regarding the processes of teacher guidance in diverse situations—rather than having a design that would allow one to make strict comparisons between the students. All 21 hours of the project were videotaped.

Data Analysis

A detailed transcript of each videotape was constructed, which included a description of what the students and teacher discussed and did in the classroom. The combination of videotaped observations and students’ postings to the database was used to create case material for the selected students.

In order to obtain detailed information on the teacher’s guidance in the context of each element of PI-model, video data focusing on the teacher’s guidance were examined. Two units of analysis were used, a proposition, and an episode. In the following section these units are described in a more detailed way.
The propositional-level analysis proceeded by first sequencing the whole set of transcribed data into units that reflected guidance focusing on one aspect of PI at a time. Thus, a single guidance proposition can be described as a meaningful communicative contribution that involved one element or aspect of PI-model. These units were then categorized according to our framework (for descriptions, see Appendix). The framework consists of several elements of the PI-model (creating context, research question, working theory, searching new information, critical evaluation, research question, shared expertise); in addition to the elements of PI-model, a further, new category, 'scaffolding the inquiry process,' was used.

When the teacher guided the students to carry out some aspect of PI, the direction was regarded as representing a guidance proposition of a certain category. The category of proposition would change when the focus of the teacher's guidance shifts from one aspect to another aspect of PI. Through fine-grained analysis of the frequency distribution of the contents of propositions, we obtained an overall picture of the focuses of guidance concerning PI at certain phases of the project. The percentage of congruence of the categorizations conducted by the two independent coders of a sample of 15% of the data was 84.

In addition of a propositional-level analysis of the teacher’s guiding patterns, we used an episode as an analysis unit. Taking the episode as a unit of analysis enables one to construct a meaningful continuum of teacher's and students' activities, and thus, demonstrate the possible reciprocal nature of the their interaction (Veermans & Järvelä,
in press). In other words, an episode can be seen as representative of the process over different propositions; through the proposition-level, we get a picture of overall guidance focusing on PI-model during the whole project, whereas the episode level offers a window for examining possible interaction between teacher and students in certain significant situations. The analysis of qualitative episodes thus complements the propositional-level analysis. It can be characterized as one meaningful aggregate of guidance - a dialogue between teacher and student(s), reflecting the possible interaction between teacher and students and how the teacher takes into consideration the students’ own processing of learning or mediating outputs (texts, mind-maps and so on).

Finally, a qualitative content analysis was conducted for the content of the students’ postings to the database to find out the students’ actual level of advancement during the process of inquiry. These were partitioned into ideas, that is, a set of propositions that formed a coherent unit of meaning. Therefore an entire note (posting) could be composed of several ideas representing various categories of knowledge, drawn from the PI-model: 1) research questions, 2) explanations (intuitive explanations and scientific information searched for by the students), and 3) comments (all other written communication). The categories were mutually exclusive (for details, see Lipponen, 2000).
Results

The Guidance for the Group of Three Advanced Students

The group of three students created an above average number of CSILE-notes, 17 in all. They started with research questions that helped them to go further with their inquiry, especially questions that were explanation-seeking rather than fact-oriented in nature (see Table 1). They also posted comments to other students’ notes, which were mainly supportive. The notes of the students were evenly distributed across the whole project, indicating the continuous nature of their working practices. Their notebooks involved a rich body of information about the problems being investigated. The video material showed that the girls had worked together, as indicated by their discussion being organized around a shared object of inquiry, i.e., the bear.

Table 1. Number and Quality of Notes Created by the Three Advanced Students

<table>
<thead>
<tr>
<th>Note type</th>
<th>Question</th>
<th>Comment</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fact-oriented</td>
<td>Explanation seeking</td>
<td>On-topic</td>
</tr>
<tr>
<td>(%)</td>
<td>5,9%</td>
<td>17,5%</td>
<td>52,9%</td>
</tr>
<tr>
<td>(f)</td>
<td>1</td>
<td>3</td>
<td>9</td>
</tr>
</tbody>
</table>
These students were also actively asking support from the teacher when they thought they needed help or advice. They managed, with ease, to go through a cycle of inquiry within the first 11 lessons. The teacher’s guidance took place within the first 11 lessons, as illustrated in Figure 2 by propositional-level analysis. Aspects of PI were intertwined within lessons, indicating the cyclic and iterative nature of inquiry.

Figure 2 also shows that the largest categories of guidance for the group of three advanced students were 'searching new information' (20), 'generating working theory' (19), and 'posing research question' (11). Other categories were represented from 2 to 5 times, except for guidance on 'critical evaluation', which was not present at all.

![Figure 2. Teacher’s Guidance for the Group of Three Advanced Students](image)
In the following subsection, we present examples of interaction episodes between the group of three advanced students and teacher. The episodes have been selected among several episodes to illustrate how externalization of the students’ own stage of advancement (by telling about the progress of their project) played the role of a mediating tool for the teacher to guide students' work on the basis of their own ideas and thoughts. The critical aspects are highlighted (italics) in relation to teacher's attempt to guide students to pursue explanation-related inquiry on the basis of the students' own thinking.

Lesson 8

Teacher to Student 1 and Student 3: What's going on with you?

Student 1: Everything is OK. Things are going well, Mia lent us this book and we are looking for more information. Also the [topic of] bears can be found there, when bears came to Finland.

Teacher: And remember all the time to consider how the bear has adapted to live in the forest.

Student 1: It will probably be found here [pointing to the book].

Teacher: I'm sure it will. Remember all the time that it's your main point. So, first we are looking for it, you've got your research question there. Then we will search for the general information, and after that begin to watch for specific information
this was related to our research question, and finally (we will see) how this can be applied in general.

Student 3: We have done this [pointing to sections of own notebook]; they live in the fields; different kinds of bears; then life span; then here's some copies and then we'll draw a map, where bears live.

Teacher: Yes, the map. Keep in mind, when you are drawing the map, where do the bears advance and why do the bears advance on those areas.

Student 3: Then you can make questions out of that and answers and think what...

Student 1 [interrupting]: The map is here [pointing to the book].

Teacher: So, now you can instead make a question why bears do not live on these areas [pointing to the map in the book]?

Student 1: First we should draw that map. Hey, do you have the map?

Teacher: Mm. Wouldn't you be able to draw the map now? Don't you have that old map-template of Finland we used last year?

Student 1: Back home.
Teacher: You can leave a space for that.

Student 1: Yes.

Teacher: But you have to explain it anyway.

Student 1: Yes.

Teacher: It's no problem. Consider carefully why does the bear live in these areas and not in these areas. What are the elements affecting where bears live [teacher leaves].

Interpretation: Students’ externalization of their process can be considered as a mediating tool for allowing guidance to be focused both on the content and on the various aspects of process. The teacher guided the students’ advancement by anchoring their ideas in the core concepts of the field (e.g., habitat, adaptation), and by clarifying the relation between the aspects of the inquiry. The episode indicates that students were involved in the process of inquiry, and reveals the importance of teacher guidance and facilitation.

The students reported in the feedback questionnaire (for the whole project) that they had learned a great many subject-related issues, gained information and created mind maps. They also stated that it was essential for the topic of the study be interesting, and study questions be formulated by the students themselves.
Teacher’s Guidance for the Less-advanced Student

The less-advanced student created, altogether, 5 CSILE-notes. Of the notes, 2, however, contained no information on the subject matter, but only jokes. The student did not create any question notes that would have been needed for initiating the actual process of inquiry despite the teacher's efforts at guidance. It is noteworthy that the student created one of the two explanation-notes during the first lessons and the remaining note during the last two lessons of the project. The last note was full of information. When almost all students were preparing their oral presentations and drawing conclusions about their subjects, the student changed the topic of his research, returning again to the initiation stage of inquiry.

According to the propositional level analysis, the teacher’s guidance for the less-advanced student was divided into two periods and occurred during lessons 2-13 and 18-21, as presented in Figure 3. The largest categories of guidance propositions were 'searching new information' (19), 'working theory' (17), and 'research question' (12). 'Shared expertise', and 'scaffolding of process' were present 7 and 6 times, respectively. Guidance on 'critical evaluation' and 'research question: specification' each occurred once. There was no guidance on 'creating context'.

From Figure 3, one may infer that the student had problems in getting his inquiry started. Even though the guidance in various elements of PI was rather evenly distributed in lessons 2-13, the teacher still had to guide the student to generate the research
questions in lessons 11 and 13. Another strong indicator of problems concerning initiating self-regulated inquiry was that the teacher guided the student regarding search for new information and externalizing of one’s thoughts in lessons 18-21, in the very last period of the project. These aspects of inquiry usually take place in the beginning or the halfway point of the project.

Figure 3. Teacher’s Guidance for the Less-advanced Student

In evaluating the outcomes presented above, it appears that the student had just begun task-oriented work when the others were finishing the project. Video-data showed very clearly that the student had many difficulties in conducting the inquiry. Even when
the teacher gave specific instructions concerning phases of inquiry, the student did not start to work on-task, but withdrew, or selected substitute tasks. After the middle of the project time, the student started, however, to show more on-task activities. Through examining the data, the reason for the appearance of on-task activities may be traced: the student had found a book about mice, and he told how he has seen some mice himself. Presumably, this authentic connection helped the student to generate the enthusiasm needed for task-oriented work. The question remains open whether and how the student would have proceeded if the project had continued for another two weeks or if he had worked in a team. The teacher tried to encourage collaboration, but the student refused to work in a pair or team. Nevertheless, while answering to the questionnaire concerning providing feedback of the whole project, the student wrote: “I would like to continue the mice research since I could not finish it yet.” Apparently, a certain level of cognitive commitment emerged toward the end of the project.

An example of the less-advanced student and his teacher’s interaction indicates how his guidance was more like the teacher’s monologue than genuine dialogue. The critical aspects are highlighted (with Italics) in relation to the teacher's attempt to guide the student to pursue explanation-related inquiry on the basis of the student's own thinking.
Lesson 10

Teacher: Do you now want to try another address [searching information from www] or would you now like to go to the web, I mean CSILE? Shall we? Let’s finish this?

The student: What should we write?

Teacher: You can just read other students notes.

The student: I'll read other notes, and then I'll make some comments.

[Logging-in to the database.]

Teacher: And then we'll look at those labels [of the database-notes]. From this bar, you can enlarge, so you can see more of these labels and what interests you; then you read them. And make comments or not. And here, you can see how nice it is to make a kind of label that tells you what it includes. I don't know, this might be an inappropriate note that doesn't help us go forward on our animal issue.

Teacher: There are many of them [referring to the amount of other students' notes]. You can look from here and read the notes and all the time you have to think if this would be an answer to your question. How the mammal has adapted to its living environment. Remember this all the time.
[Teacher leaves.]

The student: Whistles at his desk, does nothing.

Interpretation: The project was already approaching the midpoint, and the student had not been able to deepen the inquiry. Characteristic of the interaction between the teacher and this student was that teacher usually took the initiative in a guiding situation. The student had not explicated or made visible his own thoughts and conceptions up to that time, so that there was very little for the teacher to build on; guidance was entirely teacher-driven. Especially revealing is the teacher's last utterance when she tells the student what to do on a rather abstract level, which did not appear to promote the student's inquiry. This episode indicates how difficult it can be to cope with the demands of inquiry learning.

Discussion

The aim of the study was to understand a teacher's activity in guiding the inquiry process in a classroom situation of computer-supported inquiry learning by providing a unifying picture of teacher guidance in the context of progressive inquiry. Micro- and macro-level analysis was performed by studying guiding episodes, based on segmenting utterances related to guidance propositions.

Two cases of students’ guidance by their teacher were analyzed in the present study. While working with more advanced students, the teacher was able to proceed
rather straightforwardly from setting a problem, to generation of the students’ own
theories, further searching for new information and setting up new subordinate questions.
With the support of the teacher, the advanced students were able to proceed through one
cycle of inquiry within a relatively short period of time. Regulation of these students’
inquiry appeared to be distributed between the teacher and the participants rather than
carried out by either contributor alone. This interdependence shows how guidance can be
externally alike in different situations, but its relevance is dependant on students' goals
and activities. On the other hand, the teacher had a great deal of difficulty in guiding the
less-advanced student’s engagement in progressive inquiry. This shortcoming was
indicated by the fact that the student was still at the starting point of his inquiry while
others were already finishing their inquiries. To summarize, the investigation allowed us
to trace a great deal of variance in the nature of teacher guidance concerning the group of
three advanced students and the individual, less-advanced student.

An intriguing finding related to the guidance is the lack of critical evaluation, a
crucial element of progressive inquiry. Critical evaluation has traditionally belonged to
the teacher's activities. This finding indicates how difficult it is to move from the culture
of teacher-centered learning to one that is learner-centered.

The analysis indicates that teacher guidance is a process mediated by students’
externalized conceptions and processes (see Paavola & Hakkarainen, 2003); without
these kinds of externalizations, it is very difficult for the teacher to meaningfully and
productively guide advancement of the students’ process of inquiry. These results
highlighting the mediated nature of teacher guidance are consistent with the results of Lepper, Drake and O’Donnell-Johnson (1997), who studied skillful tutors. According to them, a skillful tutor can enhance the problem-solving situation, when she or he is able to first evaluate the students’ level of content knowledge and their level of skills. The same phenomenon was also found by Wood and Wood (1999), who noticed that high-achieving students are better able to utilize expanded intellectual resources emerging from tutoring and intentionally to seek help when there are difficulties. As those authors stated, students’ level of achievement affects the guidance situation: “Higher achievers are more likely to help the tutor to locate the ‘upper bounds’ of their ‘zone of proximal development’ by signaling when they are in need of assistance” (p. 155). In this way, high achievers are helping a tutor or a teacher to build a learning environment contingent on their level and needs. By the same token, the guidance provided by the teacher may be too demanding for students, as is often the case with low achievers. Students’ cognitive capabilities or epistemic horizon may be exceeded, leading to a situation of disorientation in the face of the demands of the learning task. Thus, teacher should actively work towards congruence between students’ self-regulation and the teacher’s external regulation (Vermunt & Verloop, 1999). The relational nature of guidance indicates that it cannot be set up from outside, in the absence of specific information; the teacher needs to have some access to the student’s cognitions and inquiry processes so as to ground his or her efforts on the student’s earlier achievement and present situation.
The first author was supported by a grant from Finnish Cultural Foundation. The second author was supported by a grant from Ministry of Education of Finland. The third author was supported by the Academy of Finland.

References


