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Making Meanings: Pupil Talk in Inquiry-Oriented Instruction

Abstract

This study focuses on seventh-graders' talk in inquiry-oriented instruction, aiming to describe it and assess its meaning. The study was carried out in the framework of the sociocultural theory, where learning is seen as a social activity and talk is therefore assigned an important role in any analysis learning. The data were collected in situations where the pupils were studying biology in inquiry-oriented instruction. The data comprise 10 hours of recorded discussions among a group of pupils, which were analyzed by means of a discourse analysis focusing on the construction of the pupils' meaning-making processes. The meaning-making processes were generated by means of rhetorical and dialogical speaking strategies. The results indicate that only dialogical strategies led to intersubjectivity and collaborative knowledge-construction. The findings also show that talk is a principal tool for creating a frame for pupils' collaboration and learning. It seems that in order to derive the most benefit for their learning from inquiry-oriented activities in the science classroom, pupils need to be taught how to talk together.

Introduction

In recent years, science education researchers have approached science learning as a set of common meaning-making processes. There has been a gradual development of interest in the ways meanings are developed through language and other modes of communication in the science classroom (Scott, Mortimer & Aguiar 2006). Classroom discourse is becoming an increasingly prominent area of research in education. The researchers have focused on teacher-pupils discussions (e.g., Kelly, Brown & Crawford 2000; Mortimer & Scott 2003; Shepardson & Britsch 2006; Viiri & Saari 2004) and peer discussions (e.g., Anderson, Holland & Palincsar 1997; Kaartinen & Kumpulainen 2002; Kelly, Crawford & Green 2001; Ritchie & Tobin 2001; Roth 1995). Even so, little is known as yet of the meaning-making processes in peer discussions. This study concentrates on peer discussions and tries to discover the meaning of pupil talk in inquiry-oriented instruction.

Why study pupil talk?

The theoretical framework of this study is the sociocultural theory of learning. According to that theory, we learn by taking part in social interaction, where we learn the cultural tools: the culture's dominant ways of thinking, reasoning, and valuing (Lemke 2001). The sociocultural theory is based on Vygotsky's (1978) views of learning. According to him, learning occurs twice: first at the social level (among people), and later at the individual level (inside an individual). The transformation of the interpersonal process into an intrapersonal one he calls *internalization* (Vygotsky 1978). Today's socioculturally orientated researchers agree with Vygotsky that learning involves both interpsychological and intrapsychological processes, but they have developed Vygotsky's ideas about internalization further. According to the sociocultural view, the concept of internalization constructs too dualistic a picture of learning: in the learning process, something transfers from outside to the inside of the learner (Säljö 2001; Wells 1999). However, the cultural tools learnt in social situations are not simply transferred from the interpsychological to the intrapsychological level (Säljö 2001; Wells 1999; Wertsch 1985).

Instead of using the concept of internalization, researchers nowadays speak about *appropriation* when describing the inherent connection between the interpsychological and intrapsychological learning processes (e.g., Galperin 1969; Säljö 2001; Wertsch 1985). According to Wells (1999), the cultural tools are always somehow transformed in the learning processes. Engeström (1999, p. 35) agrees with Wells that learning involves transformation processes: "people face not only challenge of acquiring established culture; they also face situations in which they must formulate desirable culture". Engeström (1999) underlines the significance of transformation by using the concept of *externalization* besides appropriation to describe the nature of learning.

According to the sociocultural view, then, learning is appropriation and externalization of cultural tools and involves both interpsychological and intrapsychological learning processes, which are inherently connected to each other: the interpsychological processes affect the intrapsychological ones and vice versa. All human action, even the intrapsychological learning processes, could be seen as social by nature: when we are sitting and studying alone, we use the cultural tools that have been learnt in social interaction (Säljö 2001). Therefore the interpsychological learning processes have a central role in learning. Research on learning could be viewed from either the interpsychological or the intrapsychological perspective (Wells 1999). However, socioculturally orientated researchers emphasize the significance of the interpsychological learning processes, because the cultural tools used have been first met in social interaction with others.

In the interpsychological learning processes, language has an important role. "Language enables us to set up intellectual networks for making sense of experience and solving problems. We use it as a tool for creating knowledge, so that language and knowledge we create with it are resources for individuals and communities" (Mercer 2000, p. 15). Language is the most powerful cultural tool (Vygotsky 1978; Wertsch 1985; 1991). According to Mercer (2000, 2002), learning in the classroom is an interpsychological process, where the teacher and the pupils must use talk and different joint activities to create a shared communicative space, an Intermental Development Zone (IDZ). In the IDZ, the teacher and the pupils negotiate their way through the activity in which they are involved. The IDZ is a dynamic frame of reference, which is constantly reconstituted as the dialogue continues. If the quality of the zone is successfully maintained, the pupils are able to operate just beyond their established capabilities. If the dialogue fails to keep the minds mutually attuned, the IDZ collapses (Mercer 2000; 2002). In classroom situations the language used by the teacher and the pupils is an important factor affecting the construction of the IDZ. According to Mercer (2000), studying the way we use language to think together may help us to understand how we can achieve effective collaboration more reliably.

Talk in the science classroom

According to the sociocultural view, the main idea in science education is for the pupils to appropriate the cultural tools that are characteristic of the domain of science (Mortimer & Scott 2003; Lemke 2001). Learning science involves becoming socialized into the language and practices of the scientific community (Newton 1999). In science teaching, the teacher invites the pupils to join a particular science subculture and its system of beliefs and values (Lemke 2001).

Science has its own cultural tools for studying and explaining scientific phenomena. Instead of talking about cultural tools, science education researchers often use the concept of *language of science* to describe scientists' main tool for conveying information about nature (e.g., Jones 2001; Mortimer & Scott 2003). The language of science is a specialized genre: "The language of science is a purpose-designed tool used in specific contexts to meet specific needs" (Jones 2001, p. 91; see also Mortimer & Scott 2003). The first requirement of scientific knowledge is that it should fit the empirical observations and measurements made of the natural world. However, new scientific knowledge will not become public knowledge until it has been checked and generally accepted by the various institutions of science (Mortimer & Scott 2003, see also Lemke 2001; Newton 1999). The social validation of knowledge may be organized through peer review of academic papers, conference presentations and discussions, or debate in scientific journals to resolve a controversial issue (Mortimer & Scott 2003; Newton 1999). Therefore, science is a social practice and scientific knowledge the product of a community (Driver, Newton & Osborne 2000).

According to Mortimer and Scott (2003), the language of science and the language of school science are different because real science is carried out in professional settings and school science in the classroom. In addition, school science has its own history of development and is subject to social and political pressures that are quite different from those of professional science. However, science can be practised in the classroom in ways similar to those used by scientists themselves. In the school context, the pupils should learn scientific ways of doing, thinking and talking (Newton 1999). Lemke (2001, p. 298) describes science education in this way: "In the sociocultural view, what matters to learning science and doing science is primarily the socially learnt cultural traditions of what kind of discourses and representations are useful and how to use them."

At school, the use of the language of science is learnt through interpsychological learning processes in the classroom, i.e., in teacher-pupils and peer discourses. Reciprocal negotiation and meaning-making are significant activities in the science classroom (Kumpulainen 2001). In the classroom discussions we use language to construct a common understanding of the world and its phenomena. Science education should provide pupils with opportunities to practise the use of the language of science: they need to develop their ability to communicate by using the discourse of science in the classroom to optimize their learning (Jones 2001). Through practice in posing and answering scientific questions, pupils become active participants in the community of school science (Newton 1999).

Inquiry-oriented instruction

The word *inquiry* has many meanings in science education. It is used to refer to the general process of investigation that scientists use as they attempt to answer questions about the natural world (e.g. Bybee 2004; Deboer 2004; Windschitl 2002; 2004) but also to refer to pedagogical approaches to modelling aspects of scientific inquiry (Deboer 2004; see also Bybee 2004; Windschitl 2002; 2004). It can further be used for models or theories of learning and for expounding how learning takes place during inquiry-teaching activities (e.g., Hakkarainen & Sintonen 2002). In this study the term *inquiry* refers to a pedagogical approach, inquiry teaching.

Inquiry teaching mirrors scientific inquiry by emphasizing questioning, investigation, and problem-solving by the pupils. Just as scientists conduct their inquiries and investigations in the laboratory, at field sites, in the library, and in discussions with colleagues, pupils engage in similar activities in the inquiry-based classroom (Deboer 2004, p.17). Through their inquiries the pupils try to advance their understanding of the principles and methods of science (Deboer 2004, p. 17). According to Deboer (2004) it is important to note that inquiry teaching is simply a metaphor for what goes on in an inquiry-based classroom. However, inquiry as a teaching strategy should capture the spirit of scientific investigation and the development of knowledge about the natural world (Bybee 2004). At school, inquiry teaching can be put into practice in different ways. Inquiry activities are classified according to their openness (Windschitl 2002). In this study, inquiry-oriented instruction means open inquiry teaching, where the teacher allows the pupils to develop their own questions and design their own investigations. Such a learning environment provides opportunities for pupils to practise the use of the language of science and to construct a common understanding of the topic. The aim of this study is to describe and understand pupil talk in inquiry-oriented instruction. There are two research questions: 1) What speaking strategies do the pupils use in their meaning-making processes? 2) What is the meaning of the strategies the pupils choose?

Design and method

Discourse analysis

By its design and method, this is a discourse-analytic study. Discourse analysis has both theoretical and methodological aspects: ways of thinking about discourses and ways of treating discourse as data (Wood & Kroger 2000). From the theoretical point of view, in discourse analysis our reality and our knowledge of it are considered to be constructed in social action, in joint meaning-making processes, and language is considered to have the leading role in that action (Hepburn & Potter 2004; Suoninen 1999). From the methodological point of view, discourse analysis means that the focus of the investigation is on language or, more precisely, on how social reality is constructed in different social contexts by means of language (Hepburn & Potter 2004; Suoninen 1999). Methodically, there are many ways of doing discourse analysis. Rather than giving detailed directions for carrying out a study, discourse analysis allows different approaches (Wood & Kroger 2000). The main idea, however, is that the focus of the study is on language, spoken or written, and the goal is to clarify how the meaning-making processes are constructed.

Discourse-analytically orientated researchers often favour natural data in their studies. Natural data are data that are collected in natural contexts and do not vary according to the researcher. Natural data can consist of everyday discussions, discussions of different institutions, newspaper articles, novels, reports, or proceedings (Juhila & Suoninen 1999; Wood & Kroger 2000). Discourse analysis focuses on language use rather than the user; therefore the units of analysis are spoken or written texts, not speakers or writers (Wood & Kroger 2000). The object of the analysis is often a small sample extracted from extensive corpus data (Juhila & Suoninen 1999).

The context of the study

Conducted in a rural eastern Finland comprehensive school in 2001, the study included an intervention of inquiry teaching for seventh-grade biology classes. The pupils studied water ecosystem issues; they formulated their own research questions and hypotheses, chose their research methods and equipment, carried out their investigations, and reported their findings. The teaching intervention offered the pupils opportunities for meaning-making processes in peer discussions and the use of different cultural tools. During their inquiries the pupils worked in six groups of three or four participants.

Collecting and selecting the data

The data was gathered by audiotaping peer discussions in the groups while they were working with their inquiries. Even though the learning environment had been manipulated for the purposes of the study, the data can still be regarded as natural, for the researcher did not intervene in the discussions. The audiotaping of the discussions of two groups failed, so that the data consisted of discussions of only four groups in the end. These audiotaped discussions were transcribed and a preliminary discourse analysis was carried out. In this analysis, the discussions of one group turned out to be the most illuminating by far, for they were more informative and showed a wider variety of different meaning-making processes than the other groups' discussions. Therefore the discussions of this group only, providing us with a total of 10 hours of data, were selected for further analysis. All the three participants in the group were girls, and their inquiry concerned the eutrophication of lakes, a theme they had chosen themselves.

Data analysis

The meaning-making processes of the group were analyzed by means of discourse analysis. First, the discussions were broken down into episodes according to the subject of the discussion. Second, the meaning-making processes of each episode were analyzed. In the analysis, the focus was on the construction of the pupils' meaning-making process: 1) Who took part in the meaning-making process and presented arguments? 2) What was the content of the arguments? 3) How did the pupils express their arguments? 4) How did the other pupils respond to their peers' arguments? 5) How did the arguments change and develop during the meaning-making? and 6) What was the common result of the meaning-making? After that, the different meaning-making processes were compared and categorized according to their similarities and dissimilarities. Lastly, the different speaking strategies the pupils used in their meaning-making processes were identified.

The basic premise of the discourse analyst is that the social world does not exist independently of our constructions of it; even research results are to be seen as constructions of the researcher (e.g., Hepburn & Potter 2004; Potter & Wetherell 1994; Wood & Kroger 2000). Nevertheless, researchers are expected to evaluate their study. In this study, the analysis results are backed up by presenting extracts from the transcribed data alongside the interpretations that are presented. The documentation of the data is particularly important in discourse analysis because the readers need to be able to make their own evaluations of the analytic conclusions (Potter & Wetherell 1994, p. 63; see also Wood & Kroger 2000).

Results

1 The pupils' speaking strategies

1.1 Rhetorical strategies

The pupils engaged in both rhetorical and dialogical discussions. In a rhetorical discussion, one pupil tried to lead the action and the meaning-making of the whole group by using rhetorical strategies. Three different rhetorical strategies were distinguished: monological, dismissive, and persuasive talk.

Monological talk

The simplest meaning-making processes of the pupils were those in which only one pupil took part in the investigation and exposed her views on the topic. In these situations the other pupils did not involve themselves in the investigative work but talked about something else. These meaning-making processes were non-interactive in that the investigation and the learning process proceeded on one pupil's terms only and there was no co-construction or intersubjectivity in the group. Even so, monological talk had a role to play in the pupils' meaning-making processes: the

pupil engaged in monological talk supported her own intrapsychological learning processes and called others' attention to the subject. After the monological episode was over, the mode of discussion would change from non-interactive to interactive.

Dismissive talk

Most of the pupils' rhetorical discussions were interactive. All the three pupils, Anne, Maria and Jenny (pseudonyms), took part in them and exposed their views on the topic at hand, as can be seen in the following extract.

HOW CAN WE PREVENT THE EUTROPHICATION OF LAKES? (Episode 54C)

M: How can we prevent nitrogen and phosphorus falling into the lakes?
J: Farming must be reduced if those nutrients come from cultivated land.
M: One of the most significant eutrophication factors of lakes is the fertilizers of agriculture. Especially nitrogen and phosphorus leach from cultivated land into lakes. The lake's nutrient level rises, and that causes the eutrophication of the lake. The high percentages of phosphorous are common in the summer, when rainwater dissolves phosphorous from the fertilized land. *[Reading information from the internet]*
A: Is it possible to use other stuff to fertilize the soil?
M: Eutrophication means that…öö…What is that research question we are looking at? *[Reading information from the internet and asking a question]*
A: "How can we prevent the eutrophication of lakes?"
M: Yes. How can we prevent the eutrophication of lakes.
J: The use of fertilizers must be reduced.
M: The most harmful nutrient is phosphorus *[Reading information from the internet]*
J: The use of fertilizers must be reduced and we must somehow try to prevent the nutrient leaching from the soil to the lakes.
M: How are we going to answer that research question?
J: We must answer that farmers must reduce the use of fertilizers.

In the above extract, the pupils tried to find a solution to their own research question on how to prevent the eutrophication of lakes. Anne proposed that farmers should use alternative fertilizers. Jenny's idea was that farming and the use of fertilizers must be reduced to prevent nutrient leach. Maria tried to find a solution to the question by reading new information from an internet website. So the pupils' views were based on new conceptual knowledge and on their current conceptual understanding of the topic.

While the pupils gave many alternative solutions to the research question, they did not listen to the others' comments and ignored them. The pupils' views competed with each other. Finally, only Jenny's ideas were noticed in the common meaning-making process. She led the joint meaning-making in her own direction. In the meaning-making processes, the pupils used dismissive talk when they wanted to dismiss other views and lead the group to work in their way. Dismissive talk is characterized by unwillingness to consider other people's points of view, and that turns the meaning-making process into a competition rather than co-construction of knowledge. For this reason, there was some arguing among the pupils. In the discussions that were constructed by dismissive talk, the pupils did not use their own resources, such as conceptual understanding, their own ideas or new knowledge, in effective ways, and important views often escaped their notice in the meaning-making.

Persuasive talk

The pupils also used persuasive talk to guide the group's action and meaning-making. In the meaning-making processes that were constructed by persuasive talk, the pupil exposed her views, listened to the others' views, gave reasons to support her views, and made insignificant concessions to bring the other pupils round to support her idea. Persuasive talk was characterized by the

pupil's goal to keep her own viewpoint and to convince and persuade the others to support it. In guiding the action and the meaning-making of the group, persuasive talk was more complimentary than dismissive talk.

WHAT ARE WE GOING TO WRITE IN THE RESEARCH REPORT? (Episode 87B)

M: In our report, we ought to use the knowledge we gather from the internet.
A: The teacher said we must report our laboratory work, too.
M: Yes. Yes. We can write about that at the end of the report. First, we'll report the information we gathered from the net, and after that we'll report our experiment. This is easier in practice because we don't need to keep many computer files open at the same time.
A: What are we supposed to do? Report only our experiment?
M: Hey, we must start the report now, we don't have that much time anymore.
A: But we can't just copy those texts from the net. We report only our own investigation. We don't just copy that stuff from the net.
M: We won't have enough text for the report if we only write about our own laboratory work. We must write more text. We don't have to write all the internet stuff word for word, we can rewrite it.

In the above extract, Maria disagreed with Anne about the content of the research report. In Maria's view the report had to include theory, and in Anne's view it had to include only the description of the laboratory work and its results. Maria accepted Anne's view but wanted to write about theory, too; so she persuaded Anne to see it her way. In the extract, the girls' points of view were based on their procedural understanding of research reporting and the instructions of the teacher. Because one pupil led the action of the group, the persuasive talk used did not promote the co-construction of knowledge or intersubjectivity in the group.

1.2 Dialogical strategies

The dialogical discussions were always interactive, for all the pupils were involved and all the expressed views were taken into consideration. The dialogical discussions were constructed by means of two strategies: cumulative and exploratory talk.

Cumulative talk

In the meaning-making processes that were constructed by means of cumulative talk (see also Mercer 1996; 2000; 2002) all the pupils were actively involved by exposing their views, both reasonable and unreasonable ones. All the views were accepted and a common understanding was constructed by either summarizing the voiced views or selecting one view and complementing it with the others. In such meaning-making processes, the speech tempo was usually fast and the pupils often broke off or continued each other's talk. The following extract demonstrates a cumulative talk episode where the common understanding was constructed by summarizing the voiced opinions.

HOW FAST DOES THE EUTROPHICATION OF LAKES PROCEED? (Episode 54B)

J: It depends on the pH-value.
M: Yes, and it depends on how large the lake is.
J: It depends on how widely those nutrients are spread in the lake. (Yes. That's it.)
A: And it depends on how fast the people interfere with eutrophication.
M: Yes. So, it depends on the size of the lake and how far the europhication is…
J: And we can write that it depends on the lake's tolerance for nutrients.
M: Yes…the lake's tolerance for nutrients and…
J: And how fast the people interfere with eutrophication.

All the speakers took part in the discussion and built on each other's contributions, added information of their own, and shared knowledge and understanding in a supportive, uncritical way. The pupils accepted all the views expressed without question. In these cases, the common understanding was constructed by collecting the pieces of knowledge together in a cumulative way. In this extract the pupils did not give reasons for their views. However, most of their views on the topic were based on information from the internet, which they had read before the discussion. In this case, the meaning-making proceeded through uncritical co-construction of knowledge, and the pupils had a shared understanding of what they were doing.

Exploratory talk

In some of the dialogical meaning-making processes, the pupils also questioned each other's views, as seen in the following extract, where the discussion about the prevention of the eutrophication of lakes continued.

HOW CAN WE PREVENT THE EUTROPHICATION OF LAKES? (Episode 54C)

J: The nutrient leach from the soil must be prevented.
A: But how does that happen?
J: If the amount of ditches is reduced? The teacher said that nutrients flow from the ditches.
M: Yes. Yes. If the amount of ditches is reduced?
A: But then the fields are flooded.
M: Yes. Then the fields are flooded (Yes).
A: That is a bad thing.
J: The nutrient flow from the ditches must be prevented.
M: It could be prevented, somehow. A filter!
J: A phosphorus filter!
M: A phosphorus condom! *[The pupils laugh at their ideas]*

In the extract, the others were critical of Jenny's first idea for solving the eutrophication problem of lakes. Anne challenged Jenny's idea and gave a reason, and the others agreed with her. After that, the pupils offered alternative and innovative solutions. The discussion got sidetracked when the girls began to laugh at their innovations. The meaning-making process was interrupted and the pupils did not develop their innovations further. Their views on the topic were based on their conceptual understanding and their own innovations.

In this extract, the common understanding was built during critical discussions and ponderings. According to Mercer (1996; 2000; 2002), such talk has been named exploratory talk. In the exploratory talk episodes, all the pupils took part in the discussion, presented reasonable and unreasonable explanations, which might then be challenged by giving reasons and offering alternatives. While engaged in exploratory talk, the pupils asked questions and gave critical comments; they also noticed and corrected each other's misunderstandings. The common understanding was constructed gradually during the conversation. The pupils offered relevant information for joint consideration and arrived at a shared solution as a result of the discussion. In this case, the meaning-making proceeded through critical co-construction of knowledge, and the pupils had a shared understanding of what they were doing. The exploratory talk episodes were often quite short and ended just when the discussion had reached a high level.

2 The utility of the speaking strategies

Rhetorical strategies promoted neither co-construction of knowledge nor intersubjectivity in the group. In these discussions the pupils approached the subject from a few viewpoints only, and many significant points escaped notice. The pupils were unable to benefit effectively from cultural tools such as their own understanding, new information, and other resources. Rhetorical strategies were also prone to cause misunderstandings. Furthermore, the use of rhetorical strategies constructed an unmotivated learning atmosphere that did not support collaboration.

Only the cumulative and exploratory strategies led to intersubjectivity in the group and to collaborative knowledge-construction. The use of these strategies created a motivated learning atmosphere that supported collaboration. In inquiry-oriented instruction, exploratory talk was the most effective way to collaborate. In the ensuing negotiations, both appropriation and externalization of knowledge took place. Exploratory talk was the only strategy that enabled the pupils to express their own innovations and use the cultural tools in effective ways to co-construct knowledge.

The pupils were unable to systematically benefit from exploratory talk in their learning processes; in their meaning-making they used mostly dismissive and cumulative talk. The use of exploratory talk was less frequent than that of the other strategies. In the pupil discussions, the strategies used would typically change fast, even with the same topic. The pupils were unable to use speaking strategies to promote their investigative work or joint meaning-making.

Discussion and conclusion

According to the results, the speaking strategies of the pupils played important roles in their interpsychological learning processes. Talk was their principal tool for creating a frame for their collaboration and learning. Through talk, they constructed their own Intermental Development Zone (IDZ) by talking. When the pupils used exploratory talk in their meaning-making, they operated just beyond their established capabilities and effectively benefited from their cultural tools in co-constructing knowledge. In contrast, when they used rhetorical strategies, their Intermental Development Zone collapsed and they benefited from the cultural tools in ineffective ways only. The IDZ of the pupils was a dynamic frame that changed according to the strategies they used.

Talk is particularly important in inquiry-oriented instruction, where the pupils are expected to construct a shared understanding of a topic by asking questions, generating explanations, searching for new knowledge, and constructing new ideas and innovations with their peers: in brief, to practise the use of the language of science. Hakkarainen (2003) uses the term *progressive inquiry* for such a sustained process of advancing and building knowledge. The agent of progressive inquiry, he points out, is not an individual but a knowledge-building community (Hakkarainen 2003). According to the results of this study, exploratory talk has a central role to play in inquiry-oriented instruction: when the pupils used exploratory talk in their meaning-making, they succeeded in creating a progressive inquiry culture. In such discussions they practised the use of the language of science in effective ways. But as soon as the meaning-making processes were constructed by means of rhetorical strategies only, the creation of a progressive inquiry culture failed.

Many science education researchers have emphasized the importance of pupil talk for learning, especially in regard to dialogical strategies (e.g., Anderson, Holland & Palincsar 1997; Dawes 2004; Kelly, Crawford & Green 2001; Richmond & Striley 1996; Ritchie & Tobin 2001; Stamovlasis, Dimos & Tsaparlis 2006). The case studies that have examined peer discussions can be categorized into two groups according to the occurrence of dialogical speaking strategies in them. Some studies have argued that pupils are incapable of dialogical discussions (e.g., Anderson, Holland & Palincsar 1996; Ritchie & Tobin 2001) or that dialogical talk is very rare in pupil discussions (e.g., Arvaja 2005; Richmond & Striley 1996). On the other hand, some studies have shown that pupils are capable of dialogical interaction, too (e.g., Dawes 2004: Engle & Conant 2002; Kaartinen 2003; Kelly, Brown & Grawford 2000; Kelly, Crawford, Green 2001; Roth 1995; Stamovlasis, Dimos & Tsaparlis 2006). It is worth noting that some of the latter studies were intervention studies designed to support the pupils in conducting arguments (e.g., Engle & Conant 2002; Kelly, Brown & Crawford 2000).

This study could be included in the latter category, for the findings indicated that meaning-making processes occurred with both rhetorical and dialogical talk. However, the pupils were unable to use cumulative or exploratory talk for effective meaning-making. In other words, they were unable to use talk as a cultural tool for collaboration. As to why exploratory talk was so rare in the pupils' meaning-making processes is an interesting question indeed.

One likely explanation is that the pupils' poor conceptual and procedural understanding precluded their use of exploratory talk. According to Kelly, Crawford and Green (2001), lack of subject knowledge rarely explains the poor level of pupils' peer discussions. They prefer to blame it on pupils' poor discussion and argumentation skills. The findings of the present study suggest, however, that there may be a mutual connection between the cultural tools and the speaking strategies. The strategies used may have affected the pupils' success in using the cultural tools for meaning-making, and on the other hand, the pupils' subject knowledge may have affected the quality of their discussions. For that reason, it might be useful in inquiry-oriented instruction to move from closed inquiry tasks towards more open-ended inquiry tasks according to the pupils' knowledge and skills.

Another possible explanation is that the pupils were not used to having exploratory discussions in the school context. Studies have indicated that teachers give few opportunities for pupils to discuss ideas in groups or for whole-class discussions about the interpretation of events, experiments, or social issues (Driver, Newton & Osborne 2000). Studies done in the Finnish school context have also indicated that dialogical strategies and the use of exploratory talk are rare in our schools (e.g., Arvaja 2005). The pupils taking part in this study had had years to absorb the Finnish school culture, so that they must have already constructed some ideas on how to study and learn at school. It seems that the fostering of successful progressive inquiry culture requires wider changes in the whole school culture (Arvaja 2005).

The low occurrence of exploratory talk in the pupil discussions could perhaps also be explained by their low involvement in their own learning. The pupils seemed to concentrate only on carrying out their inquiry task, not on their own learning or understanding. Inquiry teaching should not be seen only as a practical activity, as doing things; it should always include intellectual substance, too. Inquiry-oriented instruction gives pupils more control over their own learning, which makes the personal ownership of learning very important (Deboer 2004). Perhaps the pupils of this study were not used to taking responsibility for their own learning and therefore did not understand the importance of talk in their inquiry work.

Group activities, such as inquiry-oriented instruction, offer pupils good opportunities to practise the use of language for collaboration, but first they need to be taught how to talk and work together so as to get the most benefit for their learning (Mercer 2002). Dawes (2004, p. 693) describes the meaning of talk in this way: "We can move our children towards achieving their potential in science by teaching them what they can do with words." New language and new ways of using language are learnt by doing, which means primarily speaking and listening in the science-teaching context (Dawes 2004). The teacher must show the pupils how to use language for collaboration and must create a learning environment where pupils can explain their own understanding, express their uncertainties, ask questions, and present their own explanations, ideas and innovations (Mercer 2002). Besides the appropriation processes, the pupils should be encouraged to take part in the externalization processes typical for inquiry-oriented instruction.

This study is a contribution to the current discussion about the meaning of talk in the interpsychological learning processes that is going on among science education researchers. Even though this case study does not allow far-reaching claims to be made about the meaning of pupil talk, it has, in its own way, highlighted the importance of talk in inquiry-oriented instruction. Though many

studies have already shown that talk is one of the most effective factors in the interpsychological learning processes, more research is needed to get a holistic picture of pupils' interpsychological learning processes. What factors prevent and what promote the interpsychological learning processes in peer discussions? How do the social relationships, emotions and motivations of the pupils affect their interpsychological learning processes? How can we achieve a progressive inquiry culture in our science classrooms?

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