

Opportunities for Reflection:
E-mail and the web in the primary classroom

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Opportunities for Reflection

E-mail and the web in the primary classroom

PROEFSCHRIFT

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About four and a half years ago I took a train to Enschede to live there and start the research that is presented in this thesis. It was quite a long trip, and although I enjoyed the landscape that passed my window, the sound of the rumbling wheels on the rails also stressed a growing distance between me, my family and friends. I have felt a traveller ever since, and this thesis can therefore best be viewed as a landmark of my move to Twente, and of my personal journey across the field of educational science.

I hope that this thesis serves two goals for two different kinds of readers. On the one hand, I wish it to be a sound and nicely written "objective" scientific observation that is valuable to the field. On the other hand, for those who know me well enough, I wish it to be a traveller's diary that sheds some light on where I have been. They will probably recognize that I didn't move that far.

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Bregje de Vries
August 2004

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Chapter 1

Creating opportunities for reflection

Introduction

Constructivist learning environments emphasize the active role learners play in their own development by acknowledging the prior knowledge they bring with them when they enter a learning situation. Prior knowledge can be defined as “all knowledge learners have when entering a learning environment, and which is potentially relevant for constructing new knowledge” (Biemans, 1997, p.1). What constructivism seeks to do is tailor new classroom experiences to prior ones so that motivation to engage in the learning activity increases, and new information is embedded in existing knowledge structures. Some important theories have been developed that explain how prior knowledge can be a fruitful source for new knowledge construction, for instance conflict theory (Nussbaum & Novick, 1982), and conceptual change theory (Strike & Posner, 1985). And instructional models have been developed that are aimed at activating prior knowledge (e.g., Biemans, 1997).

In many classrooms, however, activation of prior knowledge stops after introducing a new topic or learning activity. Lessons still frequently start by inviting learners to activate and share their prior knowledge at the beginning of a lesson, after which “the lesson begins” and the teacher starts telling. In other words, learners are invited to bring in their prior knowledge and then asked to forget about it and follow instructions. At the end of the learning process, they are tested on how well they have done this. In such learning environments, old knowledge and new information do not easily meet. Rather than give rise to conflicts, it is expected that new experiences replace prior ones or become automatically related to it.

In this thesis, the aim was to enhance the opportunities that are currently given to primary school children to activate and use their prior knowledge, and to keep this prior knowledge active during the whole learning process. For that purpose, moments were built into the lessons that prompted children to reflect on their prior knowledge and on new classroom experiences to complete the learning task and reach a personal understanding in which prior knowledge and new experiences become related. Reflection is generally recognized as an important activity in learning. It strengthens the awareness of and regulative power over learning processes and can turn learners into independent and self-regulated thinkers (e.g., Baird, 1986; Lin, 2001; Simons, 2000). Reflection is also considered to be an essential learning

activity that can turn mere experience into real learning (e.g., Dewey, 1910; Kolb, 1984; Linder & Marshall, 2003; Schön, 1983; White & Gunstone, 1989). The general problem that is addressed in this thesis is:

How can reflection be embedded in the learning process to improve the development of personal understanding of a domain and learning task?

This introductory chapter gives a theoretical and methodological introduction to the studies that were conducted. In the next sections, the learning environment used in the studies is described. We depart from an approach called Learning-by-Designing. This approach is described and illustrated, and the design tasks used in this research are presented. After that, reflection is defined and we describe how moments of reflection are integrated in the design tasks through two reflective activities: narration and questioning. E-mail and the web are proposed as the means to support these activities. Finally, the methodology of the research, Design-Based Research, is described. Its specific concerns are described and the choices we made are explained. The chapter ends with a short overview of the other chapters in this thesis.

Learning-by-Designing

The approach Learning-by-Designing (LBD) is one of the forms that a constructivist view on learning can take. Historically, LBD fits within a long tradition of learning by doing (Dewey, 1910, 1916), and experiential learning approaches (e.g., Kolb, 1984). Essential to these approaches is the notion that theoretical knowledge can best be taught by engaging learners in practical learning activities. By alternating moments of action and reflection, problems can be solved and theoretical knowledge about problems can be developed. In this continuous cycle of acting and reflecting, a primary role is assigned to prior knowledge and personal preferences. They are considered to be the motor for thorough inquiry and problem solving that determine if and how newly arisen problems and available solutions are perceived (Dewey, 1910). Learning occurs when learners are engaged in problem solving activities that are relevant to them. Drawing on the work of Dewey, and Kolb, LBD values engaging learners in activities that are personally meaningful over guiding them through a preset and fixed line of reasoning.

LBD is also related to current approaches on problem solving, inquiry learning and discovery learning. It relates to problem solving in that the learning process starts with experiencing a problem. The goal of the learning activity is to solve that problem. LBD relates to inquiry learning in that it takes learners through activities such as observing, analyzing, drawing inferences, questioning, and reflecting. And LBD relates to discovery

learning because, next to reasoning, creativity and a sense of adventure are important. Personal appropriation of the problem and its solutions is central to the whole endeavour. This means that, to a certain extent, learners are given the freedom to explore problems in personally relevant directions.

But there is an important difference between LBD on the one hand and experiential learning approaches, problem solving, inquiry and discovery on the other. The difference lies in the emphasis that is put on domain-specificity. Mostly, processes of experiential learning, problem solving, inquiry learning, and discovery learning are represented by general models (e.g., Dewey, 1910; Friedler, Nachmias & Linn, 1990; Kolb, 1984; Kuhn, Black, Keselman & Kaplan, 2000; Njoo & De Jong, 1993). An example of a general model is the one that Rodgers (2002) derived from the work of Dewey. Rodgers discerns six phases: (1) experience, (2) spontaneous interpretation, (3) naming problems or questions, (4) generating possible explanations, (5) ramifying explanations into hypotheses, and (6) experimenting and testing selected hypothesis. In LBD, however, general strategies are translated into domain-specific and task-specific heuristics.

Why is domain-specificity important? One reason is that domain-specific heuristics can help instructional designers and teachers in integrating the demands of the curriculum into a constructivistic approach by specifying how general processes of inquiry and problem solving function in specific domains. Another reason is that domain-specific heuristics are probably more appropriate than general models to help learners to elaborate on their prior knowledge (cf. Janssen, 1999). A domain-specific heuristic can help to activate task relevant prior knowledge. As a result, learners have a better chance of becoming involved in the problem solving process and of being able to elaborate on what they already know. Other researchers have also suggested that self-directed approaches to learning should be integrated with domain-specific learning processes (e.g., Simons, Van der Linden & Duffy, 2000; Van Hout-Wolters, Simons, Volet, 2000).

LBD and a related approach called Problem-Posed Learning¹ have been studied at the University of Utrecht, the Netherlands, for some years now. Several domain-specific design heuristics in the domain of biology have been developed and tested in primary and secondary schools (Boerwinkel, 2003; Janssen, 1999; Knippels, 2002; Verhoeff, 2003). The domain of

¹ LBD as developed in the University of Utrecht is derived from Problem-Posed Learning (PPL) as developed by Klaassen (1995) and carried on by, among others, Knippels (2002) and Verhoeff (2003). The general aim of both PPL and LBD is to engage learners in meaningful scientific inquiry by posing a chain of partial problems that relate to their personal experiences. The main difference between PPL and LBD is that in LBD a specific kind of problem, i.e. a design problem, is solved and the process of problem solving is structured by the use of a domain-specific heuristic. In this thesis, we draw on experiences in both PPL and LBD, but the structure of LBD is adopted in the instructional design.

biology was also chosen in the research presented in this thesis, because it allows us to draw on their experiences. An even more important reason to choose the domain of biology is the fact that the Dutch government has declared a new biology curriculum (Dutch Department of Education, 1998; see also PgNOB, 1998). This new curriculum emphasizes cognitive and affective learning goals. It aims at the appropriation of concepts and facts, as well as the development of personal appreciations towards nature. Furthermore, problem solving, inquiry and discovery are put at the centre of the new curriculum. Emphasizing both cognitive and affective development, and promoting self-directed inquiry were also important goals in this research.

Learning-by-Designing in the domain of biology

What does LBD in the biology classroom look like? Generally, LBD in the domain of biology can be described as ‘learning through the act of designing a biological system according to a domain-specific design principle through guided reinvention’. Biology scientists view biological systems (e.g., animals, plants, ecosystems) as good designs in the sense that they are optimally designed to survive and reproduce themselves in their environment. The idea behind LBD in the domain of biology is that by re-inventing these good designs, children can discover how nature works. In particular, they can discover the domain-specific design principles that lie behind these good designs. The following paragraphs describe two key issues in LBD: selecting design problems, and supporting the design process.

Selecting design problems

One of the most important design principles in biology is the form-function perspective (Boerwinkel, 2003; Janssen, 1999). From this perspective, a biological design is studied by asking ‘How does form X fulfill function Y?’ By posing this question, children can learn to use one of the leading principles for looking at biological systems. An example of a design problem studied from the form-function perspective is given in Figure 1-1. The example illustrates several characteristics of a design problem. First, it shows that the kind of problems that are solved are realistic problems that can be encountered in real life. Other examples of problems could be ‘How does the blood circuit work?’ and ‘How does a tree grow?’ Second, the example illustrates that the underlying structure of the design problem is a chain of partial problems whereby the solution to one partial problem gives rise to the next. The design process starts with the

presentation of a main problem that is too big to be solved at once. Therefore, iterative steps of partial problem solving are taken.

How does a spider catch its food?

The spider could hunt actively for its prey, but that takes a lot of energy. Another possibility is to wait until an insect passes by. The disadvantage of this is that the range for catching food is very limited. This can be solved by building a web.

But the making of a web presents other problems. The first problem is how to span the space where the web is going to be built, e.g. between two trees. When the spider has constructed a first 'bridge cable', it can walk across it and build its web. But how to construct this first bridge cable? The spider could go down one side and climb up on the other. But there is another possibility. Can't spiders fly some sort of kite and attach the tread to it to be carried across?

How does the spider keep the insect in the web? If the web is too tight, it could tear. If it is too loose, it works as a kind of trampoline on which the insect can rebound. So it is important to make the web with the correct tension.

This does not mean that the insect is definitively caught, because the spider has to prevent the prey from escaping. This could be done by making the web sticky, so that the insect gets stuck. But especially larger insects manage to get free rather easily. How to prevent this? The spider could kill its prey as quickly as possible, but biting to death is difficult, because the insect is often bigger than the spider itself. Spiders can give a lethal injection and this is what they often do, in fact. Moreover they 'bandage' their prey, so that there is no way of escape.

*Figure 1-1 Example of a design problem
(Translated and shortened from the lesson series 'Living Together')*

Many partial problems can be derived from a main problem. Hence, the prior knowledge that learners bring with them to a learning situation plays a decisive role as it influences if and how a problem is conceived and which solutions will be thought of. Different kinds of prior knowledge are useful in the design process ranging from concepts/facts remembered from earlier lessons to related stories, and appreciations of the topic. For instance, when designing a fish's biotope prior knowledge about sport fishing may become relevant. When designing a fox's biotope, having chickens at home might help. In the example of the spider, children may benefit from flying kites when thinking about making webs.

Supporting the design process

The active use of prior knowledge in the design process is supported in three ways. First, a design heuristic is provided. This heuristic is derived from the form-function perspective. It contains statements or questions that decompose the main problem into partial problems that can be dealt with separately. By applying the heuristic, learners can activate and explore their prior knowledge in directions that are fruitful for solving the problem. What the heuristic looks like in detail depends on the context in which it is used. It may contain concrete questions or abstract statements, may be hierarchically structured, and provide examples. For instance, Boerwinkel's (2003) heuristic was used in primary school for designing such things as an eyebrow. It contained questions and subquestions. In addition, there were examples, and it was used in combination with hands-on activities. Janssen's (1999) heuristic was used in secondary school to design the human immune system. It contained abstract statements but no examples, and was not accompanied by hands-on activities.

Second, the teacher facilitates and guides the active use of prior knowledge and further student exploration. He facilitates the activation of prior knowledge by establishing a safe and inviting climate for their articulation and sharing. In many school settings, the teacher talks and the children listen. Therefore, it is probable that many children are not used to bringing in their prior knowledge. A climate has to be established in which this is welcomed and rewarded. Besides facilitating the activation of prior knowledge, the teacher guides the process of further exploration. He explains and demonstrates use of the heuristic. After modelling its use, he supervises the children's independent use and helps them move from one partial problem to the next. Teacher guidance is necessary to help learners stay focused on the partial design problems and the heuristic, and think through solutions (Boerwinkel, 2003; Janssen, 1999; Knippels, 2002; Verhoeff, 2003). For this purpose, the teacher has a problem structure at his disposal. It gives an overview of the partial problems, their solutions, how they relate to each other and to the design problem as a whole. With the problem structure he can see where children are in the problem solving process, and where they are heading. He can also see which partial problems are overlooked and need additional support from the teacher or fellow learners.

Third, LBD is implemented in a collaborative learning environment so that explication of prior knowledge becomes necessary and opportunities for comparison and elaboration are raised. In principle, LBD can be undertaken individually as well as in groups. But often learners find it difficult to keep the process going, especially when it comes to critically evaluating solutions

(Boerwinkel, 2003; Janssen, 1999). Group work in general is expected to stimulate articulation and elaboration of prior knowledge (Verhoeff, 2003) and reflection (Knippels, 2002). Furthermore, research has also pointed out that combining individual and group work enriches the exchange and evaluation of ideas (Renshaw, 2004; Renshaw & Van der Linden, 2002; Dysthe, 1996; Mason, 1998; Van Boxtel, Van der Linden & Kanselaar, 1997). Hence, to maximize the opportunities for sharing and comparing experiences, individual and group work could be combined.

The design tasks used in this thesis

Three LBD lesson series were developed comprising six lessons of two hours each². The lesson series had a similar set up. The first one or two lessons introduced the topic and the LBD approach. In the next lessons, the children solved a design problem. In the sixth lesson, the designs were presented and discussed. The three lesson series are shown in Table 1-1.

Table 1-1 Overview of the three lesson series

Lesson series	Global design problem	Central issues
Surviving	'How does an individual plant/animal survive?'	Forms and functions of individual plants and animals. <i>Main themes:</i> food, reproduction
Working Together	'How does a colony of insects survive by collaborating with each other and with their environment?'	Forms and functions of colonies of insects. <i>Main themes:</i> food, reproduction, task division, mutual interdependence
Living Together	'How does an ecosystem keep its balance?'	Forms and functions of ecosystems. <i>Main themes:</i> food, reproduction, human influence, mutual dependence of biotic and abiotic factors

² All lesson series were developed by a team consisting of instructional designers, LBD specialists, teacher trainers and domain experts. In the studies reported in this thesis the lesson series 'Working Together' and 'Living Together' were used (see Zwiers, Janssen & De Vries, 2000).

The lesson series covered an important part of the biology curriculum for upper grades in primary schools. They addressed three biological areas: plants, animals, and abiotic factors (cf. De Vaan & Marell, 1999). Some themes were food chains and reproduction. The three lesson series addressed these themes at different levels of biological organization. In the lesson series 'Surviving', individual plants and animals were studied and designed. In the lesson series 'Working Together', communities of insects were studied and designed. In the lesson series 'Living Together', an ecosystem with biotic and abiotic factors was designed.

In the lesson series, the three supportive measures outlined before (design heuristic, teacher guidance, and combining individual/group work) were put at the centre of the lesson plans. The design heuristic that was used in the three lesson series consisted of five questions derived from the form-function perspective. The questions were formulated in the 'I'-form to personalize the object and invite children to look at a biological system from their own points of view:

- Who am I?
- What must I be able to do?
- What do I need for that myself?
- What do I need for that in my environment?
- Who do I need for that in my environment?

The design question 'Who am I' invites children to choose the (sub)system to be designed (e.g., a fish). The design question 'What must I be able to do' invites them to think of the functions of the system (e.g., eating, breathing, reproducing). The design question 'What do I need for that myself' asks them to name the forms that the system has at its disposal to fulfill the functions (e.g., mouth, gills). The design questions 'What do I need for that in my environment' and 'Who do I need for that in my environment' ask them to name the forms in the environment that are needed to fulfill the function (e.g., water, other fish). The question of who is needed appeared only in the lesson series Working Together which was about collaboration within communities.

To support usage of the heuristic, it was presented as a paper tool. In the initial stages of the research, a worksheet presented the questions in a list. Later on, children used a design wheel (see Figure 1-2). The wheel could be rotated. This appeared to have two advantages. First, the children became more flexible in choosing which question to pose next. After answering the questions 'Who am I' and 'What must I be able to do', they could choose for each one of the other questions. Second, using the heuristic became a matter of thinking as well as doing.

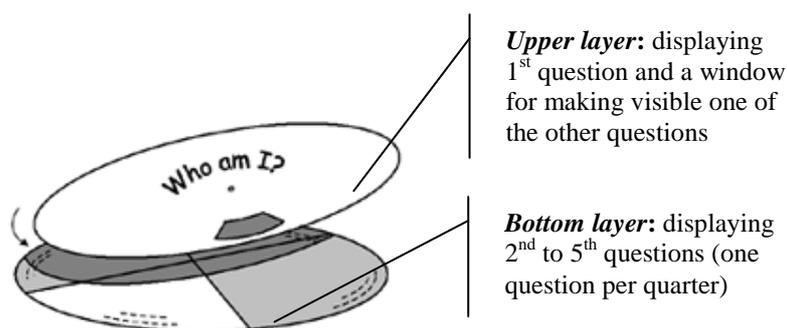


Figure 1-2 Schematic representation of the design wheel

The lesson plans contained problem structures and concept maps of the design problems to support the teacher’s preparations and his guidance of children’s group work. Table 1-2 shows part of a problem structure.

Table 1-2 Part of the problem structure of the ‘Working Together’ lesson series

Lesson	Partial design problems	Solutions
2	Learn to work with the design heuristic ‘What does my insect look like and why does it look that way?’	Make and use heuristic/paper wheel Exploring general properties of insects
3	Design an individual bee / ant ‘What must a bee / ant be able to do? What does it eat? How does it reproduce?’	Functions and forms of a bee/ant, e.g., eating, flying, housing, defence Forms that are needed to reproduce
4	Design a community ‘Which tasks have to be taken care of by whom so that the queen can reproduce?’	Task divisions: queen (reproduce), certain males (impregnation), soldiers (protect), scouts, collectors, workers (feed, take care), all (communicate)

Whereas other LBD studies have emphasized cognitive development in the domain of biology (Boerwinkel, 2003; Janssen, 1999), this research

products that the children created were concept maps of biological systems consisting of annotated form-function relationships completed with drawings and detailed written information. Examples are found in Figure 1-3. The children developed their own ways of expression, for instance by using coloured paper, windows to hide detailed information, and by adding fantasy stories.

Embedding deliberate moments for reflection

The design heuristic was intended to stimulate children to activate and question their prior knowledge in fruitful directions for problem solving. However, research on LBD in primary and secondary classrooms has shown that usage of such design heuristics is not without difficulties. For example, Boerwinkel (2003) found that children successfully used the heuristic to activate and articulate their prior knowledge, but were less successful in elaborating on it. In addition, he found that most children did not learn to see the form-function perspective as a way to approach new design problems. Similar difficulties were mentioned in related research on Problem-Posed Learning. Klaassen (1995) and Knippels (2002) therefore suggest that specific moments for reflection should be built into the design process. Knippels argues that reflection can help learners to recapture the problem solving process and formulate a final answer to a partial problem. This answer can then be connected to earlier partial problems and make learners aware of the next partial problem that needs a solution.

In the present study, moments of reflection are built into the design tasks to overcome these difficulties. It is expected that reflection helps the children go beyond what they already know and complements the usage of the design heuristic. Whereas the design heuristic aims at the activation and articulation of prior knowledge, reflection can help children to elaborate on it and recapture it at the end in light of new classroom experiences to reach personal understanding. In the context of this research reflection is now defined as:

‘thinking about the process and product of designing by elaborating on and recapturing of prior knowledge and new classroom experiences’

To embed reflection in the design task, several decisions about the setup of the lessons have to be made. First, it has to be decided which moments in the design task will be dedicated to reflection. Second, it has to be decided what kind of reflective activities will be built into the lessons. Third, it has to be decided by which means the children are going to reflect. The next sections address these issues.

Reflection in and on action

First of all, in the lessons time should be reserved for reflection. Children should be given the opportunity to reflect by having the time to do so. Moments of reflection often remain implicit. In these cases, action and reflection are not separated as two distinct ways of grasping experience. This resembles Dewey's (1910) theory of reflective thinking in which action and reflection were intertwined and taking place at the same time as if they are one and the same thing. In his theory on experiential learning, Kolb (1984) pictures action and reflection as two alternating activities. Action and reflection are viewed as two separate, complementary processes.

The distinction between action and reflection was further worked out by Schön (1983). In his studies on professional thinking and development, Schön distinguishes between reflection in and on action. Reflection-in-action is described as reflective thinking while still in the midst of task completion whereas reflection-on-action occurs after a task is completed. Reflection-in-action is triggered by unforeseen changes, surprise, curiosity and the like. For instance, when an architect has designed a house and new calculations show that the roof is too low, reconsidering earlier decisions may be needed to solve this unforeseen outcome. Reflection-on-action is triggered by the need to recapitulate the process and product of an action. For instance, when a football match has ended, an evaluation of it may take place in the changing room.

Although both reflection in and on action serve the goal of task completion and personal understanding, their timing and hence their focus differs. Reflection-in-action serves to solve the problem whereas reflection-on-action serves to understand the problem and its solution after it has been solved or abandoned. In the context of this study, moments of reflection-in-action aimed at the *elaboration* on prior knowledge and new classroom experiences. Moments of reflection-on-action aimed at *recapturing* prior knowledge and new classroom experiences.

Designing reflective activities

The most effective means that humans have at their disposal to explicate, store, and develop personal meaning is language (Dewey, 1910; Vygotsky, 1934). Two language-based activities that are often mentioned in the literature as being central to human cognition in general and reflection in particular, are narration and questioning. Bruner (1996) depicts narration as the most basic act through which we make sense of the world. Similarly, Wertsch (1998) describes the narrative as a tool for representing the past. Both Bruner and Wertsch characterize narration as a means to re-construct

past experiences. This means that the experience itself should have come to an end. To achieve the goal we set for reflection-on-action, i.e. recapturing prior knowledge and new classroom experiences, narration seems a suitable activity. Therefore, *narration* was embedded in the lessons to support reflection-on-action.

In contrast, questioning is often described as part of an ongoing inquiry. It is a short notice activity that can give direction to the learning process. For instance, Chin, Brown and Bruce (2002) argue that questioning aims at grasping experience and directing future learning. Similarly, King (1991) states that questioning gives direction to problem solving and makes learners aware of the strategies they are using. Rosenshine, Meister and Chapman (1996) argue that questioning supports processing of new information and monitoring of the learning process. In short, questioning is claimed to promote cognitive and metacognitive awareness while working on a task. To achieve the goal we set for reflection-in-action, i.e. elaboration on prior knowledge and new classroom experiences, questioning seems a suitable activity. Therefore, *questioning* was embedded to support reflection-in-action.

Reflecting collaboratively

In the lessons that we implemented in the classrooms, children worked in small groups of two to four children on the design tasks. The benefit of a social setting for reflection has been pointed out by many researchers. It is said that group work encourages reflection because of the presence of active listeners that can point out irregularities and bring in different viewpoints that can raise the awareness of conflicting ideas (e.g., Boud, Keogh, Walker, 1985; Cohen & Scardamalia, 1998; King, 1998; Knights, 1985; Knippels, 2002; Kravtsova, 1999; Lin, 2001). Because working in groups was expected to be beneficial and supportive of reflection, we wanted narration and questioning to be collaborative activities.

It has also been pointed out that written communication is more fruitful for reflection than oral discourse. It is argued that writing helps people to gain distance from the experience, slows down the communication so that learners have time to reflect, and produces written records for further deliberation (e.g., Cohen & Scardamalia, 1998; Mason & Boscolo, 2000; Walker, 1985).

Some researchers have argued that a combination of oral and written communication is the most beneficial. For instance, Dysthe (1996) used individual written preparations as the input for whole class discussions and found that the writings enriched the oral communication: "Compared to a traditional oral discussion, using written student texts as discourse initiators gave more students a chance to participate and introduced a greater diversity

of views and perspectives” (p.419). Similarly, Rivard and Straw (2000) embedded group discussions into individual writing and found talking and writing to be complementary: “Oral discourse is divergent, highly flexible, and requires little effort of participants while they collectively explore ideas, but written discourse is convergent, more focused, and places greater cognitive demands on the writer” (p.583). Thus, when designing narration and questioning as group activities, a balance between group talk and written reflection is recommended.

Providing technological means

Reflection, especially by young learners, tends not to come about easily. Besides support from teachers and fellow learners in a collaborative learning environment, technological tools can provide the necessary support. In recent years, many studies on how to use the computer for reflection have been published (e.g., Cohen & Scardamalia, 1998; Collins & Brown, 1988; Kyza & Edelson, 2003; Lin, Hmelo, Kinzer & Secules, 1999; Scardamalia & Bereiter, 1993; Seale & Cann, 2000; Schwartz, Lin, Brophy, & Bransford, 1999). In the research presented in this thesis, two computer tools were added to the learning environment to support reflective narration and questioning. E-mail was embedded for the purpose of reflection-on-action through narration. The web was embedded to support reflection-in-action through questioning.

There are several reasons to choose e-mail and the web. First, they are very commonly used applications and have become readily available in almost every Dutch primary school in the last couple of years. In addition, many primary school teachers in the Netherlands have learned how to use e-mail and the web in schooling programs initiated by the Dutch government. Thus, e-mail and the web are present in most primary schools and the majority of teachers knows how to use them. Second, e-mail and the web represent two distinct branches of ICT: communication and information. Embedding e-mail and the web provides teachers and children with the opportunity to gain experience in those two branches. E-mail provides the opportunity for learning how to use the computer for communication. The web provides the opportunity to gain experience in information processing. Third, e-mail and the web both have specific characteristics that are expected to promote reflection. E-mail has found to be appropriate for reflection because it delays communication at a self-chosen pace, resembles both talking and writing, automatically records messages, and brings together peer learners (e.g., Baron, 1998; Huang, Watson & Wei, 1998; Loveless, 2003; Russell & Cohen, 1997; Yu & Yu, 2002). The web is a rich and flexible information source. The multiple sources that are available and the flexible way in which content is organized can support the comparison of

ideas and prompt active knowledge construction (e.g., Salomon, 1998; Todd, 2000b).

Many questions related to effective e-mail use and web use in classrooms still need to be answered. The research presented in this thesis seeks to contribute to this field of research by exploring the possibilities of e-mail and the web to induce reflection in groups. The general problem addressed in this thesis can be specified into the following research questions:

- (1) *How does narration via e-mail support reflection-on-action?*
- (2) *How does questioning with the web support reflection-in-action?*

Research in the classroom is needed to answer these questions. Design-Based Research is chosen as the research paradigm. The next section describes the characteristics of this approach and gives an overview of the research presented in this thesis.

Methodology: conducting Design-Based Research

The past few decades have seen changing views on learning and instruction which have influenced the ways in which learning and instruction are studied. There has been a growing awareness of the contextual nature of learning and instruction (e.g., Bruner, 1996; Rogoff & Lave, 1984; Wenger, 1998). Traditional teacher-centered views on learning are more and more replaced by constructivist ones in which the active knowledge construction by the learner is central (e.g., Hedegaard & Lompscher, 1999; Simons, Van der Linden & Duffy, 2000). Furthermore, it is increasingly recognized that conducting educational research means becoming part of a social and political practice (e.g., Applebee, 1996; Bereiter, 2002; Eisenhart & Towne, 2003; Kernan, 1997; Schwandt, 2000). A result of these changed views is that some researchers have argued that learning and instruction should be studied within the complex and natural environments in which they occur instead of in laboratory settings (e.g., Brown, 1992; Kelly, 2003). It is further argued that new methods are needed to conduct such research: “The commitment to examining learning in naturalistic contexts, many of which are designed and systematically changed by the researcher, necessitates the development of a methodological toolkit for deriving evidence-based claims from these contexts” (Barab & Squire, 2004, p.2; see also Maxwell, 2004).

One methodology that takes the situated and transformative nature of educational research into account is Design-Based Research (DBR)³. In DBR, studies are conducted in natural settings by implementing instructional designs and observing emerging practices. The setup of DBR is characterized by design experiments that follow one another and aim at “systematically adjusting aspects of the designed context so that each adjustment served as a type of experimentation that allowed the researchers to test and generate theory in naturalistic contexts” (Barab & Squire, 2004, p.3). The goals of DBR are twofold. On the one hand, DBR seeks to develop and improve instructional designs (e.g., Barab & Squire, 2004; Fishman, Marx, Blumenfeld, Krajcik & Soloway, 2004; Kelly, 2004). On the other hand, DBR seeks to contribute to a better understanding of learning processes by developing theoretical constructs that describe and explain classroom practices that emerge from instructional designs (e.g., Brown, 1992; Cobb, Confrey, diSessa, Lehrer & Schauble, 2003; The Design-Based Research Collective, 2003). In relation to the latter, Kelly (2004) argues that design experiments are especially appropriate for idea generation: “[...] design studies, particularly to the extent that they are hypothesis and framework generating, may be viewed as contributing to model formulation (rather than for model estimation or model validation). Model and hypothesis generation is a crucial part of conducting a worthwhile scientific investigation. It does not represent some ‘pre-scientific’ messing around that should be accorded little status” (p.122). Other researchers as well have pointed out that DBR is appropriate for generating theoretical themes and constructs around educational innovations and to a lesser extent for model estimation and validation (diSessa & Cobb, 2004; Shavelson, Phillips, Towne & Feuer, 2003; Sloane & Gorard, 2003).

Exploring and understanding the nature of reflection with new technological means is the focus of this thesis. Because this is in agreement with the exploratory scope of DBR, the research presented here commits itself to the general intentions and procedures of DBR. Four design experiments were conducted in which instructional designs were developed and implemented in several primary classrooms. Conducting the design experiments was aimed at improving the instructional designs as well as at deriving theoretically oriented explanations for the emerging practices that can inform future research into computer supported collaborative reflection in the primary classroom.

³ Recently, DBR has received renewed attention in special issues (Barab & Squire (Eds.), 2004; Kelly (Ed.), 2003). This is not to say that the approach is entirely new. Under different headings such as ‘developmental research’ and ‘educational design’, many researchers have followed similar approaches (e.g., Gravemeijer, 1994; Lijnse, 1995; Richey & Nelson, 1996; Van den Akker, Branch, Gustafson, Nieveen & Plomp, 1999).

General procedure of the design experiments

Four design experiments were conducted that all examined the process of reflection with ICT in the primary classroom. The first two design experiments focused on the use of e-mail for reflective narration. The third and fourth design experiment focused on using the web for reflective questioning. General guidelines from qualitative research, grounded theory and case studies (e.g., Charmaz, 2000; Flagg, 1990; Glaser & Strauss, 1967; Yin, 1984) were followed on three important matters: case selection, data gathering, and data analysis. To select cases, it is important to consider the general aims of the study and accordingly decide which selection criteria need to be applied. The research reported here was explorative and descriptive. It sought to generate ideas about using new technologies for reflection rather than validate existing theoretical constructs. In such studies, case selection is less rigid (Mitchell, 1999; Platt, 1999; Stake, 2000). Therefore, no strict criteria were formulated and a diversity among cases was valued above representativeness and more specific qualities.

A broad range of qualitative data were collected to triangulate findings. Data were gathered to obtain insight in three matters: implementation of the instructional designs by the teachers, the children's motives for getting engaged in the lessons and in reflective activities, and the reflective nature of children's narrating and questioning. The data gathering process included classroom observations, written reports of teachers, formal and informal interviews with teachers and children, design products of the children, audio recordings of the children's group work, and computer logs, among others.

When analyzing the data, within-case descriptions were made before conducting cross-case analyses (Eisenhardt, 1999; Yin, 1984). The descriptions of the cases focused on the teachers' implementation, the children's motives and behavior, and the nature of the reflections. Sensitizing data fragments that were exemplary for the observed emerging practices were used in the case descriptions to illustrate findings. After that, cross-case analyses were conducted. Findings were summarized and structural similarities and differences between cases were listed. In the process of cross-case analyses, within-case descriptions and more data were re-consulted from time to time to make a close fit between the emerging general impressions and the individual cases.

Overview of the four design experiments

The general problem that is addressed in this thesis is how reflection can enhance the activation of, elaboration on and recapturing of prior knowledge and new classroom experiences during the learning process in order to reach a personal understanding of a domain and learning task. Two research

questions were derived from this problem: (1) How does narration via e-mail support reflection-on-action? (2) How does questioning with the web support reflection-in-action?

Four design experiments are conducted in which deliberate moments of reflection-on-action and reflection-in-action are implemented in several primary classrooms. Two conditions for reflection were created. First, collaborative reflection-on-action through the exchange of narrations via e-mail. Second, collaborative reflection-in-action through self-generated questioning with the web. In chapters two to five, the design experiments are described.

In chapter 2, the first design experiment is described that aimed at the implementation of reflection-on-action by letting groups of children exchange written narrations about the lessons via e-mail with a partner group at another school. In this first design experiment, a theoretical introduction to narration and e-mail use in primary classrooms is given and the way in which e-mail was implemented in the classrooms is described. Central to the instructional design is a paper worksheet. In the data analysis, the focus is on the teachers' implementation of reflective narration through the use of e-mail, the group's motives and behavior, and the reflective nature of the e-mails. The outcomes of the first design experiment are twofold. First, improvements to the instructional design are formulated. Second, an operational definition of reflective narration is derived from the data.

In chapter 3, the second design experiment is described. Similar to the first one, it aimed at reflection-on-action through the exchange of group narrations via e-mail. Building on the findings from the first design experiment, the instructional design was improved by adding an individual freewriting exercise in preparation of the group process of writing an e-mail. In the data analysis, we focus on the teachers' implementation of freewriting, the children's motives and behavior related to freewriting, and the reflective nature of collaborative narration. The outcomes of the second design experiment are an improved instructional design on the one hand, and a refinement of the operational definition of reflective narration by adding a collaborative perspective on the other.

In chapter 4, the third design experiment is described. It aimed at reflection-in-action by using the web to find answers on self-generated questions. A theoretical introduction to questioning and web use in primary classrooms is given and the way in which the web was embedded in the classrooms is described. Central to the instructional design are a task-specific categorical portal and a paper worksheet. In the data analysis, the focus is on the teachers' implementation of questioning with the web, the children's motives, and the reflective nature of the questions and answers. The outcomes of the third design experiment are twofold. First,

improvements to the instructional design are formulated. Second, an operational definition of reflective questioning is derived from the data.

In chapter 5, the fourth design experiment is described. Similar to the third one, it aimed at reflection-in-action through questioning with the web. Building on the findings from the third experiment, the instructional design was improved by developing the portal into a task-specific hierarchy, and by extending the worksheet. In the data analysis, we focus on the teachers' implementation of and the children's motives for using the new portal and worksheet, the reflective nature of the questions and answers, and the reflective nature of collaborative questioning. The outcomes of the fourth design experiment are an improved instructional design, and a refinement of the operational definition of reflective questioning by adding a collaborative perspective.

In chapter 6, a summarized overview of the four design experiments is given and an answer to the two research questions is formulated. A comparison between using e-mail and the web for reflection is made. Finally, some pedagogical implications and future research directions are discussed.

Chapter 2

Design experiment 1: Reflection-on-action by e-mailing narratives

Introduction

The first chapter argued that moments of reflection need to be created in the learning environment to help children make active use of their prior knowledge and build a personal understanding. We defined reflection as ‘thinking about the process and product of designing by elaborating on and recapturing of prior knowledge and new classroom experiences’. A moment of reflection-on-action was proposed to help the children recapture their learning experiences at the end of the learning process. Narration was suggested as the activity through which this could take place. And e-mail was proposed as the technological means that can engage the children in narration and reflection-on-action.

This chapter explores how narration via e-mail can support reflection-on-action. A design experiment was conducted in two classrooms in which groups of children exchanged e-mails about the lessons with a partner group at another school doing the same lessons. The design experiment sought to answer the following research questions:

- (1) *How can e-mail be implemented in the classrooms so that it engages children in reflective narration?*
- (2) *What is the reflective nature of the narrations?*

The first research question focuses on the development and evaluation of an instructional design. The second research question focuses on gaining insight in the nature of the narrations and seeks to develop a definition of reflective narration via e-mail.

The following sections explore in more detail how narration and e-mail may function in the classroom. We argue that educational researchers recognize narration as a valuable instructional activity, but also conclude that up till now its implementation has been lagging behind. Three perspectives on narration are presented that can help unfold its educational potential. Next, we consider the use of e-mail for the purpose of reflective narration. We discuss characteristics of e-mail that are likely to support it. Difficulties with writing and e-mail use as found in the literature are discussed as well. Then, the first design experiment is presented. Successively, we describe the

key elements of the instructional design, and the participants, procedure and results of the design experiment.

Three perspectives on narration

Narration lies at the heart of human thinking and learning. It is the most natural and earliest way in which we organize experiences and create personal meaning (Bruner, 1990). An early illustration of the impact of narration comes from Bartlett's (1932) famous research on people's recounts of the 'War of the ghosts' story. That research showed that remembering is an active process in which memories are re-created from a personal perspective by capturing them in a narrative structure. Similarly, Wertsch (1998) showed that pupils recall historical events by re-creating narrative accounts of such events. According to Bruner (1996), narratives bridge what is learned inside and outside the school. He states that narration is "the mode of thinking and feeling that helps children create a version of the world in which, psychologically, they can envisage a place for themselves - a personal world" (p.39). Thus narration can be considered a reflective activity, because already owned information is reorganized in a personally meaningful way.

Schools should therefore facilitate its occurrence in the classroom. Bruner (1996) argues that: "A system of education must help those growing up in a culture find an identity within that culture. Without it, they stumble in their effort after meaning. It is only in the narrative mode that one can construct an identity and find a place in one's culture. Schools must cultivate it, nurture it, cease taking it for granted" (p.42). However, schools generally give their children relatively few opportunities for narration. The prevailing classroom dialogue is the *IRF*-pattern in which the teacher *Initiates*, the learner *Responds*, and the teacher provides *Feedback* (e.g., Dysthe, 1996; Mason, 1998). These dialogues do not use narration as a central mode of thinking and give children little opportunity for practicing and improving that mode.

But what is narration? And what does it look like in the context of education? In its most general sense, narration can be described as an act of articulation in the form of a chronicle with specific narrative characteristics. The following characteristics are mentioned in the literature: a description of events organized in a plot with a beginning, middle and end, and a narrator's point of view from which these events are told (e.g., Bruner, 1996; Champion, 1998; Wertsch, 1998). In other words, a narrative contains a chain of events organized into a coherent schema from a personal perspective (i.e., the narrator). Sequencing makes visible the connection between events in a plot. And a narrator's perspective brings to light intentions, interpretations, and evaluations related to these events.

In many definitions, narrating is narrowed down to a literary endeavour of telling a specific kind of story in a specific literary structure. The focus is on classic literary stories. No distinction is made between different forms and functions of narratives, and between the different media in which narrating takes place. In the context of education, however, such a distinction is critical. First, defining narration should distinguish between different narrative forms. Research shows that children's narratives take different forms depending on their intentions and on the instruction that is given (Champion, 1998). Champion argues that different structures should not be treated as deviations from the ideal (i.e., the literary story), but should be acknowledged for what they seek to achieve (cf. Cook-Gumperz & Green, 1984). Second, defining narration should distinguish between the many functions it can have. Narration in education can be aimed at a diversity of things such as conceptual understanding (e.g., Wertsch, 1998), moral development (e.g., Champion, 1998), and reflection (Walker, 1985). Each function demands its own way of support and evaluation. Third, defining narration should distinguish between the media in which it is realized. For instance, narration can occur oral or written, electronically or on paper, collaboratively or individually. In short, to embed narration in educational settings, an approach is needed that takes into account its form, function, and medium.

Conle (2003) proposes three perspectives on narration that can help exploit the potential of narration in education. The first perspective is *the act of narrating*. It depicts narration as an act that originates in someone's willingness to tell a story in a certain context. Many contextual factors influence this willingness, for example the availability of tools, the audience, and the atmosphere in which one has to produce a narration. The second perspective is *the rhetorical statement*. It depicts narration as a communicative act in which a narrative statement is produced that has certain rhetorical characteristics to convey the message. Examples of narrative statements are a written journal, an oral presentation, a letter, or a literary story. Examples of rhetorical characteristics are enumerations in sheets used with a presentation, greeting rituals in a letter, and indirect speech in a literary story. The third perspective looks at *the story*, i.e. the content that wants to be told. This perspective resembles the general definition of narratives given above.

In this study, narration was implemented in the lessons for the purpose of reflection-on-action. E-mail was used for the exchange of the narrations between groups. Conle's (2003) three perspectives are applied to this context. They provide a framework for the instructional design and the analysis of reflective narration via e-mail. From the perspective of the act of narrating, we need to look at the context in which narration was realized. From the perspective of rhetorical statement, we need to look at the

characteristics of the e-mails and how they convey the reflective narration to a real but distanced audience. From the perspective of the story, we need to look at the reflectivity in the stories to see if and how children recapture their experiences. But first of all, an examination of the suitability of e-mail for narration is necessary.

Is e-mail suitable for the exchange of narrations?

There are several reasons why e-mail can be expected to support writing in general and reflective narration in particular. First, e-mail has a hybrid nature that combines characteristics of oral and written communication (e.g., Baron, 1998; Gains, 1999). In general, children find it more easy to talk than to write (e.g., Hidi, Berndorff & Ainley, 2002; Mason, 1998; Mason & Boscolo, 2000). Although Baron (1998) argues that e-mailing is hard for children because it is a form of writing, the talkative character of e-mail might actually help them to write with more ease. They do not need to adopt formal and unknown standards, and misspellings and imperfect sentence structures are acceptable (cf. Russell & Cohen, 1997). Children can apply their implicit knowledge about having an oral conversation to the written communication (cf. Stevenson & Palmer, 1994).

Second, e-mail use means writing for a real audience. Preserving the communicative character of writing was found to be motivating because it makes the writing task more authentic and goal-directed (e.g., Elbow, 1973; Hidi et al., 2002; Kumpulainen, 1996). Research on e-mail use in the classroom confirms that learners find it motivating when their writings are actually read by others (e.g., Riel, 1990; Tichenor & Jewell, 2001; Yost, 2000). The audience also helped learners notice details that needed to be further explained to distanced others, emphasized the need for a coherent story, and stimulated an attendance to esthetic aspects (e.g., Cohen & Riel, 1989; Michaels, 2001; Tichenor & Jewell, 2001).

Third, e-mail allows learners to take control and have a 'private' conversation without interference by a teacher. Computer use in general has found to promote learner-centeredness. For instance, Wegerif (1996) showed that working with the computer can change the IRF pattern in an IDRF pattern in which the D stands for independent Discussion between learners. The computer structures the learning activity and allows for independent deliberation. Other researchers too have pointed out that the computer allows learners to explore and communicate with peers (e.g., Jonassen, 1995; Perkins, 1991). Because e-mail is an open-ended medium that provides a format for communication without setting its content, it raises opportunities for independent knowledge construction by users (e.g., Blair, 1996; Loveless, 2003; Murphy, 2003; Tichenor & Jewell, 2001; Weiserbs, 2000; Yost, 2000).

We also expect e-mail to be suitable for reflection. There are several reasons for this expectation. One of the reasons is that e-mail is an asynchronous medium and therefore creates the time needed to reflect. In general, turn-taking moves on fast in synchronous dialogues and participants need to monitor the thread of the discourse constantly. This leaves them little room for reflection. In an e-mail exchange, however, participants take turns at a self-chosen pace. As a result, the dialogue can slow down and time is created for revising and reflection (e.g., Clark & Brennan, 1991; Weiserbs, 2000). Russell and Cohen (1997) talk about 'a delayed but rapid response': "E-mail was rapid, permitting responses within the same day or even a few hours. At the same time, it allowed time for thought and deep reflection, as we could mull over each other's words and ponder points or questions" (p.143).

Another reason why e-mail is deemed suitable for reflection is the fact that its participants are distributed at different places. This fosters self-explanation, evaluation, and awareness of differences (e.g., Tichenor & Jewell, 2001; Weiserbs, 2000). In her report on e-mail use in a primary classroom, McKeon (1999) concludes: "Using e-mail gave the children a chance to 'make public' their individuality. Perhaps this occurred because the children were initially unfamiliar with their partners and wanted to share knowledge about themselves in order to establish a relationship with a new person. If so, classroom e-mail partnerships may provide students with a new way to learn about themselves as they select information that defines who they are and send it via e-mail to another" (p.703).

Apart from these possible benefits of using e-mail, some potential difficulties also need to be considered. These difficulties concern writing skills, motivation to write, and awareness of writing as a learning activity. For children, writing is a high cost activity that requires considerable skill. Mason (1998) and Mason and Boscolo (2000) found that although children know that writing is useful, they prefer talking and evaluate writing as more difficult. Many children have not yet automatized writing and therefore find it difficult and time-consuming to carry on an e-mail dialogue. For these children, writing overshadows the talkative nature of e-mail (cf. Baron, 1998). In addition to writing skills, typing skills are involved. A considerable number of children can not type without difficulties nor can they type at an acceptable pace. Some researchers have pointed out that the children's deficient typing skills make e-mail use a time-consuming matter in the classroom (Michaels, 2001; Van der Meij & Boersma, 2002). However, although writing and typing remain hard for children, the pleasure taken from e-mail communication is expected to prevail (cf. Tichenor & Jewell, 2001). In that case, e-mail provides a useful opportunity to develop writing and typing skills.

However, the motivation to write may not always be there. This motivation depends on many factors such as perceived self-efficacy, the writing task and topic. To offset these motivational challenges, a writing task should be authentic (e.g., Hidi et al., 2002; Miller & Meece, 1999; Wells, 2003). Furthermore, a positive climate for writing and evaluating written products is needed (e.g., Fusai, Saudelli, Marti, Decortis, & Rizzo, 2003; Hidi et al., 2002). In many classrooms, writing is limited to isolated exercises that focus on linguistic correctness. Less attention is paid to things such as creativity, originality, and emotional expressiveness. Often, the written product is judged by the teacher and one can fail. For this reason, Elbow (1973) promotes the teacherless writing class as a means to establish a positive atmosphere. In such a class, writers read and evaluate each other's writings. It is expected that e-mail increases the motivation to write because it promotes teacherless writing.

Finally, research has shown that children write texts that reproduce rather than reorganize information (Bereiter & Scardamalia, 1987). One major underlying problem seems to be that children are not aware of the role that writing can play in learning. In school settings, the focus is on learning to write instead of writing to learn. It is not yet clear if the computer in general, and e-mail in particular, can change such a deeply rooted attitude towards writing. Research has found that the influence of the computer on writing is both positive and negative. Children do seem to revise more, but these revisions are aimed at grammar and spelling instead of composition and line of reasoning (e.g., Goldberg, Russell, & Cook, 2003; Kumpulainen, 1996).

We conclude that e-mail is a promising tool for reflective narration. But important impediments are also present. Attention needs to be paid to the establishment of a positive classroom climate and the development of an e-mail writing task that is perceived as meaningful and challenging. In addition, children's writing and typing skills need to be taken into account.

The first design experiment

Embedding e-mail in the design task

E-mail use was embedded in a design task in the domain of biology that comprised six lessons of two hours each. In this lesson series titled 'Living Together', the children worked in small groups (2-4 children) on the design of an ecosystem. The first two lessons introduced the topic of ecosystems. Also, the design heuristic was explained and demonstrated. In these lessons, the children designed the ecosystem of a goldfish. In lessons three to five, the groups designed an ecosystem for a self chosen animal. In the last lesson, the groups presented their designs.

Different worksheets were tried out in the course of the experiment. We began with a two-sided worksheet on which the groups wrote their e-mails (see Figure 2-1). Its front contained space for glueing down the received e-mail and for writing a response. On the back hints were given to prompt sharing experiences and problems. In addition, there was space for making notes. The worksheet was expected to move writing away from the computer lab to the classroom where more space was available for all group members to participate. In addition, it would remove typing constraints from the process of reflection and allow teachers to organize the typing and sending of e-mails according to the computer facilities and time available.

WORKSHEET LESSON...		GROUP NAME:	
<p>Glue down the received e-mail below.</p>		<p>Write down your answer to the partner group below.</p> <p>To:</p> <p>Cc: kidnet@edie.utwente.nl</p> <p>Subject:</p> <p>Message:</p>	
		<p>Too less space? Take another worksheet!</p>	
HINTS FOR DESIGNERS			
<p>You can help each other! Your partner group is also helping the professor with solving the problems. They may think of solutions that you didn't think of! Or maybe you know something that they don't know...</p> <p>How can you help each other?</p> <p>Share problems! Share solutions!</p> <p>Ask questions! Answer their questions!</p> <p>Tell them what you think of their solutions! Think together!</p>		<p>Here you can make some notes:</p>	

Figure 2-1 Front side (above) and back side (below) of a first prototype of the e-mail worksheet

Groups from different schools were paired. MS Outlook™ was used to send and receive e-mails. E-mail moments were set before and after working on the task. Before working on the task, the groups received an e-mail from their partner group. After working on the task, the groups wrote an e-mail. By allocating different moments for sending and receiving, the design task was placed between moments for reflection. As a result of the set e-mail moments, the groups sent and received one e-mail per week. This was expected to sustain a structural contact suitable for reflection-on-action.

Participants

Two schools - partly paid for their time – participated in the first design experiment. The schools were sited in villages in a rural area of Enschede, the Netherlands. Both schools participated with one classroom (grade 5-6, aged 10-12). In total, 24 groups were involved in the study (8 groups in the pilot, and 16 in the first design experiment). One school had a normal student population (school 1), the other school housed children with learning and behavioral disabilities (school 2).

The schools had access to at least one computer connected to the Internet and the teachers were familiar with the basics of e-mail software. The children varied in their experience with e-mail at home. E-mail had not been used in the classrooms before. The schools had some experience with working in groups. Learning-by-Designing, however, was new to both schools.

Before the start of the project, lesson materials were introduced and ideas, expectations, and practical issues related to e-mail use were discussed in a face to face meeting with the teachers. An e-mail schedule between schools was drawn up and it was determined how the groups would be paired. During the project, the teachers stayed in touch with each other through e-mail to share experiences and inform each other about any changes of plan.

Procedure

A broad range of data was gathered to gain insight in the teachers' implementation of the instructional design, the children's motives to engage in reflective narration and e-mail use, and the reflective nature of the e-mails. To gain insight in the implementation by the teachers, classroom observations and field notes were taken. Within-case descriptions of these observations were written on a weekly basis. In addition, the teachers wrote reports of each lesson. Protocols were used that asked the teachers to comment on each part of the lesson plan. Informal evaluations were held after each lesson and a semi-structured interview with the teachers was held

at the end of the project to recapture experiences and check initial findings. Furthermore, groups of children were observed while they worked on the design task, and received and sent e-mails. Semi-structured interviews with a few randomly chosen children from school 1 were held. Design products were collected and e-mails were archived.

The e-mails were segmented into clauses and coded for their general content (Personal Talk, Communicative Talk, Design Talk)(cf. Van der Meij, De Vries, Boersma, Pieters & Wegerif, in press). The segmentation and general coding informed us about the size, structure and rhetorical moves in the e-mail narrations. Design task related segments were further categorized to assess their reflective nature. The categorization was developed from the data. Repetitive categorization of segments was conducted (cf. Glaser & Strauss, 1967). This resulted in five categories of reflective narration: Describing, Questioning, Relating, Appreciating, and Assessing. The categories are defined in the results section. All coding decisions were recorded in a codebook. Interrater agreement was calculated for each step. A second independent coder coded about 30% of the data. For segmentation, the interrater agreement was 94%. For general coding, Cohen's Kappa yielded .94. For detailed coding, Cohen's Kappa yielded .77.

The results are presented from Conle's (2003) three perspectives on narration. Under the first perspective (act of narrating) we discuss findings on the teachers' implementation and children's motives for using e-mail. A short pilot of three lessons was run before the start of the design experiment to get a feel for the lessons. This pilot was run in the same schools with the same teachers but with different children. Findings from this pilot are solely discussed under the first perspective and prior to the findings from the design experiment. The second perspective (rhetorical statement) discusses findings from the general coding of the e-mails from the first design experiment. The third perspective (story) discusses findings from the detailed coding of these e-mails.

It is important to note that children's writings are translated from Dutch. In the act of translating the fragments presented in this thesis, our main goal was to preserve the unique characteristics of children's expressions (e.g., words, syntax) without a loss of meaning for non-native speakers. In addition, the e-mail fragments that are used to illustrate findings are *not* segmented.

Results

The act of narrating (pilot)

The teachers organized the e-mail process as indicated in the lesson plan. In each lesson there were two moments of e-mailing, one shortly before and

one after working on the task. The worksheet was used to write down messages that were sent by the groups the same or next day. The children took turns with typing. The teacher supervised the process of sending and receiving. Received e-mails were printed before the start of the lesson by the teacher and distributed in the classroom when lessons started.

The teachers positively evaluated the use of e-mail in their lessons. They noticed several benefits from its use:

Making contacts, asking questions, receiving answers, writing, linguistics, making correct sentences, formulating. There are quite some aspects that are nicely involved in it, so I think it's perfect. And the children like it a lot. Formerly they were asked to write a letter to an imaginary grandmother and there was no reaction at all. And now there is a reaction from kindred spirits a day later. Very nice.

(Teacher 1, interview, end of project)

Working with e-mail is an aim in itself. For eventually everybody will take part in it; it will be common practice. That's why you have to practise it.

(Teacher 2, interview, end of project)

Although they evaluated the use of e-mail positively, the teachers also experienced difficulties. First, the worksheet was too complex. Glueing down e-mails took too much time and the teachers indicated that they would rather keep overviews of the e-mail exchanges in other ways. For instance by showing e-mails on the pin-board (teacher 2) or keeping them in a portfolio (teacher 1). An examination of the used worksheets corroborated the teachers' observations. The space for glueing down the e-mail was small and children had to cut and paste the print in pieces. Often the space next to it, that was meant for writing the response, was used for this. Consequently, the space for making notes on the back was used to write the response. Group observations further showed that the children were so busy glueing down the received e-mail, that they did not engage in discussing its content. Moreover, the teachers reported that the hints on the back weren't used. Therefore, they gave instructions themselves.

Second, the teachers were not satisfied with the content of the e-mails. The intertwining of personal information with task-related descriptions was too strong. Although the teachers valued the exchange of personal information, they also thought it was getting too much attention. Furthermore, they found there was a too heavy focus on questioning. Although posing questions and receiving answers was sometimes functional because it led to further discussion of task-related issues in the groups, most of the time it caused problems. The teachers reported that it resulted in less

frequent exchanges of ideas and experiences, simple yes or no questions, quiz questions to which the group already knew the answer, and quick and easy answers because no time was reserved for looking up information. As a result, the teachers started structuring the process of questioning in whole-class discussions. This emphasized questioning even more and disconnected the e-mail process from the group process of designing:

Answering questions was done too easily. They just jot something down. I think it's nicer when the questions are answered seriously. That they start looking up things.

(Teacher 1, interview, end of project)

Children found it difficult to formulate questions, they are still too young. I have now just guided them by suggesting questions to them. Later on in grade six this will be a lot better. But I cleverly start off thinking up those questions with the whole group by formulating them on the blackboard and by giving one question to each group.

(Teacher 2, interview, end of project)

The children evaluated the use of e-mail positively. They were curious about their partner group, and reported that it was easy to write about a shared task. The following fragments illustrate the pleasure they took in it:

Writing this down we still have no idea who you are and what your names are. We are anxious to know.

(Group 3, school 2, e-mail, lesson 1)

Well, bye-bye, take care, sob, sob, sob, we liked working together and e-mailing with you. Best wishes from the hammerheads.

(Group 4, school 1, e-mail, lesson 3)

The children reported similar expectations about e-mail as the teachers. The children pointed out two motives: getting to know other children, and receiving answers to questions. Both motives were found in the e-mails. The fragments above already illustrated the attention paid to getting to know the other children. The following fragments illustrate the attention that was paid to questioning:

We have some questions for you. Please answer them as soon as possible.

1. Can goldfish smell under water? And if so, how ?
2. What is the average age of goldfish?

We await your questions and answers.

(Group 2, school 1, e-mail, lesson 1)

We think it's a pity you had no questions.
(Group 4, school 1, e-mail, lesson 2)

The first extract also illustrates the dominant kind of questions that was posed. Most of the questions were factual as if taken from a biology test. They were not personal and reflective, but the kind of questions one would expect to get in a quiz game.

The children also mentioned problems with questioning such as a lack of (good) answers, and a too late arrival of answers to be useful. The following field note taken illustrates this:

The e-mail from the partner group is read aloud by one of the children. They received answers to their questions and discuss them. They think the answers are wrong. One of the children says: 'They didn't look it up'. The children are disappointed and a bit angry. They tell the teacher that they received very silly answers.
(Researcher, field note, school 1, lesson 2)

This field note shows that the answers, if any were received at all, were evaluated as 'right' and 'wrong'. They did not lead to extended and open discussions, but to judgments about the intentions and efforts of the partner group. The e-mails further confirmed that questioning was not productive as only 27% of the task-related questions received an answer.

Another problem mentioned by the children was collaborative writing. They reported that the collaborative writing went well. They took turns, divided roles, and thought about the content together. But they also indicated that not everybody participated and some preferred to write individually:

Some children just sit there, and yes, they don't feel like it any more and they are just looking around. And in fact there is only three of you that are writing.
(Jacob, school 1, interview, lesson 2)

I was the one to write. I like writing things down for myself. For it brings a lot of ideas to your mind and the others react like "Please, can I bring up something?" Or something like that. Because you are writing, it just comes up like that.
(Brenda, school 1, interview, lesson 1)

This was also observed by the researcher. In some groups, four children were gathered around the worksheet and formulated the e-mail together. In other groups, one writer dominated the process.

The outcomes of the pilot led to two modifications. One, the worksheet was changed. The hints were removed, and glueing down the received e-mail was replaced by keeping them in a portfolio. The worksheet consisted of

only one side. It displayed an e-mail format with headings similar to the e-mail program (To:, Cc:, Subject). On the left, a short assignment was given that prompted the groups to share experiences. We wanted to see if these instructions could help the teachers and children focus on reflection. General (without topic indication) and specific assignments (with topic indication) were tried out to see what worked best (see Figure 2-1).

<p>WORKSHEET LESSON 2</p> <p>Assignment Things to put in the e-mail: - A reaction to the e-mail of the partner group - There are three types of organisms. Do you know which types? Tell your partner group what you found out. Ask them questions if you do not know. - Describe the ecosystem you designed. Did you succeed in rounding it? Tell them how you did that. If you didn't succeed, ask your partner group for advice (hence, give a good description of what you found, because otherwise they will not be able to help you!) You can also share what you thought of the lesson or exchange ideas about the topic. Good luck!</p>	<p>GROUP NAME:</p> <p>Write down your answer to the partner group below.</p> <p>To: Cc: kidnet@edte.utwente.nl Subject: Message:</p> <p>Too less space? Take another worksheet!</p>
<p>WORKSHEET LESSON 4</p> <p>Assignment 1. Give a reaction to the e-mail of your partner group. 2. Describe what you have done and found. 3. Describe what you have learned. Did you think it was difficult, or rather easy?</p>	<p>GROUP NAME:</p> <p>Write your answer to the partner group below.</p> <p>To: Cc: kidnet@edte.utwente.nl Subject: Message:</p> <p>Too less space? Take another worksheet!</p>

Figure 2-1 Examples of a specific (above) and a general (below) writing assignment on a second prototype of the e-mail worksheet

Two, it was decided that the groups were to write one e-mail before the start of the lessons to introduce themselves to their partner groups. While still valuing the importance of social talk between the groups (cf. McKeon, 1999; Riel, 1990; Weiserbs, 2000), sending introductory e-mails was expected to centre personal talk in the beginning of the exchange so that it became less intertwined with task-related talk (cf. Tichenor & Jewell, 2001).

The act of narrating (first design experiment)

The teachers indicated that the changes to the instructional design improved the e-mail process. Sending introductory e-mails was functional because it helped the teachers in pairing the groups before the lessons started. As a result, the groups could already address their e-mail to a partner group in the first lesson. Furthermore, it gave the teachers a better opportunity to explain the project and e-mail procedures. The teachers instructed the groups to write about things such as their names, ages, and hobbies. The following e-mail is prototypical:

To: group 4
 From: group 4
 Introductory e-mail
 Hello, this is group 4!!! There is one boy in the group, called Erik and three girls Doris, Cindy and Maria.
 We all like badminton.
 Cindy plays volleyball
 Doris likes snorkeling
 Maria plays the flute.
 Erik takes keyboard lessons
 What are your hobbies?
 Regards group 4.
 P.S. We are all eleven.
 (Group 4, school 1, e-mail, lesson 1)

The new worksheet was easier to use. Each group now kept a portfolio with prints of sent and received e-mails. The assignments didn't work as intended however. The teachers and researcher noted that the general assignments were hardly used, and the specific assignments were found to be confusing:

It is essential to pay extra attention to the content of the assignment on the worksheet in order to achieve sound e-mails. Some groups need some extra help and instruction.
 (Teacher 1, written report, lesson 1)

Four children are gathered around the worksheet. They immediately start writing. The portfolio with the received e-mails is consulted from time to time. One child starts reading aloud the assignment. The assignment confuses the children, too many words, and too difficult words (e.g., organism), too abstract.
(Researcher, field notes, lesson 2)

Because the assignments did not function as intended, the teachers gave additional instructions that again focused on questioning. For instance, one of the teachers explicitly instructed groups to 'pose two questions'. The same difficulties with questioning as found in the pilot study emerged. Groups were disappointed when they did not receive answers or when their partner groups did not pose questions, and the teachers had to explain that not all questions were appropriate (e.g., questions that needed looking up were not reckoned with in the instructional design). The teachers reported:

It is important to answer the e-mail seriously. The children sometimes thought the answers were a bit superficial.
(Teacher 1, written report, lesson 3)

The children were not always satisfied with the received e-mail. There were remarks like 'no answer to the question', 'a silly question', 'too brief'.
(Teacher 2, written report, lesson 4)

The e-mails too signaled that questioning was deemed important, but also caused problems:

SILLY QUESTIONS, really. The questions we pose are: How many feathers does a fox have? And how many eyes has a fox? If you put silly questions like that, we'll do the same.
(Group 3, school 1, e-mail, lesson 5)

Why do you ask for something you already know?
(Group 1, school 1, e-mail, lesson 6)

To change the focus of the teachers and children on questioning and raise more opportunities for reflection, an exercise of individual freewriting was implemented in the fifth and sixth lesson in school 1. This exercise preceded the group process of writing an e-mail. Freewriting (procedure adapted from Elbow, 1973) began with three minutes of silence in which to think about the lessons. No directions were given about the nature of these reflections. After the silence, the children were asked to write down their thoughts for five minutes. They were told not to pay attention to grammar, spelling, and stylistic issues. Freewriting was expected to stimulate reflection as a result of

which more elaborate descriptions and less unproductive questioning would be found in the e-mails. Furthermore, individual preparation was expected to stimulate group discussion (cf. Brown & Renshaw, 2000; Dysthe, 1996; Van Boxtel, Van der Linden & Kanselaar, 1997).

The teacher who implemented freewriting in the fifth and sixth lesson expected difficulties with the three minutes of silence. But he found the exercise to be fruitful and valuable:

After the description and explanation of the assignment and a moment of reflection (the children were serious and concentrated) they can start writing at my signal. After reading the writings, the group gives a reasonable report of what was discussed and done during the past lessons. They also report on the difficulties of working together. And on the degree of difficulty of the assignments. I think this is an excellent way of investigating the children's experiences. Formulating the e-mail works very well by starting from the freewritings; the noses are all more or less pointing the same way, because they all had the same writing assignment. The time needed to make a reasonable report is surprisingly short.
(Teacher 1, written report, end of project)

The children were enthusiastic about freewriting and produced writings ranging from 51 to 168 words ($M=109$, $s.d.=26.5$, $N=61$). They reflected on a wide range of issues related to the design task. They described what their design looked like, evaluated what they learned, how they collaborated, how they liked the lessons etc. The next two examples illustrate the richness:

Lesson 1 was about the goldfish. It's really kind of hard, normally you don't look at (think of) things like this very much. A fish is a fish, and that's it and you are not aware of all the things connected with it. And once you are busy you think hey everything was created for everything else. Everything comes around. Things were really difficult and you don't think of all the other things. And and all of a sudden it turns out that everything comes around. The lessons are great fun; you think of everything and you try to make everything fit in. Lesson 2 was about the environment of the fish. And everything comes around again.
(Ronnie, school 1, freewriting, lesson 5)

The first day I was very excited because I didn't know what was going to happen. the things you had to think up were sometimes difficult and sometimes easy. For then you reached the point of what was first the plant or the seed. The e-mails you had to make and send were nice to do. When there was an e-mail from my partner group, it was exciting to see what they had to say. But sometimes it was a pity they wrote so little. I also liked making the design. The first design

we made was very bad I thought, but you can't always be perfect and I really like our second design. The things I had to think up and deliberate kept me very busy. But it should be like that. It's a pity we had some arguments now and then but that problem has been sorted out. Now we have real team-work!

(Doris, school 1, freewriting, lesson 5)

Rhetorical statement⁴.

Weekly e-mail contact was realized during most of the project. Some unforeseen problems with the computers in school 2 limited the e-mails sent by those groups. In total, 89 e-mails were sent during six lessons ($M=5.6$ e-mails per group). The e-mails had an average length of 87.1 words ($s.d.=39.4$, $N=88$)⁵. The length of the e-mails differed between schools (see Figure 2-3).

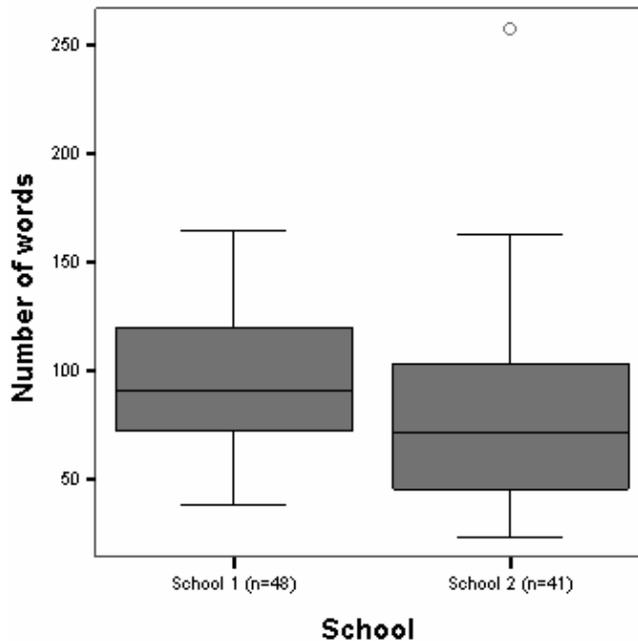


Figure 2-3 Differences in e-mail length between schools.
The boxplots show the range, median, and one outlier.

⁴ E-mails from the pilot are not included in the analysis.

⁵ One outlier was excluded from the calculations.

In school 1, the e-mails had an average length of 95.8 words (s.d.=29.8, N=48). In school 2, the e-mails had an average length of 76.7 words (s.d.=38.6, N=40). The difference was significant ($\chi^2(1, 88) = 7.0, p < .01$).

We also looked if freewriting affected e-mail length by comparing the e-mails of school 1 across lessons. The e-mails based on freewriting were significantly longer than the e-mails that were not based on freewriting ($\chi^2(1, 48) = 5.6, p < .05$).

To gain insight in the general structure of the e-mails, all segments were coded as either Personal Talk (PT), Communicative Talk (CT), or Design Talk (DT). Segments about personal matters were coded as PT (e.g., “We are eleven years old”, “We love horror movies”). Segments about the e-mail communication, including greetings at the beginning and end of the e-mails, were coded as CT (e.g., “These are the answers to your e-mail”, “We will continue this talk next week”). And segments about the process and product of designing were coded as DT (e.g., “A seal has lungs to breath”, “We drew a fish at the centre of the design”). Table 2-1 gives an overview of the distribution of the three kinds of talk in the e-mails across lessons.

Table 2-1 Personal, Communicative & Design Talk in the e-mails across lessons. The values represent percentages of segments (N=1185) coded in one of three categories and show their distribution across lessons.

Coding	Lessons			
	1&2	3&4	5&6	Total
Personal Talk	28.2	12.1	14.3	18.8
Communicative Talk	45.6	41.4	27.7	39.4
Design Talk	26.2	46.5	58.0	41.8

PT and CT took up a considerable part of the e-mails. Because the groups did not know each other and communicated at a distance, effort needed to be put in establishing and sharing a social setting. The relatively high presence of CT suggests that the conversation required permanent maintenance. The groups frequently wrote about things such as the length of received e-mails, group names, and how they valued the e-mail conversation. Table 2-1 also signals a shift from PT to DT. In the beginning, PT is high and DT is low. At the end, it is the other way around. PT ($\chi^2(1, 88) = 10.2, p < .01$) and CT ($\chi^2(1, 88) = 23.5, p < .01$) decreased whereas DT increased ($\chi^2(1, 88) = 33.0, p < .01$). This suggests that after the initial acquaintance, the groups focused on the task. These findings are comparable to those from earlier e-mail studies (Van der Meij & Boersma, 2002; Van der Meij, Van Graft & Boersma, 2001).

The most common narrative structure in which PT, CT and DT were organized was the sandwich form in which PT and CT appeared at the beginning/end and DT in between. Many e-mails had this classic setup of a letter:

Hello,
 Here are the Bluppies.
 Our group consists of Dania, she likes talking. Susan, she likes dogs.
 Lucia, she likes make-up, and the caring Rosa.
 We have two questions for you about the gold fish:
 Question 1: Do you know if a gold fish has a brain to think with?
 Question 2. Why do fish have scales?
 Thanks in advance, The Bluppies.
 (Group 5, school 2, e-mail, lesson 1)

Within this setup, specific rhetorical moves were found⁶. The e-mails were marked by extended greetings, metatags, repetitive structures, enumerations, and spoken language items. ‘Extended greetings’ are greetings that consist of more than just a greeting (e.g., “Hello”) and an addressee/sender (“Group 4”). They were found in 96.3% of the e-mails and seemed to reflect the way in which e-mail was implemented by the teachers who strongly emphasized the importance of making clear who the e-mail was for and what the e-mail was about. For example:

Concerning: Lesson 5. To The Three Mails (group 2),
 Hello Three Mails.
 (Group 2, school 2, e-mail, lesson 5)

‘Metatags’ were announcements of specific content shortly before or after the content itself was given. They were found in 37.8% of the e-mails. For example (‘metatags’ in italics):

Now about something else.
 Around the fish, insects and plants are present.
 And water, otherwise they dry out.
 We don’t know how a fish mates?
Now we tell about the lesson.
 Well, it was a bit complicated, but we did it.
 We drew a fish and wrote down different things such as waterplants,
 earth, stones.
This was it.
 (Group 7, school 1, e-mail, lesson 2)

⁶ The rhetorical moves were measured at e-mail level in contrast to the general and detailed coding of the contents of the e-mails that were measured at segment level.

Our main findings are:

Eating, genitals, water, protect and seeing.

This were our main findings.

(Group 3, school 1, e-mail, lesson 2)

'Repetitive structures' are enumerations across segments whereas the code 'enumerations' was assigned to listings within segments. 'Repetitive structures' were found in 28.1% of the e-mails. They often consisted of numberings, and repetitive use of words. Examples are:

Hello, I am Lola, I am 10 years old, my hobby is dancing.

Yo, I am Ronnie, I am 10 years old, my hobby is judo.

Yo, I am Kurt, I am 10 years old, my hobby is football.

(Group 3, school 1, e-mail, lesson 1)

We have the following questions:

1. Why does a goldfish have blood?

2. Why is he named 'goldfish'?

(Group 4, school 1, e-mail, lesson 2)

'Enumerations' occurred in 37.8% of the e-mails. Examples are:

We thought deeply about the frog, rat, owl, plants and fish.

(Group 1, school 1, e-mail, lesson 3)

We found: oxygen, space, a male and female, food (the mother or father takes care of food supplies for the little ones), speed, eyes, senses, a place to hide, cave, warmth.

(Group 3, school 2, e-mail, lesson 5)

Finally, the influence of 'spoken language' became visible in 67% of the e-mails in the form of interjections, slang, capitals and large amounts of punctuation marks that emphasized parts of the e-mail or gave expression to emotion. Examples are (spoken language items in italics):

We had to design, *well, let's say* the plant needs roots and so.

(Group 1, school 1, e-mail, lesson 3)

Bye *fokes!!!!!!!!!!!!!!!!!!!!*

(Group 1, school 2, e-mail, lesson 6)

'Metatags', 'repetitive structures', and 'enumerations' regularly occurred in combination. Together they helped form the *staccato style* that was generally found in most of the e-mails. In this style, the children changed topics without dwelling on them or making explicit connections. The following excerpts are prototypical for the staccato style:

We knew how many scales a fish has because we found it in books.
We know the pokémon rattata, except for Dave.
We liked the lesson.
We thought we had a good presentation about the deer.
We liked some of the presentations, but disliked others.
As we read it, you have a lot to do during your holiday.
We also have a lot to do during our holiday.
It was nice to get to know you via e-mail.
(Group 2, school 1, e-mail, lesson 6)

We have a new group name: The Mail Kids.
We have two questions:
1. Does a fish have ears?
2. Does a fish have a nose?
We hope you can answer our questions.
We thought the lesson was difficult but nice.
We had two days off because there was a fair.
(Group 8, school 1, e-mail, lesson 2)

Fewer e-mails showed an *anecdotal style*. In these e-mails, there are more descriptions, and different topics were connected to each other forming a more coherent story. The following extract illustrates this style:

How did you like the fourth lesson about reproduction?
We drew a hospital for pregnant fish.
Did you find it difficult to think of the things they need for reproduction?
We found very little, because we found it difficult.
You are designing the ecosystem of a wolf, isn't it? Was that difficult? Or was it easy?
Sometimes we got stuck, because it became too complicated.
(Group 4, school 1, e-mail, lesson 4)

The rhetorical moves seem to signal two important aspects of e-mail communication. First, they seem to reflect the dual nature of e-mail as being both oral and written. Extended greetings, metatags, repetitive structures and enumerations characterize e-mail communication as written. They heavily structure the e-mail and give it a concise and pragmatic tone of voice. Spoken language items characterize e-mail as orally oriented. They add an atmosphere that is more related to chatting. Second, they seem to reflect the children's audience awareness. While giving their descriptions and evaluations, the groups constantly address their audience by presenting their stories in recognizable structures and by using metatags.

*Story*⁷

All Design Talk segments were categorized into one of the following five categories: Describing, Questioning, Relating, Appreciating, and Assessing. Descriptions reveal a plot in which the processes and products of designing are reported. The other four categories give evaluations and reveal a narrator's perspective. They show how the processes and products of designing are questioned, related, assessed and valued by the children. The code 'Questioning' was assigned to segments that posed questions about the topic of the design task. The code 'relating' was assigned to segments that connected classroom experiences to prior knowledge, or personal considerations. The code 'Appreciating' was assigned to segments that valued the process and product of designing. The code 'Assessing' was assigned to segments that judged the performance of the children. It is important to note that the category Questioning does not necessarily contain all the questions posed in the e-mails. The category only contains those questions that seek to reflect on the *topic* of the task. Other questions can have a different reflective value. For instance, questions such as "Did you like the lesson?", or "What does your design look like?" would be coded as respectively Appreciating and Describing. Table 2-2 shows the distribution of descriptions and evaluations in the e-mails.

*Table 2-2 Descriptions and evaluations in the e-mails.
The values represent percentages of segments (N=495)
coded in one of five categories.*

Coding	Examples	Total
Describing	"We've worked on our design about the wood owl." "The question was: What must I be able to do and what do I need for that?"	52.8
Questioning	"Do fish play with each other?" "Why does a fox live in the woods?"	9.3
Relating	"I was thinking of my guinea-pigs." "Unfortunately, the sea is polluted with oil."	3.3
Appreciating	"We liked the lesson." "The other presentations were nice and instructive."	17.6
Assessing	"Everything went wrong during our presentation." "You discover a lot more than you thought you would."	17.0

⁷ E-mails from the pilot are not included in the analysis.

More than half of the segments were descriptions of the task. The groups described both the product and the process of designing. For instance:

And then we started working on our ecosystem again. We had to glue down things, just like the other lesson. But now humans had to be part of it. And this was the last time that we worked on the design. And our ecosystem is finished now.
(Group 4, school 2, e-mail, lesson 5)

We have invented the perfect pond. It measures 4 by 2 metres, there should be goldfish in it, but also some other fish. They have to be able to live so they will need oxygen plants. Here is a list of things they need to be able to live: oxygen, shelter, other fish, water, sunlight, rain, food and enemies, or there will be too many fish.
(Group 6, school 1, e-mail, lesson 2)

Descriptions were often accompanied by evaluations in the form of appreciations, assessments and, to a lesser extent, by relating classroom experiences to prior knowledge:

We have talked about human beings against animals. People and their environment. In the environment. Like the sun that gives us light and warmth. But also ultraviolet radiation. And that is blocked by the ozone layer. The ozone layer is also poisonous. But if we take good care of our environment, we won't suffer from it.
(Group 4, school 2, e-mail, lesson 5)

We pity the fish with the disease (white speck). Wilco has had fish with white speck in his tropical aquarium many times.
(Group 3, school 1, e-mail, lesson 6)

In addition, there were questions that sought to elaborate on the topic of designing. Most questions were factual and sought to quiz the partner group rather than elaborate on the task. The following excerpts from an e-mail exchange illustrate this:

Group 1, school 2: Do you know what the male of a seal is called?
We do.
Group 1, school 1: We don't know what a male seal is called.
Group 1, school 2: Answer to question 1 of last time: The male of a seal is just called a male seal. Question 1: Are seals endangered species or not and what are the names of the other species.
(Group 1, school 1 & Group 1, school 2, e-mail, lessons 4-6)

These questions were stated rather abruptly and appeared in isolated positions in the e-mails. Almost a quarter of the questions were embedded in

the context. They followed naturally from the descriptions in the e-mails. Their nature was more comparative or help-seeking:

Did you know that not all fish have scales? And did you also see that a fish can poop? And that some fish live in groups?
(Group 4, school 2, e-mail, lesson 2)

We had to design the ecosystem of the heron. We couldn't manage, who was first: the plant or the seeds? Do you happen to know?
(Group 4, school 1, e-mail, lesson 3)

We had to design an ecosystem of our choice and we chose the deer. We didn't really like this lesson very much. We have problems bringing it to a good end. Do you know something about the deer? And do you know anything about how they reproduce?
(Group 2, school 1, e-mail, lesson 4)

The distribution of descriptions and evaluations differed before and after freewriting (see Table 2-3). The e-mails based on freewriting contained significantly fewer questions ($\chi^2(1, 48) = 8.2, p < .01$), and more assessments ($\chi^2(1, 48) = 6.3, p < .05$), and slightly more descriptions ($\chi^2(1, 48) = 2.3, n.s.$), relations ($\chi^2(1, 48) = 3.2, n.s.$), and appreciations ($\chi^2(1, 48) = 1.4, n.s.$). This suggests that freewriting influenced the children's focus on reflection.

Table 2-3 Descriptions and evaluations with / without freewriting. The values represent percentages of segments (N=298) in the e-mails of school 1, without (N=125) and with (N=173) freewriting, coded in one of five categories.

Coding	Lessons 1-4		Lessons 5-6	
	Without freewriting	With freewriting	Without freewriting	With freewriting
Describing	51.3	58.8		
Questioning	19.0	2.7		
Relating	1.5	2.0		
Appreciating	17.9	21.0		
Assessing	10.3	15.5		

Conclusion

In this first design experiment, an instructional design for the implementation of reflective narration via e-mail was developed and tested. Central to the instructional design were a worksheet and a freewriting

exercise. Different worksheets and instructions to prompt the children to reflect were tried in the course of the experiment. A one-sided paper worksheet that presented the children with an e-mail format, and a freewriting exercise to guide the process of reflective writing were found to be effective supports. They provided the right balance between structure and freedom for both the teachers and the children (cf. Lijnse, 1995; Moonen, 1999). On the one hand, they helped the teacher structure the process of collaborative writing and sending e-mails. They could take their pupils through distinct and subsequent steps of reflective thinking and writing in the freewriting exercise:

It is important to regulate the freewriting well. In short: Set them a writing assignment, give them some minutes of silence to concentrate on what they are going to write down (silence, concentration are a necessary condition), let them all start together and indicate: keep writing, don't think, don't allow yourself to be distracted, no deliberation, indicate more or less when they have to stop so that they can round off their stories.

(Teacher 1, written report, end of project)

Freewriting helped the teachers focus on reflection. Initially, the teachers related e-mail to the exchange of questions and answers. Earlier experiences with e-mail had shown that this is a difficult goal to achieve with e-mail, because questioning demands immediate and just-in-time answers for which sending and receiving one e-mail per week is not enough. A more frequent and structural e-mail contact, however, is difficult to realize in classrooms that have no experience with using e-mail (Van der Meij & Boersma, 2002; Van der Meij, Van Graft & Boersma, 2001). Although the teachers were aware of the goal of reflection and valued it highly, in the lessons they fell back on their implicit expectations. This was successfully changed by the implementation of freewriting. In addition, the teachers could use the worksheet to structure the process of typing and sending e-mails. The worksheet allowed them to organize the typing and sending of e-mails at convenient times the same or the next day.

At the same time, freewriting allowed freedom to the children. They could reflect individually before entering a group discussion. This gave them the opportunity to reflect on matters that were of personal interest to them. Furthermore, the children did not need to pay attention to spelling, grammar and the like. Instead, they were asked to write in a free flow. This might have removed constraints from the task for children whose writing is not yet automatic. In addition, the paper worksheet provided them with an e-mail format without any further input for its content in the form of hints or assignments. The children were given a free hand in what to write about to their partner group.

Freewriting not only structured the implementation of e-mail in the classrooms, but also improved its reflectivity. Initially, the e-mails contained descriptions and evaluations of the process and product of designing. The descriptions served as a springboard for expressing appreciations and assessments and, to a lesser extent, relating old and new experiences. But the groups also posed many quiz questions that were considered to be less reflective. Only some of the questions were comparative and help-seeking. After introducing freewriting, the e-mails were longer, contained more descriptions, expressed more evaluations, and stated less questions. This suggests that through freewriting the children were more aimed at recapturing their experiences than before. The way in which they recaptured their experiences leads to the following definition of reflective narration via e-mail:

'describing the process and product of designing, posing comparative and help-seeking questions, relating old and new experiences, and expressing assessments and appreciations'

Conle (2003) states: "The milieu most conducive for narrative interactions is a classroom climate that promotes personal, experiential reactions rather than arguments. Contextual statements rather than generalizations are valued as well as expressive rather than abstract language" (p.5). Giving the children the opportunity to individually express themselves contributed to this climate. Freewriting was only implemented in two lessons in one school. In the next design experiment, we will take a closer look at how freewriting functions in the classroom by implementing it systematically in all the lessons. Furthermore, an examination of the group process of composing an e-mail on the basis of the freewritings will be conducted to gain insight in how children exchange individual ideas within their groups.

In addition, sending e-mails to a partner group contributed positively to the establishment of a positive climate for writing. Writing to a real audience motivated the children (cf. Carvalho, 2002). They were eager to get to know the other group and enthusiastically shared experiences. However, the findings also indicate that the partner groups hardly reacted to each other's e-mails. An initial exploration of the amount of reactions present in the e-mails confirms this impression. In 45% of the e-mails a reaction to previous e-mails is given. In only 18% of the e-mails, these reactions concerned the design task. Moreover, the groups only answered 27% of the topic-related questions. Most of the reactions concerned the length and quality of the e-mails. Given this low interactivity, is using e-mail for reflection worth the effort? To answer this question, a closer examination of the collaborative process of reading and writing e-mails needs to be undertaken.

Chapter 3

Design experiment 2: Reflection-on-action within and between groups

Introduction

In the first design experiment, an instructional design for reflective narration via e-mail was implemented in two primary classrooms. A key element of the instructional design was a paper worksheet. The groups wrote their reflective narrations on this worksheet before they typed it in the computer and sent it to their partner groups at another school. The worksheet successfully located the writing process in the classroom where groups could focus on task-related reflection instead of computer-centered typing. To add more structure to the process of reflection and yet keep up the children's freedom to reflect on self-chosen topics from the lessons, another key element was added: individual freewriting. The teacher and children of one of the participating schools experimented with freewriting during the fifth and sixth lesson. Freewriting positively influenced the length and richness of the reflective narrations. It yielded the structured freedom that the teacher and children needed. In the first design experiment, freewriting was introduced and employed on a small scale. In the second design experiment that is presented here, it is systematically embedded in all the lessons.

Furthermore, adding freewriting to the process of e-mailing shifts the focus from the e-mail exchange itself to the group processes surrounding the use of e-mail. At first glance, the interactions between groups in the e-mail exchange were found to be rather low. The groups shared their classroom experiences, but hardly reacted on each other's narrations. This raises the question how exchanging narrations via e-mail is beneficial to reflection-on-action. Therefore, in this second design experiment we set out to take a closer look at the group processes evolving around reading and writing e-mails. The second design experiment sought to answer the following research questions:

- (1) *How does freewriting support reflection-on-action when it is implemented in all the lessons?*
- (2) *What is the reflective nature of collaborative narration?*

Freewriting was embedded in all lessons. The children were prompted to think about the lesson for three minutes in silence and then write about it for five minutes without paying attention to grammar, spelling, and style. The freewritings served as input for a group e-mail. In the lesson plan for the teachers, a step by step procedure of freewriting was given (see Figure 3-2).

Go through the following steps with your pupils:

Step 1: Hand out a paper to each pupil on which they write down both their own and their group's name.

Step 2: Give them 3 to 5 minutes to reflect in silence on their experiences with the past lesson (experiences during the lesson, what they learned, their opinions on the lesson, collaboration).

Step 3: Give them 5 minutes to write about their thoughts non-stop. During the freewriting stimulate the pupils to write down what comes to their mind and not to think deeply on what they want to write down, not to read again, to correct or to deliberate.

Step 4: Indicate half a minute before they have to stop writing that it's almost time so that they can make a more or less complete whole.

Figure 3-2 Lesson plan: A step by step procedure for freewriting

The lesson plan gave background information about freewriting and e-mail, and explained their purpose. Examples of freewritings and e-mails were given. The lesson plan also indicated how to organize the process of composing an e-mail from the freewritings (see Figure 3-3).

Group work; formulating and sending a group e-mail:

Step 1: Hand out a worksheet to each group.

Step 2: Have them write down lesson and group name.

Step 3: Have them make one collective e-mail of:

- A reaction on the received e-mail prepared at the beginning
- The individual freewritings

Step 4: Have them type the e-mail and send it.

Figure 3-3 Lesson plan: A step by step procedure for composing group e-mails

Additional hints were provided that focused on structuring the process of reading each other's freewritings in the group (see Figure 3-4).

Hint

Reading each other's writings can be organized in various ways. The pupils can send round the writings and read them each for him/herself. In doing so they can make notes about what is important for them to be put in the collective e-mail. The writings can also be read aloud to each other. During the reading they can discuss per writing what should be put in the collective e-mail.

Figure 3-4 Lesson plan: Hint to structure reading freewritings

Groups from different schools were paired to each other. MS Outlook™ was used to send and receive e-mails. E-mail moments were set shortly before and after working on the task. Two e-mail moments were embedded in each lesson. Each lesson started with reading and discussing the received e-mail from the partner group. Each lesson ended with writing and sending an e-mail. Only in the first lesson, the children started with writing an introductory text. These texts were integrated in the e-mail that was written at the end of this lesson.

Participants

Three schools voluntarily participated in the design experiment. The schools were sited in villages in a rural area of Enschede, the Netherlands. The schools participated with one classroom each (grade 5-6, aged 10-12). In total, 12 groups participated. Two schools had normal student populations (schools 1 and 2). The other school (school 3) housed only two children because of closure at the end of the school year.

The schools had access to at least one computer connected to the Internet and the teachers were familiar with the basics of e-mail software. The children varied in their experience with e-mail at home. E-mail had not been used in two of the classrooms. In one classroom, initial steps had been taken to teach the children the use of word processors and e-mail in the months preceding the project. The schools had some experience with working in groups. In the school with two children, working independently through an individual program was the standard. Learning-by-Designing was new to all schools.

In a face to face meeting with the teachers, lesson materials were introduced and an e-mail schedule was set. During the project, the teachers

stayed in touch via e-mail to share experiences and inform each other about any change of plans.

Procedure

A broad range of data was gathered to gain insight in the implementation of freewriting by the teachers, the children's motives for freewriting, and the collaborative process of reflective narration. Audio recordings were made of three focus groups. These groups (one in every classroom) were selected by the teachers. Focus group 1 (school 1) consisted of two boys and one girl. Focus group 2 (school 2) consisted of two boys and two girls. Focus group 3 (school 3) consisted of one boy and one girl. Their group work was recorded throughout the lesson. Semi-structured interviews with the children from these focus groups were held at the end of the project. Due to technical problems these recordings could only be partly transcribed. In addition to the data gathered from focus groups, trained research assistants observed the classroom practices. They used protocols consisting of observational checklists where they could check off and describe each step of the lesson plan. Design products and e-mails of all the groups were archived.

The audio recordings were transcribed and used to gain insight in the collaborative process of reflective narration that lies behind reading and writing e-mails. The e-mails were segmented into clauses and coded for their general content (Personal Talk, Communicative Talk, Design talk)⁸. Design task related segments were further categorized in the five categories of reflective narration that were found in the e-mails of the first design experiment (Describing, Questioning, Relating, Appreciating, and Assessing). Interrater agreement was calculated for each step. A second independent coder coded about 25% of the data. For segmentation, the interrater agreement was 95.9%. For general coding, Cohen's Kappa yielded .95. For detailed coding, Cohen's Kappa yielded .80.

The results of the second design experiment are presented within the three perspectives on narration proposed by Conle (2003)⁹. The first perspective (act of narrating) presents findings on the teachers' implementation of and children's motives towards freewriting. In addition, we describe the collaborative process of composing an e-mail from the freewritings. The second perspective (rhetorical statement) presents findings from the general coding of the freewritings and e-mails. The third perspective (story) presents findings from the detailed coding of the freewritings and e-mails. Finally, we revisit the first perspective and look in

⁸ For a detailed description of segmentation and coding procedures, we refer to chapter two.

⁹ For a detailed explanation of the three perspectives, we refer to chapter two.

detail at the act of reading and discussing a received e-mail from the partner group.

It is important to note that children's writings are translated from Dutch. In the act of translating the fragments presented in this thesis, our main goal was to preserve the unique characteristics of children's expressions (e.g., words, syntax) without a loss of meaning for non-native speakers. In addition, the e-mail fragments that are used to illustrate findings are *not* segmented.

Results

The act of narrating (composing an e-mail)

The teachers used freewriting as planned. They embedded it in all the lessons (with the exception of one lesson in one school due to time limits) shortly after working on the design task. They carefully followed the step by step procedure in the lesson plan giving the children three minutes to silently think about the lesson. After that, the children wrote for five minutes. Now and then, the teachers helped individual children that got stuck by suggesting what they could write about. Sometimes, they prompted the children not to think but write in a continuous flow.

The teachers evaluated freewriting positively. They reported that it structured the e-mail process. This is nicely illustrated in an e-mail exchange between two teachers. The first teacher wrote:

I have done the freewriting exercise. The children were very enthusiastic and eager, maybe also because it was new. What was especially nice, was that I had told them that grammar and misspellings didn't matter. The most important thing now was the content of their writings, putting their observations into words. I like the work format. Do you link freewriting to the grammar lesson?
(Teacher 1, e-mail, lesson 2)

The second teacher replied:

I liked the freewriting exercise. I can see what they have learned from the lesson (which actually is quite a lot) and how the children experienced working in groups. I don't connect the exercise to the grammar lesson. I read them before the e-mails are sent away, but I don't revise their texts and don't let them revise the texts.
(Teacher 2, e-mail, lesson 2)

In general, the children too evaluated freewriting positively. They were able to think and write about the lessons and most of the children were

motivated to do so. However, freewriting was not evaluated positively by all children. Two types of negative reactions were given. Some children experienced freewriting as an obligatory exercise that simply had to be done. They didn't feel invited to express personal experiences, but rather to write down a pragmatic recount of the lesson. In addition, for some children freewriting was difficult. Although freewriting seeks to free learners from writing constraints (Elbow, 1973), some children found it physically and mentally difficult to engage in a flow of writing. The following fieldnote illustrates both types of reactions:

They didn't like freewriting. Pim indicates he can't write that fast. He also says there are so many thoughts crossing your mind. Pim says it wasn't nice that Ellen wrote much more each time. For Ellen, on the other hand there is no challenge in it: in sequential order she considers what was done during the lesson and writes that down.
(Researcher, field note, lesson 6)

After freewriting, the groups composed an e-mail. Often, this process started with reading each other's freewritings. Sometimes, the children read each other's writings silently for themselves. Other times, they took turns and read their own freewritings aloud. After reading the freewritings, the children used a worksheet to write an e-mail message. The teachers instructed them to write a reaction to the received e-mail and to compose a group e-mail on the basis of the freewritings. In the process of composing group e-mails, the freewritings played an important role. The children frequently referred to the freewritings while discussing options, chose parts that could be used in the e-mail, and discussed similarities and differences to reach an agreement about what they should write to their partner group. The following fragment illustrates the composing process. Jan, Dave and Sarah have just read aloud their freewritings and start writing the e-mail:

[1] Dave: The e-mail
[2] Sarah: Jan does the writing
[3] Jan: O.K., I'll start writing. Today was a very dull e-mail lesson, yes? That's the beginning. Today....
 Come on, Dave get with it. Today, what's today?
[4] Sarah: Today is thirteen, eleven
[5] Jan: Thirteen, eleven
[6] Sarah: November
[7] Jan: We had a very dull e-mail lesson.
[8] Dave: Why? I liked it.
[9] Sarah: Except for Dave.
[10] Dave: Yes, but. Write it down, will you. I liked it.
[11] Jan: A very dull e-mail lesson. Only Dave liked it.
[12] Dave: I liked it a lot.

- [13] Jan: Today, November 13, we had a very dull e-mail lesson. Only Dave liked it.
 [14] Dave: You are doing fine, Jan.
 [15] Jan: The e-mail lesson was about fish.
 [16] Sarah: And their environment.
 (Focus group 1, audio recording, lesson 2)

Jan, who is proposed as the writer, immediately starts formulating a first sentence. The topic of this sentence, that the lesson was boring, is derived from his freewriting. Sarah also wrote down that she didn't like the lesson. Dave, however, had written that he did like the lesson. He defends his position during the writing process (lines 8-12). This leads to an adjustment of the e-mail (lines 13-14) and the writing process moves on (lines 15-16).

The fragment illustrates that children now had a means to participate in group discussion by using their freewritings. Comparisons between the content of the freewritings and the e-mails also suggest that there was equal participation. Most e-mails contained parts from at least two freewritings. Often, groups looked for similarities between the freewritings that could be summarized into a group opinion. For example, Etiën wrote that he liked doing the presentation, Robby that he liked it but was nervous, and Patricia that she liked the presentation but found it difficult. They summarized these experiences into the following sentence: "We all found it very difficult, but nice to do".

The most commonly used strategy for composing an e-mail from the freewritings was adoption. By adoption we mean copying parts from the freewritings and pasting them into the e-mail. This does not mean that adoption was a mindless process. The children seemed to become aware of the specifics in each writing, and combined the unique topics from the writings into a group story. The following fragment illustrates the adoption strategy:

- [1] Felix: Hey! you got quite a story, how did you do that?
 [2] Lisa: Here is another story. Or do you mean these?
 [3] Felix: No, I mean the one....about all you write that down
 [4] Lisa: Do I have to copy all this?
 [5] Felix: No, just some fragments, take some fragments from each one
 [6] Lisa: Okay. So, from Daniel's I take.. Okay, this fragment comes from Daniel's. And from Felix's we take this whole piece. From Karen's we take, Karen what have you got here? (Lisa reads Karen's writing aloud) What should I take from Karen's? The teacher was ill, the children weren't.

- [7] Daniel: We heard your teacher was ill.
 [8] Lisa: Look, I've got something on the presentation lesson, Felix has something on...With Karen we have something on the environment. From Karen we have what it can do and such things, with Daniel we have 'Biotopia'¹⁰ and with Felix about balance and all that.

(Focus group 2, audio recording, lesson 5)

Although freewriting was successfully implemented in the classrooms, some problems were also noticed in relation to the composing process. First, reading each other's freewritings often happened in a somewhat chaotic and unstructured way. No specific time was reserved for reading and discussing the freewritings. Instead, this was often mixed with writing the e-mail:

- [1] Karen: Hello, Blackboys
 [2] Felix: The lesson was great fun, but things went worse than last time
 [3] Lisa: Karen, we can't send a photograph for we have no scanner at school
 [4] Felix: I can't read this any more
 [5] Lisa: Yes, the same with Karen, I can't read it any more, she has crossed out a large part
 [6] Felix: Hello, Blackboys
 [7] Lisa: I'll start writing very neatly now
 [8] Felix: We have chosen the animal, the owl
 [9] Lisa: The wood owl it was. We have chosen the wood owl, for you could choose an animal yourself.
 [10] Felix: For you could not choose an animal yourself. We had to choose one from a group, didn't we?
 [...]
 [11] Felix: What else can we write down? We have thought of quite a lot
 [12] Lisa: Thought up quite a lot, thought up is more beautiful. It was a very nice lesson.
 [13] Felix: Yes, but not so difficult. Daniel wrote: it wasn't an easy lesson like normally
 [14] Lisa: It was a nice and easy lesson. Full stop.
 (Focus group 2, audio recording, lesson 3)

The group just started writing (lines 1-2). Several times, they explicitly refer to the freewritings (lines 3-5, 13). A short discussion evolves around

¹⁰ 'Biotopia' is a fictitious planet in a story that was read to the children at the beginning of each lesson. The children helped 'professor N.A.Ture' to build an ecosystem on this planet.

two topics that are derived from the freewritings: the animal they chose (lines 8-10), and how they appreciated the lesson (lines 12-14). That the children only incidentally read and discussed the freewritings and only after they started writing an e-mail might explain the strategy of adoption that emerged in most groups.

The teacher in school 1 skipped the composing process after the second lesson. In the months preceding the project, the children in this classroom were trained in word processing. For the teacher, a side aim of using e-mail was to increase the children's independent use of word processors. Therefore, he let the children type their freewritings in a group document. The children did not read and discuss each other's freewritings. They merely sent out their group document to the partner group in an attachment.

Rhetorical statement (freewritings)

In total, 231 freewritings were produced in six lessons. Their length differed between schools (see Figure 3-5).

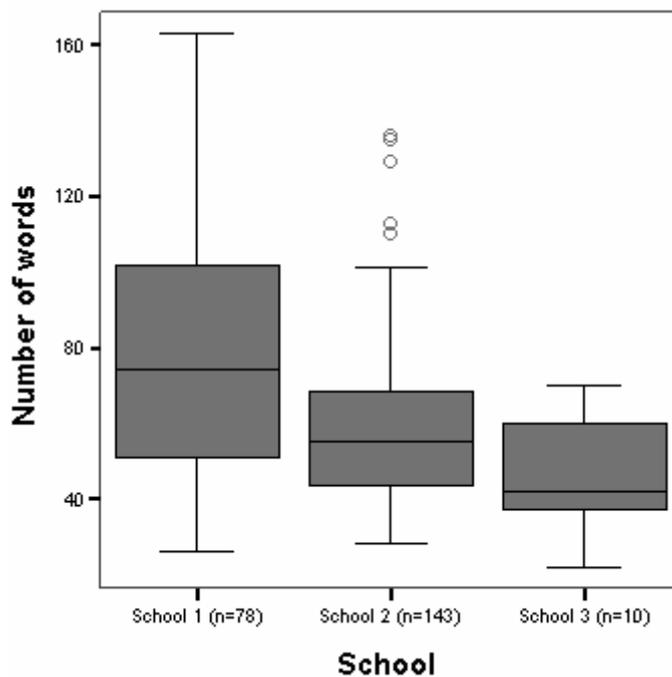


Figure 3-5 Differences in the length of freewritings between schools. The boxplots show the range, median, and five outliers.

The freewritings had an average length of 63.7 words (s.d.=25.3, N=226)¹¹. In school 1, they had an average length of 78.0 words (s.d.=31.3, N=78), 56.9 words in school 2 (s.d.=17.3, N=138), and 46.0 in school 3 (s.d.=14.6, N=10). It differed significantly between schools 1 and 2 ($\chi^2(1, 216)=23.3, p<.01$), but not between schools 2 and 3 ($\chi^2(1, 148) = 3.5, n.s.$).

In addition, the length of the freewritings changed across lessons (see Table 3-1). In school 1, the length was highest and increased across lessons ($\chi^2(4, 78) = 11.0, p<.05$). In school 2, the length decreased ($\chi^2(5, 138) = 21.2, p<.01$) whereas in school 3 it fluctuated ($\chi^2(4, 10) = 4.6, n.s.$). Why do these patterns differ? The fluctuations in school 3 can be explained by the fact that the two children in this classroom did not like freewriting, but liked the lessons. These mixed feelings might have affected the length of the freewritings in variable ways. In schools 1 and 2, the implementation of the composing process can explain for the differences in length. In school 1, composing an e-mail based on freewritings was skipped after the second lesson and freewriting functioned rather independently from the e-mail use. As a result, the children in school 1 developed less audience awareness during freewriting. In contrast, the children in school 2 were very aware of the audience while freewriting. Disrupted e-mail contact between the schools in lessons three and four may therefore have decreased these children's motivation for freewriting.

Table 3-1 Average length of freewritings in three schools across lessons. The values represent the length of freewritings ($N_1=78, N_2=138, N_3=10$) in average number of words across schools and lessons.

School	Lesson						Total
	1	2	3	4	5	6	
1	59.1	69.4	82.6	85.3	91.8	- ¹²	77.9
2	67.9	60.8	55.4	60.2	50.4	47.2	56.9
3	56.0	30.0	- ¹³	41.0	48.5	54.5	46.0

The freewritings support the view that the children in school 2 and 3 saw freewriting as the running start for writing an e-mail more than did the children in school 1. Their freewritings show audience awareness in several ways. The freewritings were larded with greetings (54.5%), and with

¹¹ Five outliers were excluded from the calculations.

¹² Missing values.

¹³ Missing values.

personal information, questions and reactions addressed to the partner group (25.2%). In school 1, only 19.2% of the freewritings contained greetings, and 2.6% addressed the partner group. The following excerpt illustrates the audience awareness found in most of the freewritings in schools 2 and 3:

I thought it a pity we didn't get an e-mail but I heard there was an illness and that's why you couldn't work. [...] And I hope now nobody is ill with you for in that case we won't have an e-mail again.
(Bram, school 2, freewriting, lesson 4)

Rhetorical statement (e-mails)

In total, 72 e-mails were sent during six lessons (M=6 e-mails per group). Weekly e-mail contact was realized between school 2 and 3. However, the e-mail contact between school 1 and 2 was hampered due to illness of the teacher. In school 1, lessons were rescheduled. As a result, school 2 received no e-mails from school 1 in lessons 3 and 4, and received two e-mails in lesson 5.

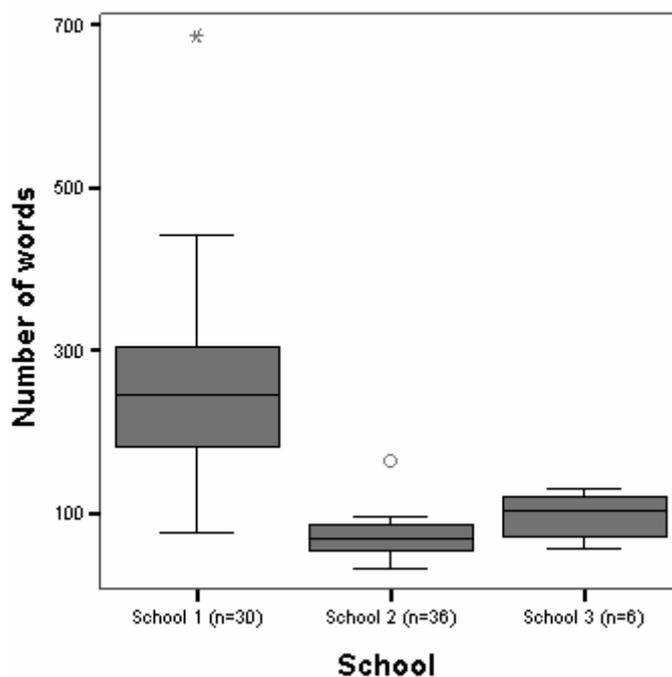


Figure 3-6 Differences in the length of e-mails between schools.
The boxplots show the range, median, and two outliers.

The e-mails had an average of 148.5 words (s.d.=122.0, N=70)¹⁴. This differed between schools (see Figure 3-6). In school 1, the average length of the e-mails was 237.5 (s.d.=99.6, N=29). In school 2, the average length was 67.5 (s.d.=17.0, N=35). In school 3, the average length was 98.5 (s.d.=29.2, N=6). The difference was significant between schools 2 and 3 ($\chi^2(1, 41) = 6.0, p<.05$), and between schools 1 and 3 ($\chi^2(1, 35) = 8.6, p<.01$). The latter can probably be ascribed to the fact that in school 1 freewritings were pasted into the e-mail.

The e-mail segments were coded as either Personal Talk (e.g., “Mary’s hobby is horse riding”), Communicative Talk (e.g., “We received your e-mail”), and Design Talk (e.g., “We added new animals to our ecosystem”) to gain insight in the general rhetorical structure of the e-mails. An almost similar distribution pattern of PT, CT and DT across lessons was found as in the first design experiment (see Table 3-2). PT was most present in the beginning and decreased towards the end ($\chi^2(2, 70) = 20.8, p<.01$), CT was present during the whole communication ($\chi^2(2, 70) = 2.8, n.s.$), and DT increased across lessons ($\chi^2(2, 70) = 13.9, p<.01$).

Table 3-2 Personal, Communicative, and Design Talk in the e-mails across lessons. The values represent percentages of segments (N=1599) coded in one of three categories and show their distribution across lessons.

Coding	Lessons			
	1&2	3&4	5&6	Total
Personal Talk	48.5	8.5	7.3	21.1
Communicative Talk	19.7	21.4	22.1	21.1
Design Talk	31.8	70.1	70.6	57.8

In school 1, the freewritings were literally pasted into word files with only minor adjustments. In addition, their freewritings showed few signs of audience awareness. Therefore, we expected to find a lower percentage of CT and PT in the e-mails of school 1. This expectation was confirmed (see Table 3-3). A significantly larger part of the e-mails was dedicated to DT ($\chi^2(1, 70) = 37.5, p<.01$). Still one third was dedicated to establishing a personal and communicative relationship with the partner group.

¹⁴ Two outliers were excluded from the calculations.

Table 3-3 Personal, Communicative, and Design Talk in the e-mails across schools. The values represent percentages of segments of school 1 (N=1075) and schools 2/3 (N=524) coded in one of three categories.

Coding	Schools	
	1	2 / 3
Personal Talk	17.2	28.1
Communicative Talk	18.5	26.9
Design Talk	64.3	45.0

In the first design experiment, most e-mails had a sandwich structure. The e-mails started and ended with communicative and personal information, and contained design task related talk in between. This sandwich structure was also expected to be the most common structure in the e-mails of schools 2 and 3. Because in school 1 freewritings were literally pasted into the e-mail, a different structure was expected in their e-mails. This expectation was confirmed. In schools 2 and 3 and in the first two e-mails of school 1, a sandwich structure was present. In the other e-mails of school 1, a block structure was found. Sometimes, but not always, the e-mail started with a greeting and reaction to the received e-mail. This was followed by blocks of freewritings, headed by the children's names. Often, there was no greeting at the end. Instead, greetings appeared in between the blocks. The following fragment of an e-mail illustrates the block structure:

The dolphins for group The Monkey Tails

Answer to question 1 : Robert was ill

Answer to question 2 : No, we won't attach a photo

Robert group 4

At first we received the e-mails from the other from the other group we got some we had to read and answer. Next our teacher told us about Professor N.A.TURE¹⁵ later we had to look up things in books and we had to draw then some ten to fifteen minutes later we had to stick on everything. On quite a big piece of paper. We had a yellow one and it was about the wood. We had added all kinds of things and animals. Then we had to write and that's what I'm doing right now. That's all I can write about the lesson so I'll stop here.

Best wishes from the Dolphins group 4

Theo group 4

Today we had another e-mail from Prof. N.A.TURE this time our group a green piece of paper and you had to make drawings and stick

¹⁵ 'Professor N.A.Ture' is a fictitious character in a story that was read to the children at the beginning of each lesson. The children helped professor Ture build an ecosystem on the fictitious planet called Biotopia.

them on it. I drew a butterfly and some trees. N.A.TURE said that in Biotopia many animals were dying.
(Group 4, school 1, e-mail, lesson 4)

The same rhetorical moves that we found in the e-mails of the first design experiment (i.e., extended greetings, metatags, repetitive structures, enumerations, and spoken language) were present¹⁶, but their frequency differed. Fewer extended greetings (55.6% opposed to 96.3%, $\chi^2(1, 158) = 38.8$, $p < .01$) and spoken language (11.1% opposed to 67%, $\chi^2(1, 158) = 49.4$, $p < .01$) were found whereas more metatags (56.9% opposed to 37.8%, $\chi^2(1, 158) = 6.1$, $p < .01$), repetitive structures (69.4% opposed to 28.1, $\chi^2(1, 158) = 27.1$, $p < .01$) and enumerations (51.4 opposed to 37.8, $\chi^2(1, 158) = 3.1$, n.s) were present. The repetitive structures took different forms in school 1. They did not consist of repetitive sentences or numberings, but were constructed around headings, tables, and chronological structures (e.g., “First we..., Then we..., After that we...”). Part of the differences, for instance the limited use of spoken language items, may be explained by the fact that different styles and genres can evolve in communities (cf. Bhatia, 2002). In addition, the fact that school 1 used a word processor probably influenced the rhetorics of their e-mails as can be seen in their use of headings and tables to format the information.

The style of the e-mails differed between the schools. In the e-mails of school 2 and 3, the staccato style that was found predominant in the first design experiment was most frequent. In these e-mails, descriptions and evaluations were summed up without extensively elaborating on them. In the e-mails of school 1, an anecdotal style was found. Within the blocks, extensive and chronologically related descriptions and evaluations of the lessons were given.

Story (freewritings)

The freewritings contained descriptions of the process and product of designing. Many times children gave a detailed chronological account of the lessons illustrated by the following fragment:

This afternoon we had another kidnet lesson. We talked a little about last week. Next the teacher read the e-mail from Prof. N.A.TURE to the class. It was about Biotopia that there are too many animals and too little food. Then we looked at some e-mails from this week and last week. Then we could do our own ecological community on a large piece of paper. That took us about half an hour and then we had

¹⁶ The rhetorical moves were measured at e-mail level in contrast to the general and detailed coding of the contents of the e-mails that were measured at segment level.

to clean up and finally as usual the five-minute letter last of all. It was a quarter to three and school was over.

(Tim, school 1, freewriting, lesson 4)

And they frequently described their designs. Some descriptions were more general than others:

This time we discussed the adder and what it lives on. It feeds on mice so we had to make lots of questions about mice where they live and all that.

(Daan, school 2, freewriting, lesson 4)

It has gills to breathe with. The goldfish has a bum hole. It poops and pees at the same time. It must be able to swim and has fins for that. The eyes may be very big, sometimes they are small.

(Mija, school 2, freewriting, lesson 1)

The descriptions were enriched by evaluations by relating old and new experiences, and expressing appreciations and assessments. No comparative or help-seeking questions nor other kinds of questions about the topic were found in the freewritings. The children expressed their appreciations of the design task in almost every freewriting. Sometimes, these appreciations were expressed in rather general terms such as “I liked the lesson” or “I thought the lesson was difficult”. Many times, however, the children added reasons why they (dis)liked the lesson, the topic, the group work and so on. For example:

I don't like fish for it just swims about like that in circles and you can't do anything with it. it doesn't make any sound and only says blub, blub sometimes fish die just like that.

(Mustafa, school 2, freewriting, lesson 1)

I sometimes liked the lesson and sometimes I didn't I think our group is nice we can work together nicely I think fish are quite dull animals. The lesson you had to think up all the things fish need I didn't like so very much I think it's nice to have a fish in our classroom.

(Marion, school 2, freewriting, lesson 1)

In addition, they frequently assessed their own behavior in the lessons. They reviewed their design products and what they had learned from it. They also evaluated their own role in the collaborative learning process. The following excerpts illustrate this:

I have learned from this afternoon's lesson something, that we have to discuss in our group and that we have to discuss things in the group and not keep them to ourselves and about fish I didn't know very much yet but a lot more now and I like that.

(Willem, school 1, freewriting, lesson 1)

But Kevin didn't cooperate very much he hardly ever does. And Jenny was being silly now and then but I was a bit like that as well. And again !! Saskia was the boss.

(Stijn, school 2, freewriting, lesson 2)

In some freewritings, the children explicitly related new experiences to personal experiences from out of school. This occurred in two ways. In these cases, the children related what happened in the classroom to earlier experiences, or to current circumstances at home and in their lives:

It was about fish I liked that because I have some myself (at my father's).

(Saske, school 2, freewriting, lesson 1)

A fish in the classroom we liked most of all some didn't listen to the teacher at all most of them were constantly watching the fish for they were anxious to know how it swam and how it breathed most of our class had never yet seen a live fish and that's why they were watching the fish all the time.

(Dieuwer, school 2, freewriting, lesson 1)

Some of these accounts were fantasies that went beyond reality and related the classroom experiences to what might happen elsewhere:

An adder is a beautiful and dangerous animal. When you come across it on the moor I'd better take care if I were you. For it has fangs and once it has hold of you I think you have little chance to stay alive for poison is very dangerous.

(Bram, school 2, freewriting, lesson 3)

The many personal perspectives that appeared in the freewritings illustrate that the freewriting exercise helped the children in expressing an awareness of their own role in learning. Freewriting encouraged self-reflection, reflection on others, and reflection on the process and product of learning.

Story (e-mails)

All Design Talk segments of the e-mails were categorized in one of the five categories (see Table 3-4). In general, the results for the e-mails reflected those for the freewritings. Most design talk was of a descriptive nature. Furthermore, the groups frequently expressed their personal perspectives on the design task by appreciations and assessments and to a lesser extent by relating old and new information. Just like the freewritings, the e-mails were not directed at posing questions about the topic of designing. Only a few such questions were found.

Table 3-4 Descriptions and evaluations in the e-mails across schools. The values represent percentages of segments of school 1 (N=691) and schools 2/3 (N=236) coded in one of five categories.

Coding	School		
	1	2 / 3	Total
Describing	76.4	59.4	72.6
Questioning	0.9	0.2	0.6
Relating	2.6	1.4	2.3
Appreciating	10.7	26.6	14.4
Assessing	9.4	12.4	10.1

Table 3-4 shows that the content of the e-mails differed between schools. In school 1, relatively more descriptions were found than in schools 2 and 3 ($\chi^2(1, 70) = 39.6, p < .01$). The e-mails gave detailed chronological accounts of the process and product of designing, sometimes by presenting complete tables of what was found as is illustrated by the following fragments:

We received a paper with all animals on it. Like the fox, the wolf, hamster, seal and a lot of others. and also questions. We had to choose an animal and this animal we had to put it on another paper. Later on I had to type everything we found and what I had typed I had to put it in a table. Steven and Ginny had to make drawings while I was typing. Steven drew a hare and what it needed and what it needed in the environment. And Ginny drew a head and did exactly the same as Steven did. It was a nice lesson. Not like other times, the previous lessons were a bit more boring. Then we had to write for five minutes what we thought of the lesson and about what we did.

(Group 5, school 1, e-mail, lesson 3)

We have made a model¹⁷.
 Dunes: fox
 What must I be able to do, What do I need for that, What do I need
 in the environment
 Eat, mouth, food
 Walk, feet, ground / soil
 Mate, sexual organs, partner
 Hear, ears, sound / rest
 Smell, nose, scent
 See, eyes, sun
 Hunt, self defense, prey (opponent)
 Urinate, penis or vagina, tree
 Poop, bum, a hole in the ground
 Grow, bones / muscles, food
 Feel, nerves, thing
 Play, body, pleasure
 Clean, tongue, water
 Swim, legs, water.
 (Group 1, school 1, e-mail, lesson 3)

In schools 2 and 3, the descriptions were less extended. The e-mails summarized what had happened in the classroom. Relatively more evaluations were found than in school 1 ($\chi^2(1, 69) = 4.8, p < .05$). Their descriptions were larded with appreciations and assessments:

We chose the wood owl for you could choose from some animals.
 We had thought up quite a lot. It was a nice but also an easy lesson.
 Did you think so, too?
 (Group 6, school 2, e-mail, lesson 3)

We liked the lesson about the goldfish. And especially it's nice to
 have a fish in our classroom. We also liked the letter from prof
 N.A.TURE. We knew a lot about fish. We think it a rather dull
 animal because it just swims around in circles. It has scales to protect
 itself.
 (Group 3, school 2, e-mail, lesson 1)

Overall, the e-mails of schools 2 and 3 seemed more general than the e-mails of school 1. In school 1, freewritings were literally pasted in the e-mails which preserved the detailed and personal character of the freewritings. In contrast, the e-mails of schools 2 and 3 were composed by adopting from the freewritings. A phase of group thinking to reach

¹⁷ For matter of convenience, the original table that the children put in their e-mail is presented textually.

agreement followed the phase of individual expression. As a result, some details of the individual freewritings were lost.

The act of narrating (receiving an e-mail)

We enter the classroom at the beginning of the second lesson. Focus group 2, consisting of two boys (Daniel and Felix) and two girls (Lisa and Karen), is about to complete their design of a fish's ecosystem. In the first lesson, they designed the fish itself by using the first three questions of the design heuristic: 'Who am I', 'What must I be able to do?', and 'What do I need for that myself'. In the second lesson, they are to design the habitat of the fish by using the design question 'What do I need for that in my environment?'. Before they start working on the design, an e-mail from their partner group is received. In the next fragment, they are reading the e-mail aloud and shortly discuss its content:

- [1] Daniel: Wageningen. As leader of the group I named the group 'the Kippos'. What should a fish be able to do and what does it need for that? We think the following: what must I be able to do? Swimming, seeing, eating, breathing...
- [2] Felix: Pardon?
- [3] Daniel: Stability
- [4] Karen: Eating is there two times! Look, there it says eating, and there again.
- [5] Lisa: Stability?
- [6] Daniel: Yes, stability.
- [7] Lisa: What is that?
- [8] Daniel: That you survive (continues reading aloud) What do I need: fins, eyes, mouth, gills, grey cells, waterplants.
- [9] Karen: Waterplants, yes
- [10] Daniel: Sexual organ and a female. Have you thought of anything else? Mail us back. Regards the Blackboys.
- [11] Karen: Well, what else do we need with this?
- [12] Lisa: Well, we had to discuss what is interesting
- [13] Daniel: Eating two times
- [14] Lisa: Yes, why have you got eating two times?
- [15] ?: Pardon?
- [16] Lisa: But look here, that's strange I think, for here they have eating-mouth, and here eating-waterplants. So here they mean with environment, waterplants. So this doesn't really belong here. They eat waterplants.

- [17] Daniel: Swimming, seeing is eyes, eating is beak,
breathing is gills, thinking grey cells, eating
- [18] Lisa: Waterplants, but (recording not clear)
- [19] Daniel: I think they eat waterplants
- [20] Lisa: Yes, but that is in the environment
(Focus group 2, audio recording, lesson 2)

The fragment shows that the content of the e-mail is already discussed while it is being read aloud. Questions arise (lines 2, 5, 7), and striking things are pointed out (lines 4, 9). After the e-mail is read, it is further discussed (lines 11-20). Daniel starts the discussion by bringing in a fact that was pointed out by Karen before, namely that the partner group mentions 'eat' two times (line 13). Lisa elaborates on the problem by indicating that different matters are related to the function of eating (16). This short discussion draws the group's attention to the environment of the fish. For eating, the fish needs a mouth, but it also needs waterplants for eating in its environment (lines 16-20).

Next, the group starts working on their design. It appears that their understanding of waterplants as food for the fish was only temporary. As soon as they start working on the design, the topic of waterplants re-enters the discussion:

- [1] Daniel: O.K., a fish needs, a waterplant, it can breathe,
and then it can again
- [2] ?: And then it can eat!
- [3] Daniel: Yes, but then we must again
- [4] Felix: Well, how to do that now?
- [5] Daniel: They have made a mistake, a fish has no
waterplants
(Focus group 2, audio recording,, lesson 2)

Daniel brings in the topic of waterplants and elaborates on it by stating that the fish needs waterplants for breathing (line 1). Another child brings in that the fish needs waterplants for eating too (line 2). This they had already found out from discussing the received e-mail. Then the group becomes confused about the double role of the waterplants (lines 3-4) and about the distinction of what a fish needs to have itself and what it needs in the environment (line 5). In this confusion, explicit reference is made to the partner group (line 5). The most noteworthy thing in this discussion is that the group adopts an issue from the received e-mail with the intent to integrate it in their design. On several occasions during the ensuing lesson, the group resumes their discussion on the waterplants until their problem is resolved and the waterplants become fully integrated in their design:

[1] Felix: I don't know, are there any plants in fresh water?
 [2] Daniel: Yes, I think so
 [3] Lisa: Yes, of course, for when at home
 [4] ? : Yes, for it eats plankton as well

[..]

[5] Daniel: Wait a minute, an oxygen plant
 [6] Lisa: Yes, we have got that already? Waterplants
 [7] ? : A waterplant is something quite different
 [8] Felix: No, they are oxygen plants.
 [9] Lisa: Because in that waterplant there is oxygen.
 [10] Daniel: Yes, but what have they got?
 [11] Lisa: We aren't going wrong, Peter

[..]

[12] Lisa: Dirt, bacteria, they need clean water, no
 [13] Felix: No
 [14] Lisa: Waterplants
 [15] Felix: Yes
 [16] Lisa: For you often find those bacteria on waterplants
 [17] Daniel: Clean water
 [18] ? : Yes! And clean water, that's what waterplants need.
 [19] ? : No, sunlight
 [20] ? : No, waterplants and then to the bacteria.
 [21] ? : And next from clean water to the waterplants.
 [22] Lisa: Oh, no, we have done it the wrong way. Bacteria need clean water.
 [23] Daniel: Yes, the bacteria clean the water.... The sun just doesn't belong.
 [24] Felix: Of course, it does! Waterplants grow with the help of sunlight.

(Focus group 2, audio recording, lesson 2)

Then the design reaches completion. The waterplants are now integrated in the design. The environment is ready to welcome newborn members of the fish family that of course will be in need of food and shelter:

[1] Felix: Now I know: fish, partner, young fish.
 [2] Karen: Yes
 [3] Felix: Food, for those young fish need food
 [4] Lisa: Oh yes, food
 [5] Daniel: Fish, partner, young fish...
 [6] Lisa: And they in their turn need food...
 [7] Karen: Hiding place

[8] Lisa: And those are the waterplants
(Focus group 2, audio recording, lesson 2)

The fragments show that while designing, the group talked about waterplants on several occasions the first one of which was while reading and discussing a received e-mail. The group adopted the topic from the received e-mail and adapted it until it fit their design. Analyses of other audio recordings showed that the e-mails did not give rise to the same kind of elaborate discussion in the other lessons of all focus groups. Other group work protocols indicated that the groups read aloud the received e-mails and discussed these. But mostly, these comments were about less vital issues such as misspellings, group names, personal talk, and whether they liked the e-mail. As a result, these comments did not lead to explorative discussions within the groups but resulted in short and shallow reactions such as 'We have already mentioned that' and 'They make a lot of mistakes' that did not influence their subsequent group work.

Although the Waterplant-discussion appears to be an exception, it illustrates that using e-mail can comprise more than just the exchange itself. Besides stimulating an interaction between groups, it can also generate fruitful discussion within groups. Writing e-mails together gives rise to within group discussion as was illustrated at the beginning of the results section. Reading received e-mails can do the same as was illustrated by the Waterplant-discussion.

Conclusion

In the first design experiment freewriting was embedded in only two lessons in one school. In the design experiment presented in this chapter, freewriting was built into the lessons systematically to structure the process of reflective narration for both teachers and children. In each lesson, the teacher guided the children into subsequent steps of reflective writing. For the most part freewriting was successfully implemented in the classrooms. The teachers and most children valued freewriting. The writings contained rich and reflective accounts. Freewriting encouraged self-reflection, reflection on others, and reflection on the processes and products of learning. This was continued in the e-mails as most e-mails were constructed by adopting parts from the freewritings.

Composing an e-mail with the group by using the freewritings as a starting point proved to be valuable in several ways. First, it provided children with the opportunity to bring in their personal voice and defend it in the process of constructing a group opinion. Second, the children became aware of individual differences. This often led to acknowledging the uniqueness of each writing by copying very specific parts into the group

story. In other cases, it led to the construction of a group summarization that did justice to the different opinions of the group members.

However, the composing process was performed in a rather unstructured and inconsistent way. In two schools, the children read and discussed each other's writings and composed an e-mail by adopting parts from them. This passed off rather unstructured. The children often read and discussed each other's freewritings only incidentally and shortly. In the other school, the collaborative composing process was skipped entirely. The children did not read and discuss each other's freewritings but typed their own in a shared document that was sent to the partner group.

The way in which the composing process was implemented strongly influenced the process of reflective narration. It affected children's motives for freewriting which shifted from 'private reflection' to 'addressing an audience' in the schools that used the freewritings to co-construct group stories. It had an impact on the rhetorical characteristics of e-mails. The e-mails in which entire freewritings were pasted had a different structure and contained other rhetorical forms. It also affected the reflective nature of the stories. In the two schools that co-constructed from the freewritings, the descriptions were shorter and less detailed. They contained relatively more evaluations. The e-mails in which entire freewritings were pasted contained more detailed descriptions.

We conclude that more attention needs to be paid to the composing process in the instructional design. First of all, it should preserve the individual nature of it by emphasizing that freewriting aims at producing individual and personal accounts of the lessons without yet taking a specific audience in mind. Second, a step by step procedure should be provided that helps teachers and children structure the collaborative process of reading and discussing freewritings. Therefore, the freewriting procedure given in the lesson plan should be extended to comprise additional steps that structure the composing process. Steps could be added that explicitly reserve time for reading and discussing freewritings. Although they might still adopt parts from freewritings and as a result lose some details in the communication between groups, these details would at least be explored and adapted within groups.

Besides looking at the collaborative process of writing an e-mail, we also examined reading and discussing a received e-mail together. Central to the emerging practices appeared to be reading the e-mail aloud and giving comments. Although the received e-mails were read aloud and commented upon, these comments often were not about the design task. Rather, they concerned personal and communicative talk. We only found one instance of a more extensive discussion in one of the focus groups and presented this in the Waterplant discussion. The children read and discussed the received e-mail and adopted the topic of waterplants from the e-mail for further

discussion while completing their design. In this discussion, they sometimes explicitly referred to their partner group. The Waterplant discussion showed that valuable discussion *within* a group can rise from e-mail contact *between* groups. Other researchers have also found that different processes take place within and between groups. For instance, Windschitl (2001) found that: "In contrast to the increasing homogeneity of thought within groups, profoundly different approaches to problem solving evolved between groups. The diversity of approaches adopted by different groups was the key underlying condition for interactions between groups that were not possible as intra-group phenomena" (p.32). Howe, Tolmie, Duchak-Tanner and Rattray (2000) found that reaching within group consensus before confronting an expert computer program was profitable for learning procedural knowledge. And Finholt, Sproull and Kiesler (1990) found that within group discussions were aimed at negotiation and decision making whereas e-mail contact with another group was used for making reports.

Within group discussions while reading a received e-mail occurred only once in the present data. Therefore, we conclude that the reading process was not implemented successfully in the classrooms. Similarly to the composing process, it needs to be structured through a step by step procedure. The first step could be to read the received e-mail aloud. The next step could be to point out remarkable, interesting or unclear parts in the e-mail. A third step could be to choose one or two of these pertinent matters for further discussion within the group. A final step could be to make notes about the discussion that can be resumed at the end of the lesson in the e-mail communication between the groups.

Chapter 4

Design experiment 3: Reflection-in-action by questioning with the web

Introduction

In chapter one we argued that reflection in-action and on-action is needed to improve the development of personal understanding. Narration via e-mail was suggested for reflection-on-action and this was investigated in chapters two and three. We suggested questioning with the web for reflection-in-action. In this chapter, we explore if and how the web can be used for this purpose. A third design experiment was conducted in four classrooms in which groups of children used the web to find answers to self-generated questions while working on a design task in the domain of biology. The third design experiment sought to answer the following research questions:

- (1) *How can questioning with the web be implemented in the classroom so that the groups become engaged in reflection-in-action?*
- (2) *What is the reflective nature of the questions and answers?*

The first research question aims at the development and evaluation of an instructional design. The second research question aims at gaining insight in the nature of the questions posed and answers found and seeks to develop a definition of reflective questioning with the web.

The following sections explore in more detail how questioning and the web function in the primary classroom. We depart from general information seeking models and develop a more situated view of questioning by dividing it in three stages. Next, we consider use of the web as a means for reflective questioning. We discuss the possibilities and limitations of children's questioning behavior as well as their web searching capabilities in relation to the stages of questioning. Then, the third design experiment is presented. Successively, we describe the key elements of the instructional design, and the participants, procedure and results of the experiment.

Three stages of questioning

Questioning has been recognized as one of the most important activities in learning. Several functions of questioning are mentioned in the research literature. First, posing questions and pursuing their answers personalizes the

learning process. According to Dewey (1910), a personal interest in problem solving and inquiry is crucial for meaningful learning to occur. Through questioning, learners can become aware of their interest in a topic. The key role of having a personal question is well articulated by Dillon (1988) when he states: "If the question formulates the student's experience of perplexity, it gives motive and form to inquiry while providing those affective, cognitive, and behavioral propensities that dispose the student not only to seek out the answer but also to receive and accommodate it" (p.105). Second, questioning facilitates the construction of meaning. It stimulates learners to become actively involved, increases the awareness of differences between learners and promotes an exchange of views (Baumfield & Mroz, 2002; Chin, Brown & Bruce, 2002; King, 1991, 1998; Rosenshine, Meister & Chapman, 1996). Third, questioning can raise the awareness of the process of learning. From the perspective of the teacher, questioning can help to diagnose learners' needs (Baumfield & Mroz, 2002). From the learner perspective, the use of strategic question stems makes cognitive strategies more apparent (e.g., King, 1991).

Although deemed important, learners have limited opportunities to pose questions in the classroom. In his review of research on questioning in education, Dillon (1988) concludes that it is the teacher who poses questions. The teacher poses questions to draw attention, enhance participation, check the students' knowledge, or introduce a new topic. And teachers frequently pose questions: several per minute. In contrast, learners produce very few questions. And most of their questions are aimed at managing school work (e.g., "How much time do we have to finish the task?"). Recent research indicates that learners still have little room for questioning. A dearth of student questioning exists even in new approaches to learning that do recognize its importance. Watts and Alsop (1995) describe how children's questioning in primary classrooms is limited because teachers are afraid that they don't know the answers. And Rop (2003) shows that high school students that are motivated to pose questions during chemistry lessons are discouraged by both teacher and peers who want to save time for the standard curriculum. The latter research indicates one of the most important problems related to student questioning: that of how to create space and structural opportunity in the curriculum.

One way in which questioning indirectly has become a point of interest is by the attention that is currently being paid to information seeking. In its most general sense, questioning can be viewed as an information seeking process. There is an information need, and information is sought to satisfy this need. Many information seeking models have been developed to implement information seeking into the classrooms (for an overview of models, see Spitzer, Eisenberg & Lowe, 1998). These models generally distinguish six processes: (1) defining an information need, (2) locating

sources, (3) selecting information, (4) organizing information, (5) using information, and (6) assessing the product and process. Questioning encompasses all these processes, but emphasizes some over others. First, the process of 'defining a need' gains importance because it takes the form of a question. In the beginning of the information seeking process careful attention has to be paid to: (a) becoming aware of a need and (b) putting this need into words by formulating a question. In other information seeking processes, defining a need could result in an unspecified idea or a set of keywords. In questioning, the information need is carefully articulated in a question. Second, the process of 'organizing the information' is emphasized in questioning. Relevant information has to be synthesized into a question-related answer.

Although the information seeking model can inform the implementation of questioning in the primary classroom, it also gives little concrete handhold. The model is not context or task-specific. The six processes are expected to occur in all kinds of information seeking. The model does not differentiate between exploring a topic or seeking answers to specific questions, turning pages in a book or searching the web, preparing a presentation or writing a review. The model describes any information seeking process regardless of the context in which it takes place and does not specify the task, the sources, or the product. Furthermore, the model is not learner-centred in that it does not take into account the personal motives for information seeking. Information scientists hold a strong plea for embedding the training of information seeking skills within and throughout the regular curriculum (e.g., Spitzer et al., 1998; Todd, 2000b). And we already pointed out that research on questioning emphasizes that student questioning is especially beneficial when the questions stem from a strong personal interest. However, the information seeking model remains rather abstract in this respect and only starts with defining an information need instead of feeling it rise first. To embed reflective questioning with the web in the design task, as was the purpose of the present study, a model that takes the specific and situated nature of questioning into account is desirable.

Therefore, we adopted a questioning model that consists of three stages (Van der Meij, 1998). The first stage is *Perplexity*. In this stage, an information need evolves. The need is rooted in a personal experience of puzzlement, conflict or the like as a result of thinking over earlier experiences or encountering something new and unexpected. Several researchers see perplexity as the source for personally meaningful questioning. For instance, Dewey (1910) says that all learning should be rooted in aroused states such as curiosity, doubt, difficulty, or emotional shock (cf. Abrandt Dahlgren & Öberg, 2001). The second stage is *Asking*. In this stage, a question is formulated and posed. It can be formulated in the mind or externalized orally or written. Several factors influence if and how

perplexity is translated into a question: (a) presence of an interrogative mood (Van der Meij, 1998); (b) verbal ability and prior knowledge (Chin et al., 2002; Watts & Alsop, 1995); and (c) positive or negative stimuli from the teacher (Beck, 1998; Rop, 2003; Van Zee, Iwasyk, Kurose, Simpson & Wild, 2001; cf. Covington & Beery, 1976). The third stage is *Answering*. In this stage, an answer to the question is sought and formulated. This stage encompasses several processes of the information seeking model. Relevant information is located, and the selected information is organized into an answer. Van der Meij emphasizes that in this stage the retrieved information should be considered in light of the question to determine its appropriateness. Hence, the stage of answering refers back to the stage of perplexity in which the personal need to know emerged. The three-staged model emphasizes the importance of becoming aware of a personal need, translating this need into a task-specific question, and transforming relevant information into a question-related answer that is personally satisfying.

The stage of perplexity is crucial for reflection. Perplexity anchors questioning in the task, because it is raised by the task. This is a prerequisite for reflection-in-action. And when questioning departs from perplexity, personal motives of children are at the centre. The stage of perplexity emphasizes the importance of generating your own questions and takes into account the personal needs of learners. This is a prerequisite for the kind of reflection we aim for. Furthermore, the stage of answering draws back to the stage of perplexity and closes the circle that started with a personal need by formulating a personally satisfying answer. Closure of the circle of questioning is crucial for reflection. The information that is found should be evaluated in light of the question as well as in light of the question poser. In other words, the information should be related to the question and be useful to the one who posed the question. The stage of asking lies in between. It bridges the felt need and the satisfaction of that need. The question formulated in this stage should do justice to the felt perplexity, and make finding an answer possible.

In this research, questioning was embedded for the purpose of inducing reflection-in-action. We wanted children to pose personally relevant questions and formulate personally meaningful answers. The three-staged model was used as a framework for the instructional design and analyses of reflective questioning with the web. In the stage of perplexity, we should consider the classroom climate and children's emerging motives for questioning. In the stage of asking, we need to look at the amount and type of questions that are posed. The amount of questions indicates the children's willingness and ability to formulate questions. The type of questions indicates the questions' reflective nature. In the stage of answering, we need to look at the relatedness of the answer to the question, and at the relevancy of the answer to the question poser. Relatedness of the answer to the

question is a first indication that the stage of answering closes the circle that started with perplexity and continued in the stage of asking. The relevancy of the answer to the question poser indicates its reflective nature. The way in which the answer is formulated needs to be examined here.

Is the web suitable for questioning?

Increasingly, the web has been used in educational settings. It has been put to use in several ways. Among others, it has been used as an information source in addition to the school library. Such usage is described by Lindsay & McLaren (2000) who let students use the web as a source for writing essays. Greene & Land (2000) let teacher training students use the web to develop instruction. Their students searched for websites on different topics that were to be embedded in learning tasks for primary school children. Wallace, Kupperman, Krajcik and Soloway (2000) let primary school children use the web to find answers to self-generated questions. In addition to using the web as an information source, web environments have been developed in which task descriptions, sources, and additional scaffolds are integrated. For instance, Brush and Saye (2001) describe an environment called 'Decision Point!' in which groups of secondary school students worked together to solve a problem in the domain of history. The environment offers the students hyperlinked essays and lists of recommended documents to help them select relevant information. Student guides and a student journal are provided to support the process of problem solving. Finally, the web has been used to establish and promote the use of collaborative learning across schools and regions. For instance, Linn, Bell & Hsi (1998) report on the Knowledge Integration Environment in which middle-school students solve science problems together. A web-based discussion tool was built into the environment to support critical exchange of ideas among learners.

Using the web for questioning falls into the first category: the web as an information source. There are several reasons why the web can be expected to support questioning. First, the web can make learning more learner-centered and give space to self-generated questioning. In many classrooms, questioning by learners is rare and serves only marginal purposes. Learners' questioning behavior is strongly influenced by factors such as peer culture, predominant goals in the curriculum, and authority roles in the classroom (Dillon, 1988). Watts and Alsop (1995) and Rop (2003) showed that one of the most severe constraints is teacher behavior that seeks control. Similarly, Van Zee et al. (2001) state that instead of rhetorical lectures by the teacher and Initiation-Response-Feedback patterns of classroom conversation, student generated inquiry and small group interaction should dominate to foster student questioning. The web is expected to contribute to a climate in

which learners can take the lead by generating and pursuing their own questions independently from the teacher.

Second, the web is a rich repository of information. It contains a lot of information on many topics and has answers to many questions. Moreover, the web presents the information in different modes. The computer's multimodality has found to be motivating and encourage the construction of personally meaningful answers (e.g., Carroll, 1999; Fusai, Saudelli, Marti, Decortis & Rizzo, 2003; Jacobson & Archodidou, 2000; Loveless, 2003; Salomon, 1998). The web's richness in what information is available, is expected to give room to personal motives for questioning. Because the answer is probably out there somewhere, all kinds of questions can be posed. Therefore, it is expected that the web can help establish a positive and motivating climate for questioning in the classroom. Such a climate is a prerequisite for an interrogative attitude in learners (Beck, 1998; Van Zee et al., 2001).

Third, the web presents information from multiple perspectives. It contains websites from local and national institutions as well as from individuals. And it provides information from sources all over the world. All these different websites give their opinions from their own points of view. Research has shown that provocative learning materials that expose multiple perspectives can invite learners to problematize (e.g., Abrandt Dahlgren & Öberg, 2001; Chin et al., 2002). Visiting different websites that talk about the same topic from different perspectives is therefore expected to raise the awareness of the need to formulate personal answers. Hence, the web is expected to help sustain a learning environment in which multiple perspectives are raised and valued, comparisons are made, and personal interpretations are given.

Fourth, constructing answers can be pursued in personally relevant ways. The web has a non-linear and hyperlinked structure. This (lack of) structure reflects the cognitive flexibility with which it can be navigated. Children can follow their own search paths and can become actively involved in pursuing their ideas by making navigational choices: "Computer technology enables the traditional linear flow of information to be replaced by a hyperlinked structure enabling multiple pathways of moving through the information, with the possibility of following, even creating, linkages as ideas evolve" (Todd, 2000a, p.83). Therefore, the web is not only expected to encourage children to pursue their own answers because of the diversity of information that is present, but also because of the way the information is structured.

Although the web seems to be a promising tool and is expected to be supportive of reflective questioning, difficulties with questioning and using the web have also been reported. Many of the difficulties relate to the stage of answering. First, children often have trouble with searching the web, locating websites and selecting information. In general, primary school

children do not plan their searches and seem to prefer browsing over keyword searching (Bilal & Kirby, 2002; Large, Beheshti & Rahman, 2000; Schacter, Chung & Dorr, 1998). In browsing, they often get lost. Chiu and Wang (2000) found that children frequently don't know where they are, where to go next, or how to get somewhere. When using keyword searching, children often use too broad or too specific keywords (Bilal, 2002). Wallace et al. (2000) found that children use the same keywords repetitively and unsystematically and do not use Booleans to specify their search. Furthermore, they have problems with selecting relevant information. They search quickly in many websites instead of thoroughly in a few ones and hardly read or scroll to see what is there. Bilal (2001) therefore characterizes their navigational styles as backtracking (moving backwards to pages visited before) and looping (repeating whole searches). Children also expect to find literal answers instead of topic-related information (Bilal, 2001, 2002; Wallace et al., 2000). Most of the research on children's web searching is carried out in the United States. An observational study with Dutch children from the upper grades of primary schools showed similar results (Lazonder, Van der Meij & De Vries, 2000).

Second, research on questioning has shown that learners find it difficult to evaluate new information in light of their question. Van der Meij (1998) found that children did not process the response they received and posed the next question from the same ignorance as before. Research on web use signals that primary school children as well as older students often do not interpret information. Instead, they copy information from the source without adapting it to their personal needs and without judging the website's quality (Bilal, 2001; Schacter et al., 1998; Todd, 2000b). Jones (2002) states that spending lots of time on searching and locating relevant information comes at the cost of processing information. In her research on internet inquiry projects in high schools, Jones therefore provided the students with links to relevant sources. As a result, the students could allocate more time to processing the websites' content. Other researchers also suggest using task-specific web environments to facilitate the search process (e.g., Bilal & Kirby, 2002; Greene & Land, 2000; Hoffman, Wu, Krajcik & Soloway, 2003; Wallace et al., 2000).

In short, we conclude that the web is a promising tool for reflective questioning. It has the potential for answering many questions and presents information in multiple formats and perspectives that can be searched in a flexible way. The web is expected to promote a positive climate for questioning, and hence the emergence of personal motives and construction of personally meaningful answers. But the web is also a complex environment that needs supportive measures to be used effectively. The picture painted of primary school children's difficulties with the web is consistent across studies: finding answers on the web causes many problems.

It was felt that if we did not free the children of some of the constraints, little reflection with the web would take place. The solution suggested by some researchers to provide relevant links in a portal would free the children from keyword searching, and locating relevant websites. Hence, it would provide more time to read and interpret information. Moreover, the links could be organized in such a way that it would help the children become aware of multiple perspectives. This might invite them to compare related sources and adapt newly found information into a personal answer.

The third design experiment

Embedding the web in the design task

Web use was embedded in a design task in the domain of biology that comprised six lessons of two hours each. In this lesson series titled 'Working Together', the children worked in small groups (2-4 children) on the design of a community of bees or ants. The first lesson introduced the topic of insects and the children learned to use the portal. In lessons two to four, the groups designed a community of bees or ants with the heuristic that was introduced in the second lesson. In lessons five and six, the groups presented their designs and compared them to human society. In lessons two to four the web was used to find answers to self-generated questions.

A portal was developed to support questioning with the web, in particular the stage of answering (see Figure 4-1). The portal contained a single web page opening up to 110 websites divided in five categories. Two categories ('Unbelievable, so many insects!', and 'In a garden of insects') were related to the world of insects in general which was the topic in the first lesson. Three categories ('Beehive', 'Anthill', and 'Men's world') related to lessons two to six in which a colony of bees/ants was to be designed and compared to human society. The hyperlinks to the websites were given meaningful names that indicated their general content (e.g., 'This is what a bee looks like', 'Being strong together'). A short introduction at the top of the web page warned for difficult wordings and foreign language (i.e., English). Simple browser buttons (e.g., Home, Back) were used to navigate through the portal and the web. The children were allowed to visit the web during the entire group work in lessons two to four and pose as many questions as they wanted. MS Internet Explorer™ was used as a browser and the portal was set up as the default home page.

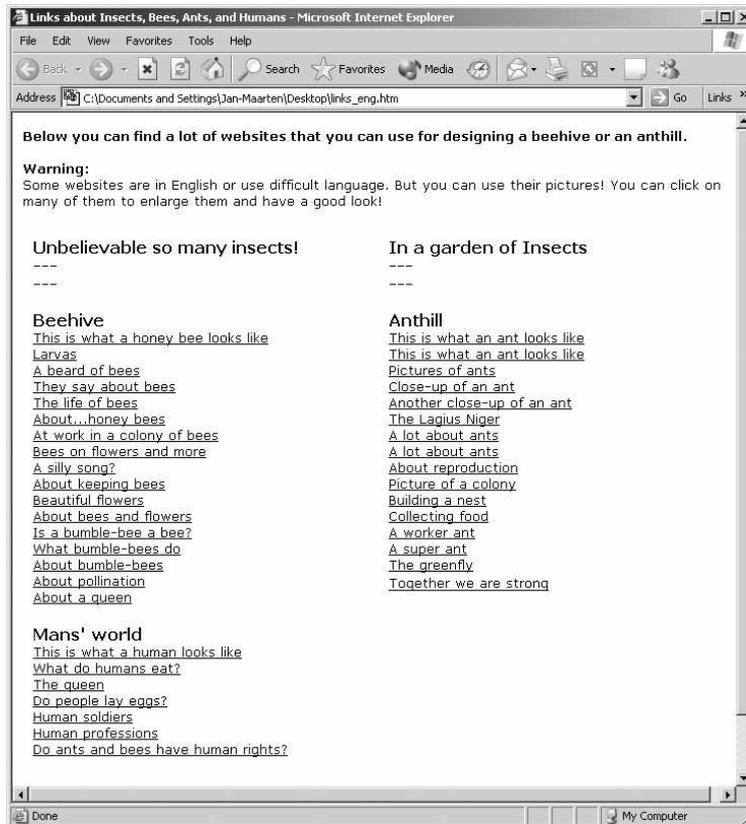


Figure 4-1 First prototype of the task-specific portal with (1) a short introduction and warning, (2) five categories, and (3) descriptive hyperlinks. To improve the overview, hyperlinks of two categories are removed from the picture.

In addition to the portal, a paper worksheet was developed (see Figure 4-2). The worksheet was an A4 paper containing two sections: 'Our question is', and 'Write down the answer you found below'. In the design experiments with e-mail, a worksheet had been used to support the group process of writing a message and connect e-mailing to the design task. For similar reasons, the worksheet was used again here. By providing a paper worksheet, questioning became located in the classroom and connected to the design task. The worksheet was expected to support the translation of perplexity into a concrete question before visiting the web, and to serve for transporting the answer back to the classroom. Furthermore, writing down the answer instead of printing it or keeping it in mind was expected to promote the formulation of personally meaningful answers.

Designing was new to schools 3 and 4. The other two schools had participated in the first design experiment on e-mail use.

In a face to face meeting with the teachers, the lesson materials were introduced and ideas, expectations, and practical issues related to web use were discussed.

Procedure

A broad range of data was gathered to gain insight in the teachers' implementation of reflective questioning, the children's motives for reflective questioning, and the reflective nature of the questions and answers. To gain insight in the teachers' implementation, the teachers produced written evaluations after each lesson. In schools 1 and 4 lessons were observed and field notes taken. Informal evaluations with the teachers from these schools were held after each lesson. Within-case descriptions of all their lessons were written weekly. In addition, the worksheets of all groups (N=14) in these two schools were collected. To gain insight in the children's motives for questioning, the group work of the children in the two schools was observed. In addition, written evaluations in the form of freewritings and e-mails¹⁸ were collected in schools 1 and 2. In school 4, semi-structured interviews about the lessons were held with four children after the fourth lesson.

To gain insight in the reflective nature of the questions, the worksheets were collected in schools 1 and 4. Questions and answers on the worksheets were archived. Averages of the amount of questions posed were calculated to get a general impression of the questioning behavior within classrooms and groups. The question form (open/closed, use of interrogatives) was scored to get a first impression of the kinds of question that were posed. Then, questions were categorized. Many categorizations of questions can be found in the literature (e.g., Abrandt Dahlgren & Öberg, 2001; Chin et al., 2002; Wimer, Ridenour, Thomas & Place, 2001). Often, a distinction is made between lower-order questions that seek factual information, and higher-order questions that aim at deeper understanding. But it is also pointed out that categorizing is a delicate matter because one cannot infer its function from its form (cf. Beck, 1998; Walls & Alsop, 1995). It is therefore important to derive the criteria for categorization from the context. In addition, the categorization of questions should be interpreted with care because the true meaning of a question can only be fully appreciated by viewing it in light of the motives from which it stemmed, and the answer to which it leads. In this research, questioning aimed at reflection in a design

¹⁸ Freewriting and e-mail were used in two schools on the initiative of the two teachers. These teachers had participated in the first design experiment on e-mail use.

task in the domain of biology. Central to the task was the use of a design heuristic. This heuristic contained questions that helped the children to generate forms and functions from memory. Questioning with the web was expected to lead to follow-up questions that sought to elaborate on generated forms and functions. For instance, a group could generate 'laying eggs' in answer to the question 'What must a queen bee be able to do'. Next, they could pose the follow-up question: 'How many times a year does a queen bee lay eggs?' We categorized all questions as either a design question seeking to generate forms and functions, or a follow-up question seeking to elaborate on already generated forms and functions.

Next, the answers were coded for their reflective nature. Their relatedness to the question was scored as question-related, and/or containing extra information. Question-related information was viewed to be a prerequisite for reflectivity. Next, their relevancy to the question poser was scored. Research on children's web use shows that learners often copy information without giving an interpretation (e.g., Bilal, 2001; Todd, 2000a; Wallace et al., 2000). Therefore, the answers were also scored as being either adoptions (i.e., literal copies) or adaptations (i.e. explicit interpretations for instance by referring to prior knowledge, or by adding evaluative comments).

All coding decisions were recorded in a codebook. A second independent coder coded about 25% of the data. Interrater agreement was calculated for the categorizations of questions and answers. For the categorization of questions, Cohens kappa yielded .71. For the categorization of the question relatedness of answers, Cohens Kappa yielded .66. For the categorization of the reflectivity of answers, Cohens Kappa yielded .90.

Results

Perplexity

Questioning with the web was successfully implemented in the classrooms. The teachers reported that the children were interested in the topic and enjoyed working on it. They reported a collaborative atmosphere within and between groups. The teachers highly valued questioning and web use. The following fragments illustrate the teachers' positive evaluations of the lessons in general, and web use in particular:

The children were very enthusiastic about the lesson. They clearly fancied it. So the material appealed to them. [...] It's funny to see that very soon there is a discussion in class of the experiences about and with insects.

(Teacher 3, written report, lesson 1)

Advantages of the use of the Internet: it motivates strongly. Children difficult to stimulate in other ways, were very enthusiastic. The animal is presented in an enlarged form. The details are clearly visible. The animal doesn't move. There often is written information. The combination of reality and the Internet complement each other very well.

(Teacher 1, written report, lesson 1)

The way in which the teachers organized questioning with the web depended on the number of computers they had at their disposal. In schools 1 and 2 in which there were only three computers, the groups took turns and web use was spread across the whole lesson. Time to visit the web was divided between groups. The children were stimulated to ask one question at a time because they could only visit the web for a limited amount of time. We call this approach the *integrated scenario*, because designing and questioning with the web were intertwined activities:

In the groups the children worked on the subjects bees and ants with the design heuristic. If there were questions during working on the design task the children were allowed to go to the Internet with their question, after this had been read by the teacher. Every time they were allowed to look up one question. With their writing and drawing materials the children (two children per computer) went to the computer lab and had a limited period of time to look things up.

(Teacher 1, written report, lesson 1)

Schools 3 and 4 had enough computers for groups to visit the web at the same time. In these classrooms, the teachers allocated parts of the lesson to working on the design task, and parts of the lesson to questioning with the web. The groups started with the design task. Then, they were asked to generate questions and visit the web. Finally, the groups applied the answers to the design task. We call this approach the *separated scenario*, because designing and questioning with the web became separated activities:

As an introduction a brief focus on the bee and ant queens. Also briefly pointed out the importance of these two animals. Next the worksheet was introduced. At that moment we have clearly explained the design heuristic. To most children things were much clearer now! Next we had them fill in the worksheet only with what they knew from earlier lessons. After some ten minutes we discussed the worksheets. Together we then made another sheet with everything the children had thought up. Then we had them go to the Internet again looking for answers and reference material. [...] When they had found their information, they worked it out into a design.

(Teacher 3, written report, lesson 3)

The differences in classroom organization also affected the use of the worksheet. In the classrooms with an 'integrated scenario', it was used to transport one question and its answer back and forth between the classroom and the computer lab. In the classrooms with an 'separated scenario', it was used in a more diverse way. Sometimes, worksheets were handed out after working on the task to write down a list of questions. Sometimes, they were not used at all and questions and answers were scribbled down in the margins of the designs.

No differences in using the portal were noticed. In general, the teachers and children positively evaluated the portal as making it possible to find relevant information in a relatively short time. But the teachers also mentioned that the portal was experienced as an overwhelming list:

For the children it was not easy to get an overall view of the information (much and often in English). Specific questions such as How do bees smell? couldn't be found. Yet the children have been able to find quite some information. A link like the one to ants was good and well-organized. The detailed picture material can be used excellently.

(Teacher 1, written report, lesson 2)

With the browser set for the project portal it was at first a bit awkward for the children to find information. There were links to so many sites! The children couldn't see the wood for the trees. Besides, a lot of information appeared to be in English. That proved to be a problem for a number of children. Yet, most children could find the answer to their question.

(Teacher 3, written report, lesson 2)

The children evaluated the lessons positively. They were enthusiastic about the topic and the design task:

We learnt about ants and bees. How they live and how they reproduce and how they feed and eat. I worked together with Jonas and that was great fun! We also did a brief play.

(Group 4, school 2, e-mail, lesson 6).

I really liked the last six lessons. Especially when we had to perform a play. I learnt quite a lot. Especially about the ant also about the bee but more about the ant. I really learnt about things I didn't know the existence of.

(Corine, school 1, freewriting, lesson 6)

Motivation for the topic and the design task is a prerequisite for self-generated questioning and perplexity to occur. In the first lesson, the topic of insects was introduced to the children. The children observed real insects and pictures of insects on the web and were asked to describe these. In this lesson, it already became apparent that the children's curiosity about the topic was high. The children noted and marked with colours what they found remarkable or beautiful about the insects they were observing. They were eager to find scary insects, and walked around the classroom to look at what others had found. After the lesson, the children wrote evaluations that illustrated this general curiosity:

Since I saw a wood louse from so close, I can see that such a wood louse is a beautiful animal. And they have solutions for everything, e.g. a shell to protect themselves, so after all a wood louse is a beautiful animal

(Ronnie, school 1, freewriting, lesson 1)

I still think they are slimy and itchy but they no longer give me the creeps. It is really interesting for you get to know things about you didn't know about before. Such as how they live exactly and how they defend themselves and how they eat and how they catch their prey and where exactly everything is on their body that's the kind of thing you get to know about.

(Wieteke, school 1, freewriting, lesson 1)

In the lessons that followed, this curiosity remained an important motive for questioning. But also new motives emerged as questions stemmed from an experienced uncertainty or lack of knowledge to complete the design. Two teachers reported that when the children had to draw detailed bees and ants in lessons four and five, they became aware of things they did not know yet. As a result, questions about how bees and ants look were posed expressing this experienced ignorance. The children's reports also indicate that questions emerged from reaching a certain point in the task at which they didn't know it anymore:

We were to think about bees and ants and if we didn't know a question we could write it on a piece of paper so that we could look it up on the web.

(Lyra, school 1, freewriting, lesson 6)

We talked a lot about ants and bees that was quite difficult sometimes but when it was too difficult we deliberated with the group sometimes we found a solution but sometimes we didn't then we could often look up things on the web.

(Marloes, school 1, freewriting, lesson 6)

I've still got a thousand questions. How does a bee or an ant become a queen not just like that I suppose and what about the children which of the thousand becomes the descendant and I can just go on.
(Tineke, school 2, freewriting, lesson 6)

The children also liked using the web to find answers. Hence, another motive for raising questions was a general eagerness to use the web:

I like the website very much. But the most important thing is that you can find a lot of information there.
(Els, school 1, freewriting, lesson 6)

Very good, really, really very good. Tadzio and I had printed a lady bird. A useful insect, which does no harm at all. And it flies about nicely in summer and you can catch it and let go again.
(Frans, school 4, interview, lesson 4)

Asking

We analyzed the worksheets of the groups in schools 1 and 4 (N=14). In school 1 an integrated scenario was realized, whereas in school 4 a separated scenario was realized. In the separated scenario, an average of 13.5 (s.d.=2.9, N=81) questions per group was written down. In the integrated scenario, 5.1 (s.d.=2.2, N=41) questions per group were written down. In total, the groups generated 122 questions in three lessons (M=8.7, s.d.=5.0, N=122). The number of questions varied significantly between schools ($\chi^2(1, 122) = 8.6$, $p < .01$). This difference is probably due to the fact that in the separated scenario the groups produced lists of questions. Sometimes this was done individually, so that many questions emerged per group.

Most questions were open (95.9%) and started with 'how' (68.9%). This suggests that they were follow-up questions that sought to elaborate on generated forms and functions. Categorization of the questions as either design questions or follow-up questions supported this impression (see Table 4-1). Most questions were follow-up questions (82.0%). Less than one-fifth of the questions (18.0%) were design questions. Although in the separated scenario twice as many questions were posed than in the integrated scenario, the distribution of question types showed a similar pattern. This suggests that in both scenarios questioning with the web was complementary to using the design heuristic. The heuristic was used to generate and relate forms and functions, whereas the web was used to seek explanations and specifications.

Table 4-1 Types of questions posed in the integrated and separated scenarios. The values represent the frequencies and percentages of question types posed by the groups in the integrated (N=8) and separated scenario (N=6).

Type	Integrated	Separated	Total
Design question	9 (21.9)	13 (16.1)	22 (18.0)
What do ants eat?			
What must a greenfly be able to do?			
For what does an ant use his antenna's?			
Follow-up question	32 (78.1)	68 (83.9)	100 (82.0)
How do ants build a nest?			
How many eggs does a queen bee lay?			
Why do ants walk in rows?			
Total	41 (100)	81 (100)	122 (100)

Answering

Generally, two children of a group sat behind a computer to search for answers. The teachers and children reported benefits of searching together as the children frequently helped each other, both within and between groups:

For some children the phenomenon of the web was a bit unknown. By having them work behind the computer in pairs they could help each other. Without effort they got used to the browser.
(Teacher 3, written report, lesson 3)

It was fun to sit behind the computer together. You can discuss it then too. That's easier. Where we look, about an insect.
(Maria, school 4, interview, lesson 4)

Besides collaborative searching, the portal played a critical role in finding answers. Both the teachers and the children reported that the portal helped them to locate relevant websites:

Introduction to the web via the portal: works well, catches on well with the pupils. Reactions like: 'oh, look here'.
(Teacher 2, written report, lesson 1)

By putting all the sites together on a page you don't make it too difficult for the children and that's an advantage.

(Teacher 3, written report, lesson 3)

The portal was nice. Makes searching easier I think.

(Olga, school 4, interview, lesson 4)

Nice, else you have to type everything first and you have to wait before it comes. When you can go to the portal straight away, you are sooner there. First you look everywhere with the bees. If you don't find anything then, you go to a different site. [...] We have only discussed insects, the bee and the ant. There is also the bumblebee, there is the firefly, there are a lot of them.

(Frans, school 4, interview, lesson 4)

The answers that the children found were categorized for their relatedness to the question as either 'no information found', 'related', 'related + extra', or 'extra'. Examples of related and extra information are:

Q: How many eggs do they lay?

A: about 1500 a day

(Related information; Group 6, school 2, worksheet, lesson 2)

Q: How does an ants' colony start?

A: They look for a hole in the ground, if there isn't one, they make one. They lay eggs. That is the start of an ants' colony. Important! after about a year, the worker ants get tasks. They have to look for food for the babies, from then on also soldiers are born!

(Related + extra; Group 1, school 2, worksheet, lesson 2)

Q: How many eggs does a queen bee lay?

A: Workers cut off leaves with their jaws. With their antennas they sign. The other ant recognizes this. They stand up and two ants keep their jaws against each other. That's how they feed each other. There are 6000 sorts of ants. Sometimes up to 100.000 ants live there. A worker can become 3 years old. An ant can become 6 years old. Soldiers recognize their fellow ants by their smell.

(Extra information; Group 3, school 2, worksheet, lesson 3)

The groups wrote down question-related information in a minority of the cases (see Table 4-2). In most cases, the groups did not find question-related information. In 61% of the cases, they did not find any information. And in 8.1% of the cases, they only noted extra information that was relevant to the task but not to the question they posed. In 30.9% they did write down question-related information, sometimes accompanied by extra information.

Table 4-2 Question relatedness of answers in the integrated and separated scenarios. The values represent the frequencies and percentages of answer types found by the groups in the integrated (N=8) and separated scenario (N=6).

Relatedness	Classrooms		
	Integrated	Separated	Total
No info	14 (34.2)	60 (74.1)	75 (61.0)
Related	20 (48.8)	13 (16.0)	33 (26.8)
Related + Extra	3 (7.3)	2 (2.5)	5 (4.1)
Extra	4 (9.7)	6 (7.4)	10 (8.1)
Total	41 (100)	81 (100)	122 (100)

Successfulness (related & related + extra info) differed between classrooms. In the separated scenario, significantly fewer answers were found ($\chi^2(1, 122) = 17.9, p < .01$). In this scenario, lists of questions were generated after working on the design task. Although the teacher let the children search for up to thirty minutes, this may have resulted in too many questions to focus on. Also not all questions were written down on a worksheet. Instead, some were scribbled down in the margins of the designs that were not taken to the computer lab. This too may have led to a loss of attention to some of the questions. Moreover, the generation of questions was sometimes a more individual rather than collaborative activity. Although the questions were shared and children searched collaboratively, the children may not always have felt they owned the question they were searching for. In the integrated scenario, the teacher supervised the process more closely and helped the children to focus. He judged the questions before they went to the computer lab and allocated limited search time:

Before the children go to the computer it is advisable for the teacher to go through the question (he can make a reasonable assessment if one thing or another can be found on the web and if a question is meaningful. [...] Every turn the children are some ten minutes on the computer. Then the children will try harder to look for specific information within that period. Attention will soon be distracted when the children are longer behind the computer.

(Teacher 1, written report, end of project)

Two factors seem to have influenced the children's unsuccessful searching. First, not all the websites in the portal were useful. The teachers and children reported that the English websites were too difficult. Others were said to be too detailed, too specialized, or uninviting. Second, the

children's search strategies were insufficient. The children were impatient readers who found it difficult to select useful information, and who looked for ready made answers (cf. Bilal, 2001). But they also showed an increased awareness of their search behavior and started reflecting on the product and process of finding answers:

The children sometimes have difficulty finding the answer to their questions. The quantity of text frightens a number of pupils; they aren't selective in dealing with the information. Go through the info too 'briefly'. Pictures have a lot of appeal here.
(Teacher 2, written report, lesson 3)

This one was a bit difficult, because it wasn't mentioned anywhere and I think you won't be able to find it very easily. [...] With other lessons I didn't know where to look. Now, it's much easier. That we don't have to ask things like that.
(Olga, school 4, interview, lesson 4)

That you have to search well on the web, or you won't find it. Look carefully.
(Boris, school 4, interview, lesson 4)

To gain insight into the relevancy of the answers to the question posers, the answers (n=48) were categorized as either adoptive or adaptive. A majority of the answers (75%) were adoptions. In these answers, the children copied literal information from websites or only adapted the information syntactically without interpreting it:

She carefully covers the walls of the beehive. After that, she starts collecting pollen and nectar and bakes a bee bread from it. On top of that, she places an egg, and closes the room.
(Group 3, school 1, worksheet, lesson unknown)

The queen bee can become 6 years old and the worker bee 3 years.
(Group 3, school 2, worksheet, lesson 3)

In only 25% of the cases (n=12) did the children explicitly interpret information. They did this by making reference to their question, drawing inferences, and adding affective remarks and punctuations:

We did not find how much weight an ant can carry. But we did find that ants can drag a dead butterfly. After that they tear it apart.
(Group 2, school 1, worksheet, lesson unknown)

No, but they have a secret room for keeping cells!
(Group 7, school 1, worksheet, lesson unknown)

That the children mainly adopted information instead of adapting it into personally meaningful interpretations is in line with the findings from other studies on children's web use (e.g., Bilal, 2001; Wallace et al., 2000).

Conclusion

In this third design experiment an instructional design for the implementation of reflective questioning was developed and tested. Central to the instructional design were a portal and a worksheet. Questioning with the web was successfully implemented in the classrooms. In the stage of perplexity, the children developed motives for questioning from a general eagerness to search the web and a curiosity about the topic. In addition, they experienced task-related perplexity. In these cases, the children expressed uncertainty and assessed a lack of knowledge to complete their design. This is viewed to be a more reflective motive for questioning because they arise from articulated and task-related prior knowledge. In the stage of asking, the children appeared to be willing and able to translate their information needs into questions. Most of the questions were follow-up questions. This suggests that using the web to find answers to self-generated questions was complementary to using the design heuristic. In other words, the groups used the web to reflect-in-action on the forms and functions they generated with the heuristic. In the stage of answering, we found that the children enthusiastically used the portal to search the web. They found question-related as well as extra information. Most answers were adoptions from websites, but in some cases personal interpretations of the information were made explicit. In addition, the children reflected on the search process by wondering what questions could be answered by the web, and stating they had to read carefully. This is an important gain, because in general primary school children have found to be rather unaware of search strategies (e.g., Schacter et al., 1998).

Based on these findings, the following operational definition of reflective questioning with the web is formulated:

'posing follow-up questions based on task-related uncertainty, and leading to adaptations of information'

To increase the opportunities for reflective questioning, however, the instructional design was found to be in need of some improvements. We found that most questions did not receive answers. In addition, most of the answers were adoptions from websites. Only in a couple of instances did the children adapt the information into personally meaningful answers. This indicates that the stage of answering was not very reflective. Several factors

that might have influenced the finding of answers were pointed out. First, the teachers implemented questioning with the web differently in their lessons. An integrated scenario was found in which questioning was intertwined with designing. And an separated scenario was found in which designing and questioning also were connected but became separated in time. This difference in scenario affected the number of answers found. In the integrated scenario fewer questions were posed and more answers were found than in the separated scenario. This suggests that the integrated scenario was more effective. Factors that seem to have contributed to its success were a strict use of the worksheet, limited time allocation, and group ownership of questions. Therefore, the instructional design should be improved so that it fits the integrated scenario.

Second, the portal was experienced as an overwhelming list with too many options that were difficult to overview. Observations of the children showed that they used both data-driven and goal-driven searching. Land and Greene (2000) define data-driven navigation as “being led by what information is available” and goal-driven navigation as “being led by what information is desired”. Data-driven browsing has been found to serve an open mind, and an exploration of the search space and information available (e.g., Land & Greene, 2000; Levin, Stuve & Jacobson, 1999; Wallace et al., 2000). In this study, the children may have browsed data-driven for similar reasons. But classroom observations also showed that the children engaged in data-driven browsing during all lessons. The five categories and hyperlink names didn’t give enough of a handhold to decide on a website’s appropriateness. As a result, the children made short and shallow visits to many websites to judge their usefulness. Hence, we conclude that the portal should be structured more heavily to better support goal-driven searching. This is expected to lead to more answers.

Most research on children’s web use investigates web searching as a rather isolated activity that is only loosely embedded in a learning task. These web searching tasks are not authentic because they fix moments for raising questions (e.g., Wallace et al., 2000), provide queries (e.g., Bilal, 2000, 2001; Todd, 2000b), or make web searching the main goal (e.g., Hoffman, et al., 2003; Schacter et al., 1998). At the same time, the need to research web use in authentic learning situations is emphasized by many researchers. For instance, Schacter et al. (1998) conclude: “It is not enough to only ask students to search for and find relevant information to solve various problem types. Research must move forward by analyzing not only what students find, but also how students use the information they find for a purpose” (p.848). Making the search task more authentic has been found to positively influence search results. Bilal (2002) found that children became better in searching when they could choose the search topic themselves. She

mentions several possible explanations among which are increased motivation, and higher prior knowledge for self-chosen topics.

In the design experiment presented in this chapter, we tried to make web searching an authentic activity by embedding it in a design task, and letting questions emerge from children's own motives and at self-chosen moments. The questioning model that was used as a framework to describe the emerging practices acknowledged the importance of authenticity by paying explicit attention to the onset of questions in the stage of perplexity. In the stage of perplexity, personal information needs arise that form the onset of concrete questions. The design task successfully raised personal motives. The children were curious about the topic and became aware of what they did not know yet.

If questioning stemmed from such personal motives, why didn't the children adapt the information found in light of these motives? One reason could be that their perplexity was not always task-related. Part of the questions emerged from a general eagerness to use the web and search for new information. In those cases, the chances for explicit interpretation may be low because children have not become aware of what they are in need of and have no expectations about what to find. This would suggest that more attention should be paid to raising certain kinds of perplexity. Another reason could be that the web, similar to books from a library, is considered to be an authoritative voice that one does not easily adapt. Todd (2000a) argues that: "Students traditionally work in a school environment where library resources are assumed to be 'good' by their mere presence in the collection. The assumption that all information is 'good' has been carried over to the Web, an inappropriate assumption in this ambiguous virtual world" (p.95). This would suggest that more effort should be put not only in raising perplexity, but also in extending this feeling of perplexity to the subsequent stages of questioning. Finally, the limited number of adaptations may have a similar explanation as found in the design experiment on e-mail use presented in chapter three. In that study the children adopted information from received e-mails and freewritings (i.e., written sources) and only adapted information within their groups. Maybe similar patterns for adoption and adaptation are present here. Adaptations should then be expected in the group talks evolving around questioning rather than on the worksheets. We explore this issue in the next chapter.

Chapter 5

Design experiment 4: Reflection-in-action by delayed perplexity

Introduction

In the third design experiment, an instructional design for reflective questioning with the web was developed and implemented in four primary classrooms. At the core of the instructional design were a portal and a worksheet. The portal provided task-specific entries to the web so that the children could quickly locate relevant websites. The worksheet consisted of spaces to write down questions and answers. We found that questioning with the web was implemented differently in the classrooms. An integrated and a separated scenario were found. In the integrated scenario, questioning and designing were intertwined activities, whereas in the separated scenario questioning followed designing. In both scenarios, questioning was partly reflective. Questions stemmed from personal motives, and the groups mainly posed follow-up questions that sought to elaborate on generated forms and functions. However, many questions did not receive answers. Also, most answers were adoptions instead of personal adaptations. The integrated scenario was more successful than the separated scenario as fewer questions were posed but more answers retrieved. The influencing factors seemed to be posing one question at a time, and stronger supervision by the teacher. In the design experiment that is presented in this chapter, the lesson plan was slightly adjusted so that an integrated scenario would be realized in all classrooms. In addition, the portal was structured more heavily. Although the teachers and children had valued the portal in the third design experiment, it was also experienced as overwhelming. The implementation of an integrated scenario and a more heavily structured portal is expected to lead to more successful searches.

In the conclusion of the third design experiment, we also discussed what might be the reason that children hardly adapted the information found into personally meaningful answers. They started off the questioning process from their own motives, but did not end with personal answers. We suggested that this might be due to the fact that perplexity was not always task-related. In addition, the children may have lost contact with the perplexity from which their question originated, because the web was perceived as an authoritative voice. In the design experiment presented here, we sought to extend the children's perplexity to the other stages so that the

chances for personal answers increase. Therefore, the worksheet is extended with space for articulating question-related prior knowledge in the form of provisional answers. We also suggested that, parallel to what we found in the second design experiment on e-mail, adoption could be the strategy for the interaction with the web whereas adaptation could be the strategy for developing questions and processing answers within the group. Therefore, we want to take a closer view on the group talk evolving around questioning. The fourth design experiment sought to answer the following research questions:

- (1) *Does the articulation of provisional answers lead to delayed perplexity and more adaptations in the stage of answering?*
- (2) *What is the reflective nature of collaborative questioning?*

The fourth design experiment

Embedding the web in the design task

The design task was the same as in the third design experiment except for a difference in the structure of the lesson series. In this lesson series titled 'Working Together', the children worked in small groups (2-4 children) on the design of a community of bees or ants. The first two lessons introduced the topic of insects (lesson one), and the heuristic and the portal (lesson two). In lessons three to five, the groups designed a community of bees or ants. In lesson six, the groups presented their designs. Making comparisons of communities of insects and human society was integrated in whole-class discussions in all lessons. In lessons three to five the web was used to find answers to self-generated questions. Second prototypes of the portal and worksheet were developed. The portal was rebuilt into a hierarchy of four main topics (History, Insects, Mammals, Plants) and several subtopics (see Figure 5). The topics varied in their relevance to the task. 'Insects' was relevant for all groups in all lessons, 'Plants' for groups that designed a beehive. 'Mammals' and 'History' were sideways relevant to make comparisons with other animals and human society. Relevance was varied to stimulate critical searching and mimic the real web that also contains relevant and irrelevant sources. The hierarchy ran four levels deep. In total, the portal contained 75 pages and 246 links to websites (an average of 61.5 per main topic).

To support goal-driven searching, the navigational structure of the portal was visualized in a strict page layout that consisted of a title (e.g., Ants), a colored navigational bar that displayed the search path (e.g., Index -> Insects -> Social insects -> Ants) and a body that contained hyperlinks to the lower level. The hyperlinks were put in alphabetical order and accompanied by

descriptions of their general content, e.g., ‘Social insects’ was described as ‘Some insects live in groups: they collect food together, and take care of reproduction together. Here you can find information about some social insects’. Extra support for navigation was given in the form of: (a) numbers in parentheses indicating the number of websites in a lower level, (b) icons indicating the type of information present in a website (text/pictures; language), (c) a sitemap giving a hyperlinked overview, and (d) a Help page that explained the portal’s layout and navigation. Guidance tools such as sitemaps and help pages have been recommended to support children’s orientation in web-based environments (Chiu & Wang, 2000; Hammond & Allinson, 1989). MS Internet Explorer™ was used as a browser and the portal was set up as the default home page.

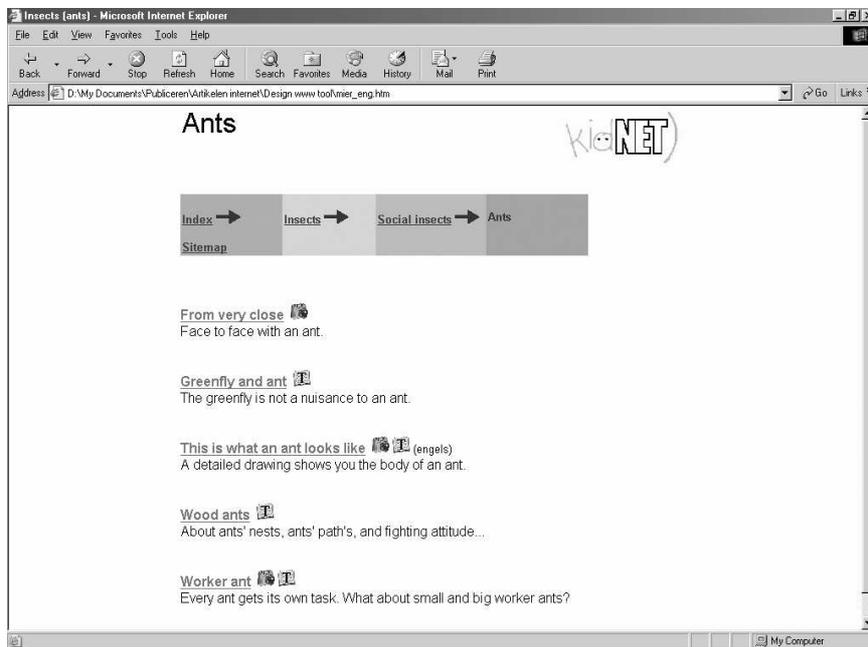


Figure 5-1 Second prototype of the task-specific portal showing a regular page with (1) a page title, (2) a navigational bar with colour and darkness indicating topic and level, (3) a link to the sitemap, (4) descriptive hyperlinks and short descriptions, and (5) icons and a language tag indicating type of information.

On the worksheet, a third space was created for provisional answers (see Figure 5-2). Provisional answers can be defined as ‘explications of what one believes to be (part of) the answer before new information is searched’. By

formulating provisional answers, children give expression to their question-related prior knowledge. Provisional answers have been found to raise feelings of commitment and safety, and help assess the information need (Van der Meij, 1990). In the context of the present research, we expected provisional answers to do more than just express the information need more precisely. Articulating provisional answers was also expected to stimulate task-related perplexity. In the process of formulating provisional answers, children may become more aware of their uncertainty or the existence of conflicting ideas within the group. In turn, the increased task-related perplexity was expected to affect the stage of answering and lead to more personal answers. Now that they expressed their prior knowledge, new information could be compared to their own expectations.

WORKSHEET
GROUP NAME:
Our question is:
We think that:
On the web we found:
You can continue on the back.

Figure 5-2 Second prototype of the web worksheet

The instructional design aimed at realizing an integrated scenario in the classrooms. The background information in the lesson plan explained that the web was used for finding answers to self-generated questions while working on the design task. Rationales for the portal and the worksheet were given. Figure 5-3 shows the explanation of the worksheet that was given in the lesson plan.

In order to streamline the web use organizationally and didactically the pupils use a worksheet. On this worksheet there is room to formulate the question, a provisional answer and the answer that is found.

Having them formulate the question beforehand, prevents the pupils from aimless searching and makes their purpose for web use explicit. Formulating a provisional answer (what do the pupils themselves think) is also intended to help the pupils focus in searching for the answer. Writing an answer on the worksheet forces the pupils to write down an answer in their own words. This makes for greater awareness of question- and look-up behaviour.

The worksheet keeps record of the questions asked by the pupils and of the answers they find. This gives the teacher an insight into the functionality of web use and during the lesson itself it gives the teacher something to hold on to: when the pupils have written down a question and a provisional answer, they show it to the teacher. In this way the teacher can regulate the process of who goes to the Internet, and when.

Figure 5-3 Lesson plan: Explanation of the worksheet

In addition, there was a checklist for organizing web use that helped the teacher to organize and prepare the available technology. Furthermore, a short instruction for web use was provided in the lesson plans of each lesson that emphasized integrating the web with working on the design task (see Figure 5-4).

At different times during the design task, groups go to the web with their question and provisional answer. Back in the classroom the group discusses the answer that has been found. The information found is worked into the design.

Figure 5-4 Lesson plan: Short instruction for web use

The instructions mentioned no time limits for web searching. It was expected that the worksheet, that now demanded a provisional answer, would stimulate focusing on one question at a time. Asking one question per visit was found to be one of the factors that made the integrated scenario successful in the third design experiment.

Occasionally, the lesson plans gave teachers extra tips to help them structure the process of questioning with the web. An example of such a hint is given in Figure 5-5.

Hint

Besides room for questions and answers, the worksheet also gives room for what the pupils can think up themselves before searching. This 'provisional answer' gives the pupils something to hold on to when searching. It is possible you might have to stimulate the pupils a little in writing down this provisional answer. You can keep an eye on this by asking the pupils to show their question first before they go to the web.

Figure 5-5 Lesson plan: Hint to support use of the worksheet

Participants

Two schools (schools 1 and 2) sited in a rural area of Enschede, the Netherlands participated in the experiment. The schools were partly paid for their time. In total, 16 groups (grade 5-6, aged 10-12) took part. The schools had normal student populations.

The schools had access to 10 to 15 computers connected to the web. The teachers were familiar with the basics of web use. The children varied in their experience with the web at home. The web had not been used in the lessons of either schools before. The schools had some experience with working in groups, but Learning-by-Designing was new.

In individual face to face sessions with the teachers before the start of the project, the lesson materials were introduced and ideas, expectations and practical issues related to web use were discussed.

Procedure

A broad range of data was gathered to gain insight in the teachers' implementation of web use, the children's motives, and the collaborative process of reflective questioning. Audio recordings of two focus groups were made to gain insight in the collaborative processes evolving around questioning with the web. These focus groups (one in each classroom) were

selected by the teachers. Focus group 1 (school 1) consisted of four girls. Focus group 2 (school 2) consisted of two boys and two girls. Their group work was observed and recorded throughout the lesson and their web sessions were logged. Semi-structured interviews with seven children from these focus groups were held after the fourth lesson. In addition to the data gathered in these focus groups, whole class activities were observed and field notes were taken. At the end of the project, semi-structured interviews with the teachers were held to summarize and check the researcher's observations. Design products and worksheets of all the groups were collected.

The audio recordings were transcribed and used to gain insight into the collaborative process of reflective questioning that lies behind formulating questions and answers, and searching the web. Questions, provisional and final answers on the worksheets were archived. The form of the questions was coded (open/closed; interrogatives), and the questions were categorized as design or follow-up question. The provisional answers were coded for their presence, length and mode (written, drawn, combined). The final answers were coded for their question-relatedness and categorized as either adoption or adaptation¹⁹. A second independent coder coded about 25% of the data. Interrater agreement was calculated for the categorizations of questions and answers. For the categorization of questions, Cohen's Kappa yielded .78. For the categorization of the question relatedness of answers, Cohen's Kappa yielded .72. For the categorization of the reflectivity of answers, Cohen's Kappa yielded .75.

The results of the fourth design experiment are presented according to the three-staged model proposed by Van der Meij (1998)²⁰. In the stage of perplexity, we present the teachers' implementation of the integrated scenario, and the children's motives for questioning. In the stage of questioning, we present the categorization of questions. In the stage of answering, we describe the provisional answers and present the categorization of final ones. Furthermore, in the stages of perplexity and answering, group recordings will be presented that give insight in the collaborative process of questioning with the web.

Results

Perplexity

Both classrooms realized an integrated scenario. The groups posed questions and visited the web whenever they felt the need while working on

¹⁹ For a detailed description of coding procedures, we refer to chapter four.

²⁰ For a detailed description of the three stages, we refer to chapter four.

the design. The teachers instructed the groups to use the worksheet to write down one question at a time and then transport it to the web. The teachers evaluated the worksheet positively:

I think it is necessary to have the worksheet, for there are also groups who can't manage. We also had a group here who (a) couldn't get on well together and (b) who often didn't agree with each other, what do you want to know, yes, she wants this and I want that, and what do you want to know and write it down then.

(Teacher 1, interview, end of project)

The fact that the web is pre-structured, that is quite a find. You go there with a specific question, [...] they go there with specific questions, first what they think themselves is the answer and after that, eh, what they find as an answer on the web. That, I think, is a nice thinking indicator. [...] if you want to use the Internet here, aimed at insects, then I would certainly not want to leave out the worksheet. No, most certainly not. Then you focus the attention first.

(Teacher 2, interview, end of project)

The teachers did not limit search time. Observations in the computer labs showed that the duration of web visits varied between five to twenty minutes per question. The average duration of web visits varied strongly between the focus groups. For focus group 1, the average was 6.8 minutes per visit (s.d.=3.4, N=9). For focus group 2, the average was 20.8 minutes (s.d.=6.7, N=4). This shows that focus group 1 paid more and shorter visits whereas focus group 2 paid fewer but longer visits. The difference was significant ($\chi^2(1, 12) = 5.7, p < .05$).

The same personal motives emerged as in the third experiment. The groups displayed an eagerness to visit the web. The following excerpt illustrate this:

A lot of children take the bees as their subject and we have been talking about bees a lot of times and we already know practically everything about them and our teacher did a talk about them and I also like just looking things up, things we don't know yet and about bees we know about everything, the teacher once did a very long talk about them and about ants we know nothing at all and so it's fun to look everything up.

(Maaïke, focus group 1, interview, lesson 4)

But the children also developed more task-specific motives such as curiosity about the topic, and uncertainty rising from a lack of knowledge. This process of developing their motives was observed by one of the teachers:

They rather went to the web first of all and via the web to the question. At a certain moment I made them first think up What do I want to know?, and try to formulate that into a good question, but that gave very strange results. [...] In the beginning it was just hop, trial and error, click, click,click, ah, here we are, and at the end it was more like what do I want to know?
(Teacher 1, interview, end of project)

The talk of the two focus groups gives a closer view on the emergence of perplexity. Focus group 1 designed an anthill. They generated forms and functions with the heuristic. This sometimes led to a further need to know:

- [1] Masha: What must I be able to do?
 [2] ?: O.K., what was it, being impregnated
 [3] Masha: What have I got for that myself, also a vagina,
 isn't it
 [4] ?: I don't know how is she fertilized
 [5] Masha: She needs a vagina for that as well. I think a
 vagina.
 [6] Coby: A male, is that a worker, or no, it must be a
 soldier or not
 [7] Masha: I don't think I know
 [8] Maaike: A worker
 [9] ?: A worker bee
 [10] ?: An ant
 [11] Masha: Let's look it up
 [12] Coby: There is also a worker ant. I think a worker ant.
 [13] Masha: Who fertilizes the queen
 [14] Petra : A male
 [15] Masha: We think it's the worker ant
 (Focus group 1, audio recording, lesson 4)

The group has just started the design process by using the design heuristic (lines 1-3). Soon, uncertainty arises (line 4). The group discusses who is needed to impregnate the queen ant. Several options are mentioned (lines 6-10,12). Then, the possibility of looking up the question on the web is suggested by one of the children (line 11), and the question and provisional answer are formulated (13-14). In focus group 1, the observed pattern of using the heuristic, noticing uncertainties, and formulating a question and provisional answer was repeated in subsequent lessons.

In focus group 2, most of the questions emerged from an eagerness to use the web and curiosity about the topic. The next fragments illustrate this. During the whole class introduction at the beginning of the lesson, three of the four children whispered a question to each other. This question was posed aloud immediately when group work started:

- [1] Emily: Our question was how does a bee make a beehive
 [2] Paul: A bee a beehive
 [3] Emily: How does a bee make a beehive
 (Focus group 2, audio recording, lesson 3)

After formulating the question, the group thought about a provisional answer:

- [4] Esther: We have to know ourselves how they do it
 [5] Emily: A beehive is made of honey, isn't it so?
 [6] Esther: Something like it but
 [7] Emily: I myself think but I'm not sure, they take honey first then they start putting it in there and then they start blowing and things like that, yes phantasy, and that they baked it and put leaves against it, for it gets quite firm, twigs
 [8] Esther: What was it to do with wax honeycomb
 [9] Paul: Yes
 [10] Emily: Can it take a piece of paper?
 [11] Paul: It is a kind of octagonal thing, isn't it so?
 [12] Esther: With honey on it
 [13] Paul: Wasn't there a queen bee?
 [14] Emily: I don't think so, but I'm not sure
 [15] Esther: I think it's made of honey, but firm honey
 [16] Emily: That seems a bit strange to me for
 [17] Paul: In my opinion honey is just soft. How do they make it firm? How then do they make that honey firm, by blowing or something like that?
 [18] Emily: Yes, that's what I said as well, but that's pure phantasy, I myself think that with honey, if you just put honey down somewhere, I don't know where, it just gets firm by itself, so if for example you
 [19] Paul: But
 [20] Esther: Wax honey they eat as well
 [21] Emily: Jeez, we can't know all this, can we
 (Focus group 2, audio recording, lesson 3)

The fragment shows that although the question emerged from eagerness, uncertainties and conflicting ideas became apparent when formulating a provisional answer. The children express and discuss their prior knowledge by suggesting parts of the solution (e.g., lines 6-9, 16-18), and by requesting confirmation (e.g., lines 5, 10, 11, 13). The discussion ends when one of the children officially declares the confusion (line 21). Next, they write down a provisional answer and go to the web. In focus group 2, the observed pattern

of posing questions out of eagerness, and noticing uncertainty when formulating a provisional answer was repeated in other lessons.

The findings suggest that in both focus groups task-related perplexity emerges sooner or later, either in the onset to a question or while formulating a provisional answer. In focus group 1, uncertainty arose from the task and led to a question and provisional answer. In focus group 2, questions emerged from eagerness and led to delayed uncertainty.

Asking

In total, 76 questions were posed in three lessons ($M=4.8$, $s.d.=3.1$, $N=16$). Although the teachers implemented questioning and web use similarly, averages differed between the classrooms. In school 1, the groups posed 3.0 questions ($s.d.=1.2$, $N=9$), in school 2 they posed 7.0 questions ($s.d.=3.6$, $N=7$). The difference was significant ($\chi^2(1, 16) = 6.9$, $p < .01$).

Most questions were open (84.3%) and started with 'how' (31.6%). This indicates that they were follow-up questions that sought to elaborate on generated forms and functions. The categorization of questions as design or follow-up questions supported this impression (see Table 5-1).

*Table 5-1 Types of questions posed by the groups.
The values represent the frequencies and percentages
of question types posed by the groups (N=16).*

Type	Total
Design questions	34 (29.1)
“Who do ants need to collect food?”	
“What must a drone be able to do?”	
“Can ants fly?”	
Follow-up questions	83 (70.9)
“When does an ant fly?”	
“How many larvae are there in one colony?”	
“Why is a bee called a bee?”	
Total	117 (100)

Most questions were follow-up questions (70.9%). Less than a third (29.1%) were design questions. This suggests that questioning with the web was complementary to using the design heuristic.

Provisional answering

The children came up with provisional answers for 92.1% of their questions. This indicates that the groups were motivated and able to express question-related prior knowledge. Most provisional answers were put in words. Some contained drawings (see Figure 5-6). The provisional answers varied in length from a single word (e.g., a numerical answer) up to 48 words ($M=6.2$ words, $s.d.=7.3$, $N=70$).

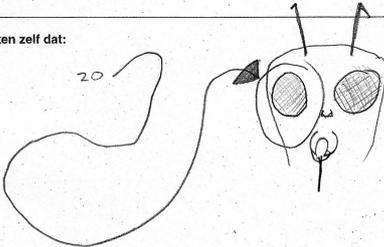
INTERNETBLAD	BRUCE MARIKE
GROEPSNAAM: Friebees!	RUUD Yveronique
Onze vraag is: hoe ziet een oog van een bij eruit?	
Wij denken zelf dat: 	
Op Internet hebben we gevonden dat: een bij 20.000 facetten (oogjes) heeft in een oog	
Je kunt op de achterkant verder schrijven of tekenen.	

Figure 5-6: Example of a drawn provisional answer (Group 5, School 2, Lesson 3).

Most of the provisional answers consisted of concepts and facts that directly tried to answer the question (90%). For example:

Q: From which flowers do they get nectar?
PA: the sunflower, the daffodil, the dandelion
 (Group 4, school 2, worksheet, lesson 3)

Q: How many bee-keepers are there in the Netherlands?
PA: 1200
 (Group 6, school 2, worksheet, lesson 4)

In 10% of the provisional answers, the groups articulated related experiences and drew analogies and inferences from them. By doing so, they made visible their way of reasoning. For example:

Q: Can bees sleep?
PA: Yes, because people and other animals have to sleep as well.
 (Group 4, school 1, worksheet, lesson 3)

Q: What is honeydew from the greenfly?
PA: We think it is something like milk from a cow.
 (Group 5, school 1, worksheet, lesson 5)

Final answering

In comparison to the third design experiment (see Table 5-2), significantly more answers (related & related +extra) were found ($\chi^2(1, 117) = 9.8, p < .01$). The groups found question-related information to 82.9% of the questions. In less cases, only extra information was written down (2.6%). The findings suggest that the groups searched goal-driven and succeeded more in locating relevant information.

Table 5-2 Question-relatedness of answers across design experiments. The values represent the frequencies and percentages of answer types found by the groups in the integrated scenario in the 3rd (N=8) and 4th (N=16) design experiment.

Relatedness	Study	
	Design experiment 3	Design experiment 4
No info	14 (34.2)	11 (14.5)
Related	20 (48.8)	59 (77.6)
Related + Extra	3 (7.3)	4 (5.3)
Extra	4 (9.7)	2 (2.6)
Total	41 (100)	76 (100)

The new portal seems to have contributed to this success. The teachers and the children from the focus groups compared the portal to more regular ways of searching the web and reported that the portal helped them find relevant information:

If you would really go to the web. I think there will be a great many side-paths, and then I wonder what the real output is. I myself compare it to an encyclopedia on paper, that is as a book, you can nicely leaf it through, but there are lots of side-paths, but your focused attention is considerably fragmented.

(Teacher 2, interview, end of project)

When you go to the library you have just the starting page in front of you and you have to look what you are going to do next. Searching 'ants' and you'll come to all kinds of sites. [...] I think this is different. That very first page and then you arrive, and then you click on ants again and again and you get further and further. In the library you start at the starting page and you have to find all the rest yourself.

(Maaike, focus group 1, interview, lesson 4)

In addition, the teachers and children reported that searching the web together was beneficial, because it helped organize and coordinate group work:

Also give them a chance to go together, for often this will lead to quite a discussion behind the computer, "of, hey, just look here!", for that's also part of it and that's what they see while reading, for the one is, say, focused on that's what I want to know whereas an other gets to read it as a group.

(Teacher 1, interview, end of project)

First of all it was Paul who was on the web and then Esther asks Paul: "Can I go now?" and then Paul just says: "Yes, you can", and Esther goes on the web. And then Esther said: "Yes, would you like to?", "Yes, okay with me" and so I went a little later. Each time we were on the web Dylan was ill. So I really think that next time we are on the web, he should go first if he is there then.

(Emily, focus group 2, interview, lesson 4)

Also, it contributed to the search process:

Sometimes difficult, I don't always know how to go about it, interesting, nice, yes, great fun to do. Looking up things, sometimes I don't know how to do it. Yes, the others do know then.

(Masha, Focus group 1, Interview, Lesson 4)

To further explore why the groups were more successful at finding answers, we examined the weblogs and audio recordings of the focus groups while they were working at the computer. These data showed that the children of the focus groups searched goal-driven, scrolled pages, and took considerable time for reading the information. They mainly used the navigational bar and the Browser buttons. In addition, they used the hyperlink names, descriptions and icons to navigate. The sitemap and the Help page were not used. The following two excerpts illustrate how the hyperlink names and descriptions were used to make navigational choices (words in brackets are quotations of hyperlink names and descriptions):

There was this page and with a lot of different words and there were some data, so you could guess a little where it belonged, but after that we still had to look for things for a long time.
(Masha, focus group 1, interview, lesson 4)

- [1] Esther: ‘Insects’
- [2] Dylan: In what do they live?
- [3] Emily: They live in social life, then you have to look at
 ‘Social living’, right?
- [4] Dylan: ‘Bees’, ‘Ants’, ‘Road ant’.
- [5] Esther: ‘This is what an ants’ nest looks like’
(Focus group 2, audio recording, lesson 4)

The icons, names and descriptions helped the focus groups locate relevant information. In addition, they also seemed to make the children more aware of the presence of different kinds of information, i.e. text and pictures, and the usefulness of pictures. The presence of pictures on websites was indicated by an icon. Moreover, hyperlink names and descriptions sometimes drew extra attention to the pictorial value of the website (e.g., ‘This is what a beehive looks like’, ‘Eye to eye with an ant’, ‘A detailed drawing shows the anatomy of the honey bee’). In the websites, many pictures could be enlarged by clicking on them and it showed from the web logs that this was frequently done. The children reported about their use of pictures in the interviews:

I thought it was very interesting to see on the web what such an animal looks like with those very big eyes.
(Paul, focus group 2, interview, lesson 4)

At first we couldn’t find it, we had to look for it for a long time. Quite instructive, interesting, yes, I also liked it because there were these pictures you could see everything quite clearly. Yes, in which

you saw them carry something or so, just things like that, you could see eggs, I like that, normally you don't see it from so close.

(Masha, focus group 1, interview, lesson 4)

By indicating what kind of information they could expect, the children seemed better prepared. In the third design experiment, the children sometimes were disappointed when they found only pictures, or entered English websites. No indications of such disappointments were found in this design experiment. The English websites were tagged as such and indicated as containing pictures. When entering English websites, the children were prepared and focused on pictures instead of being disappointed about the textual information.

The formulation of provisional answers may also have contributed to locating and selecting relevant information. By having thought about the possible answer in advance, the children had clearer and more articulated ideas of what to look for in the websites. Although the children in the focus groups made no explicit reference to their provisional answers during searching, these may have influenced how they approached new information and recognized its relevance.

Most of the answers were literal adoptions with only minor syntactical adjustments in which the children did not explicitly interpret the information found. In only 24.6% of the cases (n=16) did the children explicitly interpret information. Examination of these answers showed that although the provisional answers did not lead to more adaptations, they sometimes became a reference point to construct them for some groups. For example:

Q: How many larvae are in a colony?

PA: 50.000.

FA: It was a little bit more... 5500000000000000 eggs are produced, that is about 1500 a day.

(Group 2, school 2, worksheet, lesson 4)

Q: Why do ants keep greenflies?

PA: Ants keep greenflies to fatten and eat them. They maintain them and then eat them.

FA: We found that they don't eat the greenflies, but their excrements!

(Group 2, school 2, worksheet, lesson 5)

However, the audio recordings of the focus groups at the computers made it clear that the groups discussed information during searching and selecting information. Three verbal activities dominated the collaborative searching process: reading aloud, discussion, and relating new information to personal experiences.

First, the children frequently read aloud hyperlink names and short descriptions to make navigational choices together. In addition, they pointed out things on the screen and read aloud parts of the information found on websites. Reading aloud had an important function in the collaboration behind the computer. By reading things aloud, the children coordinated their actions, gave their approval of navigational choices, or suggested new directions. For example:

[1] Emily: 'Solitary'. 'Social'. They live in social groups, don't they?

[2] Esther: Yes, I think so too.

(Focus group 2, audio recording, lesson 3)

[1] Paul: 'Road ant'.

[2] Emily: I don't see it.

[3] Paul: Road ant, over here, a little bit down, here.

[4] Emily: I think that's only a picture.

(Focus group 2, audio recording, lesson 4)

Second, the children discussed the information they found. For instance, focus group 1 went to the web with the question 'How do ants carry their food?' and the provisional answer 'On their back and with their legs'. The following excerpt illustrates their discussion about new information during searching:

[1] Coby: 'Insects'

[2] Masha: 'Social', 'solitary'

[3] Coby: 'Bees', 'ants', 'Road ant'?

[4] Masha: 'Each ant has its own specific task'. So it also has something about. Hey!, that's a good one. They do put it on their backs.

[5] Coby: No, but also with their feet.

[6] Masha: Yes, but they put it between the head and their feet.

[7] Coby: Yes, that's true

(Focus group 1, audio recording, lesson 4)

In the first lines (lines 1-3) the children start navigating the portal departing from the Index. After clicking on the main topic 'Insects', they are facing a choice between 'Social living' or 'Solitary living insects'. They choose 'Social living insects' and find a link to the topic of 'Ants'. In the fragment, a hyperlink name (line 3) and a description (line 4) are read aloud. Then, a picture is found on which they can see how ants carry food. The two children shortly discuss what they see (lines 4-7). In their fifth lesson, this group designed the relationship between ants and their food source, i.e. greenflies. They posed the question 'What is honeydew of a greenfly?' They

found that it is the excrement of a greenfly and that the ants eat this. They also found that lady birds eat greenflies. In the course of that lesson, the group invented a story in which ants had to fight lady birds to protect their food source. While discussing how to tell and draw this story, the group returned to the web twice to find answers to related questions such as ‘What do greenflies look like?’ and ‘How do ants get the honeydew?’ Thus, finding answers and elaborating on them led to new information needs.

Third, the children related their own personal experiences to what they found on the web. They told stories about such things as being stung by a bee, liking or disliking specific insects, and experiences abroad. The following fragment illustrates this:

- [1] Paul: This is a flying ant
 [2] Esther: Ooooh, yes
 [3] Emily: Do they exist as well?
 [4] Paul: Hmm, yes
 [5] Esther: Oh yes, those flying ants bite. I saw them once, flying ants.
 [6] Paul: Red ants are bad enough
 [7] Esther: They fly around you in swarms. I had that once in France, they fly around you in swarms. They are real nasty animals. And if you trample them with your feet, with your naked feet, it hurts, too.
 [8] Emily: Yes, and nobody wants to believe that once there was a spider in my bed. Such a big spider, and nobody believes me. That was also in France.

(Focus group 2, audio recording, lesson 4)

In the first line, the attention is drawn to a picture of a flying ant (line 1). After that, the children start sharing their experiences with flying ants and other small animals.

Instances of reading aloud, elaborative discussion, and relating new information to personal experiences were frequently found in both focus groups in all lessons. This suggests that discussion and adaptations of information were within group activities that took place during searching. It raises the question whether the groups further discussed the answer when they returned to the design task. The audio recordings of the two focus groups show that this was not the case. They processed the answers into their designs. This is illustrated in the following fragment taken from the focus group that posed the question ‘How do ants carry their food’. After writing down their answer (i.e. “They carry it with them using their legs and head”), they returned to the classroom to start working on their design again:

- [1] Masha: What do I have for that myself
 [2] ? : Feet and a head

- [3] Maaike: Put it here or
[4] Masha: I would put it under here I think
[5] Maaike: Here
[6] Masha: They drag it between feet and head
[7] Maaike: Yes, I know
[8] Petra: Well, we've just discovered something
(Focus group 1, audio recording, lesson 3)

No evidence was found that the children further discussed and adapted the answer. Rather, they adopted it by pasting it into their designs. Thus, most discussion took place in the stages of perplexity, and asking and in the stage of answering while still searching for the answer. After writing down the answer, adoption predominated.

Conclusion

In the design experiment that was presented in this chapter, a portal and a worksheet were implemented in two classrooms to support groups of children in the process of reflective questioning. The portal provided a task-related hierarchy that helped the groups locate relevant websites. The worksheet supported the groups to focus on one question at a time. Furthermore, with the worksheet questions and answers could be transported between the classroom and the computer lab. At the core of the instructional design was provisional answering. When the groups posed a question, they had to formulate a provisional answer on their worksheet. By doing so, the groups made explicit their question-related prior knowledge. With the provisional answers we aimed at improving the reflectivity of the answers. It was expected to extend perplexity because in the process of formulating a provisional answer delayed uncertainty and conflicting ideas could become apparent. Furthermore, it was expected to stimulate the adaptation of information found on the web. Because prior expectations about the possible answer were written down, new information could be compared and adjusted.

Formulating provisional answers was found to lead to delayed feelings of perplexity in one focus group. In focus group 1, the stages of questioning occurred in the order in which we presented them. This group worked on the design task by exploring their prior knowledge with the design heuristic. At some point during the design process, uncertainty was raised that led to the formulation of a question and provisional answer. The group went to the web to find an answer to this question and processed the answer into their design. In focus group 2, however, a different pattern of questioning was found. In this group, questions arose from an eagerness to visit the web and a general curiosity about the task before they started working on their design. The

group formulated a provisional answer and in this process, uncertainties were met and discussed. The group went to the web to find the answer and processed the answer into their design. In short, different patterns of questioning in the two focus groups were found. In focus group 1, perplexity led to a question, whereas in focus group 2 a question led to (delayed) perplexity.

The findings suggest that the stages in the framework for questioning are not linear. Rather, they are cyclic activities that reoccur in the process of questioning and are intertwined rather than strictly consecutive. The three-staged model suggests that questioning begins with perplexity. Next, a question is formulated and an answer to the question is searched and found. The present data show a less linear process. Questioning can start with all three activities. It may start with perplexity emerging from the learning task, as was the case in focus group 1. It may start with asking a question from eagerness or curiosity which was the case in focus group 2. Perplexity then follows the stage of asking. Questioning may even start by finding answers as instances were found in which finding an answer gave rise to new questions. In these cases, perplexity follows answering.

The findings also suggest that the interpretation of information is not bound to writing down a final answer on the worksheet, because we found that valuable discussion of new information took place during web searching. Most of the answers were adopted from websites. These answers gave no explicit interpretation of the information found. The group talk of the two focus groups, however, showed that the children did think about the information. Group discussions evolved around formulating the question and the provisional answer. Furthermore, the children discussed new information while searching. Three verbal activities were found to be central to the collaborative searching process: (a) reading aloud new information, (b) discussing its meaning, and (c) relating it to prior and personal experiences. Reading aloud the information was important because it helped the children share their focus of interest. The discussion of information that often followed can be seen as valuable for the development of personal understanding. Hence, the dialogic setting of questioning created important opportunities for reflection.

Based on these findings, we conclude that the operational definition of reflective questioning that was developed in the third design experiment can be adjusted to fit the present data as follows:

'posing follow-up questions based on immediate or delayed uncertainty and leading to adaptations of information during or after searching for the answer'

Chapter 6

Conclusion and discussion

Introduction

In chapter one, we introduced the following research problem:

How can reflection be embedded in the learning process to improve the development of personal understanding of a domain and learning task?

In this thesis, four design experiments were presented in which moments of reflection were embedded in Learning-by-Designing tasks in the domain of biology. Reflection was expected to help children to activate, articulate and recapture their prior knowledge and new classroom experiences. By doing so, chances would increase that new classroom experiences are integrated with existing knowledge structures and that children develop a personal understanding of the learning task and domain. The instructional designs presented in this thesis sought to encourage reflection in several ways. First, the children used a design heuristic to activate and articulate their prior knowledge. Second, deliberate moments for reflection in-action and on-action (Schön, 1983) were embedded in the design tasks. Third, the children worked in small groups which was expected to stimulate articulation of old and new experiences more than when working alone.

In the context of the design experiments, reflection was defined as:

'thinking about the process and product of designing by elaborating on and recapturing of prior knowledge and new classroom experiences'

E-mail was used to engage the children in reflection-on-action by the exchange of narratives about the task with a partner group at another school. It aimed at recapturing prior knowledge and new classroom experiences. Each lesson, the groups wrote an e-mail to their partner group shortly after working on the design task. The children prepared individually through an exercise of freewriting and composed a group story on a paper worksheet. Furthermore, the groups read and discussed e-mails from their partner group shortly before working on the design task. Using e-mail at the beginning and the end of the lessons was expected to help recapture prior knowledge and new classroom experiences in order to add personal meaning to the learning task and domain. Five classrooms participated in the experiments. The

findings of these design experiments were reported in chapters two and three.

The web was used to engage the children in reflection-in-action by looking up answers to self-generated questions. By using the design heuristic, the children could activate and articulate their prior knowledge. When questions arose to which they did not know the answer, the web could be consulted. The groups prepared web visits by writing down the question as well as a provisional answer. A task-specific portal was provided as an entry for the web. Six classrooms participated in the experiments. The findings of these design experiments were reported in chapters four and five.

In the remainder of this thesis, we, in turn, reflect on the four design experiments to answer the general research questions:

- (1) *How does narration via e-mail support reflection-on-action?*
- (2) *How does questioning with the web support reflection-in-action?*

First, we recapture the learning environment in which reflection was embedded to see if the learning tasks set the stage for reflection. Next, we summarize the most important findings from the four design experiments to provide insight in the question if and how e-mail and the web supported reflection. Then, we focus on the nature of reflection as it unfolded in the classrooms and explore what kind of reflection emerged from the learning environment. After that, we shortly elaborate on two pedagogical issues that are considered worthwhile to take into account when designing instruction aimed at reflection, and point out some directions for future research.

Recapturing the learning environment

In the studies presented in this thesis, Learning-by-Designing tasks in the domain of biology were implemented in primary school classrooms. The design tasks involved the reinvention of biological systems such as individual plants and animals, communities of insects, and entire ecosystems. The children worked in small groups on these tasks. They used a design heuristic consisting of five design questions to activate and articulate their prior knowledge on the topic. Did the design tasks set the stage for reflection?

According to Kirschner (2002), central to any learning environment are three factors: (1) task ownership, (2) task character, and (3) task control. Task ownership is concerned with who owns the task, steers its process, and judges its outcomes. Task character is concerned with the authenticity of the task. And task control is concerned with who regulates the events, contents, and strategies of the instruction. Further, Kirschner describes that in traditional learning environments, it is the teacher who owns the task, judges

its relevancy, and controls the instruction. In self-regulated collaborative learning environments, ownership lies within the group, authenticity is determined by learners, and the flow of events is controlled by learners. Of crucial importance in such collaborative learning environments is the way in which learners perceive the task because that determines if and how they take control, self-regulate their learning, and are intrinsically motivated to complete the task.

One of the main purposes of the learning environments presented in this thesis was to engage children in thinking about their prior knowledge and new classroom experiences to improve the development of personal understanding of the learning task and domain. A prerequisite for such reflection is that children have a feeling of ownership, find the task relevant, and are motivated to take control over their own learning. In chapter one, we described the design tasks by pointing out the instructional theory that lies behind them. Here, we shortly reflect on how the children perceived the learning tasks and see if from their perspectives the designs tasks afforded reflection.

Did the children own the tasks?

A diversity of activities were implemented in the classroom. Besides working on the design task itself, the children engaged in role playing, drawing, presenting, whole class discussions, short excursions outside school, freewriting, e-mail and web visits, and observing real animals as well as enlarged pictures, among others. Implementing a diversity of activities was aimed at two things. First, it aimed at increasing the children's motivation for learning. Second, it aimed at reaching a balance between doing and knowing, between action and reflection.

The children enjoyed the diversity. It provided them with the opportunity to use their imagination, think of new things and generate ideas each time the focus was shifted to another kind of activity. The teachers, however, sometimes found it difficult to alternate between activities. They thought the lessons were very busy. They also reported that they were not used to some of the activities, such as role playing and freewriting. After they had tried them, they recognized the motivational power of the diversity. They also recognized the gains of using more active forms of thinking and processing information. Overall the teachers expressed an appreciation of the richness of the children's ideas that emerged from the diversity of activities.

The diversity also increased the children's ownership of the task. In group settings, it is often difficult to promote equal participation. Some children are more dominant than others, and give fast reactions at the cost of children who need more time to grasp a new experience. A solution to unequal participation can be found in the way in which groups are

composed, and in ways of structuring group interaction for instance by role specialization (e.g., Webb & Palincsar, 1996). The findings from the present studies suggest that a diversity of tasks may also increase equal participation within groups. Children have different talents. By implementing a diversity of activities, these talents have a chance to become recognized and used. For instance, in one group a boy was silent most of the time. He cared about the task, but was more of an observer than an active participator. A girl in the same group was just the opposite. She often took control by distributing materials, proposing task divisions, and performing things herself while the others assisted her. But when the focus of the task shifted from thinking and writing to drawing, the silent boy all of a sudden took control. He proposed styles and stories, delegated parts of the task, and distributed the materials.

Did the children like the tasks?

The domain of biology was chosen for several reasons. Biology had been used before in Learning-by-Designing tasks at the University of Utrecht hence we could draw on their experiences (Boerwinkel, 2003; Janssen, 1999). Another reason for choosing this domain was that the current curriculum stresses the importance of learning by doing. Biology is presented as a domain in which children need to learn certain concepts and facts, but should also be invited to develop an awareness of their own roles in nature. Experiencing natural phenomena and taking care of nature are important learning goals (cf. De Vaan & Marell, 1999). For this purpose, approaches such as problem solving and inquiry learning are promoted.

The children appreciated the domain and the topics that were central in the lesson series. In the lesson series that was used in the first and second design experiment, animals of their own choice were central in most of the lessons. Groups could choose animals that interested them. In the lesson series that was used in the third and fourth design experiment, the children initially could choose between all kinds of insects, and later on in the design process between bees and ants. The children also appreciated the approach of inquiry learning. In several lessons, real animals and plants were observed by the children. For instance, the children collected insects and other small animals in the lesson series 'Working Together' and observed them with magnifying glasses. In the lesson series 'Living Together' real goldfish were present in the classrooms and became the topic of whole class discussions. The children highly valued these activities. They became very enthusiastic about the topics and shared prior experiences and feelings towards them. This was especially the case with the topic of insects.

Besides being of interest to the children, another reason for liking the domain was the fact that it easily merged with their own experiences. Most of the children have animals and plants at home. They keep animals, grow

plants, build tree houses, go fishing, and they are bothered by mosquitoes, flies, or other kinds of summer visitors. In short, they have prior experiences that motivate them to enter the world of ecosystems and communities of insects for further exploration. They do not feel ignorant, but knowledgeable; they can put their prior experiences to use. This was found to be an important motivation to get engaged in the task as children frequently came up with what they felt, knew and thought of a topic.

Did the children take control?

An important tool that the children had at their disposal to take control over their own learning was the design heuristic that was introduced in chapter one. Use of the design heuristic was demonstrated and exercised in the first lesson(s). After that, the children used the heuristic independently in their groups to complete their designs. Two characteristics of the design heuristic promoted the children's independent use of it. One, the heuristic consisted of simple questions that were used repetitively across all lessons and were easy to remember. Two, the design heuristic was provided on paper. Initially it was presented as a list of questions on a paper sheet but over the course of the design experiments it became a paper wheel. The children successfully used the heuristic independently. They internalized the questions after a few lessons. From time to time they pointed them out to each other when the design process got stuck or they returned to its paper format to regasp their meaning. Hence, the design heuristic helped the children to take control over the strategy of Learning-by-Designing and to self-regulate the process.

In contrast, the contents of the design task were left free within boundaries. As pointed out before, the children could choose their own topic of interest to a certain extent. Within these topics, they could emphasize some aspects over others. This made every design product unique. Although important aspects of ecosystems and insect communities were pointed out in whole class discussions at the end of each lesson, the designs by the children were not judged against a preset list of goals and contents. By leaving the choice of content and the format of presentation to the children, their control over the task increased.

In short, the design tasks created a learning community in the classroom in which the children were in control of their own learning. They liked the lessons and the topics, gained ownership over the process of collaborative learning, and took control over the flow of events within the boundaries of the task and teacher guidance. This motivated them to articulate their prior knowledge and engage in new classroom experiences, and it set the stage for reflection.

Did e-mail and the web create opportunities for reflection?

Learning-by-Designing engaged the children in a diversity of learning activities in which they took notice of new concepts and facts, explored new biological phenomena, and learned to care and appreciate. The tasks set the stage for reflection as children liked them, and were in control. Two technological means were embedded in the lessons to further promote reflection, e-mail and the web. In that way specific time and space was reserved to step back from the act of designing and reflect on it. Did e-mail and the web induce reflection? And how did reflection come about in their context?

The opportunities of e-mail

The children used e-mail with great pleasure and enthusiasm to exchange narratives about the task. They gave rich descriptions of the process and product of designing, and added evaluative remarks. The following operational definition of reflective narration via e-mail was derived from the studies:

'recapturing new classroom experiences by describing the process and product of designing as well as by posing comparative and help-seeking questions, relating old and new experiences, and expressing assessments and appreciations'

Assessments and appreciations did not only concern the learning task itself. They were also about the self in the process of learning. The children frequently spoke of their own roles and those of others in the classroom. For instance, they wrote about how much they knew before and after the learning activities, about their social behavior, and reconsidered their preferences. Hence, using e-mail resulted in opportunities to reflect on a wide range of personally relevant issues.

One of the reasons for using e-mail was that children could write for a real audience which has found to be authentic and motivating (e.g., Riel, 1985; Weiserbs, 2000). In the present studies we also found this. The children displayed much audience awareness. For instance, they mentioned 'getting to know the others' as one of their motives. For that purpose, they exchanged personal information such as ages and hobbies. And they addressed the partner group in the freewritings and e-mails by using personal pronouns directed at them, and by posing questions. Although freewriting was an individual and private exercise, the e-mail context sometimes raised

the children's audience awareness to such a degree that they also addressed their partner groups in their freewritings. Hence, using e-mail was an authentic and motivating task in which the communicative nature of writing was preserved.

The children's audience awareness was reflected in the rhetorical moves of their writings. Parts of the freewritings and e-mails were concerned with establishing and maintaining a collaborative platform with the partner group by larding their stories with extended greetings, metatags, repetitions and enumerations. Together, these rhetorical moves produced a staccato style that structured the stories in recognizable patterns and gave them a pragmatic tone of voice. The presence of spoken language items and personal information made the e-mails resemble oral communication.

Writing for a real audience also encouraged reflection, especially within the groups. The way in which e-mail use was implemented in the classrooms created different collaborative platforms. Freewriting was individual, sending and receiving e-mails was a group activity, and the e-mail exchange itself was an activity between groups. These different collaborative settings created opportunities for sharing and comparing thoughts. For example, the children read and discussed each other's freewritings in the process of composing an e-mail. They became aware of their own and each other's standpoints and acknowledged or summarized these in the e-mails. In addition, receiving e-mails sometimes led to reflection. On one occasion, the e-mail was read aloud and discussed, and one particular topic (waterplants) was resumed a couple of times while working on the design task. Although e-mails from partner groups thus could give rise to discussion, further deliberation between partner groups was not found. The partner groups exchanged stories, but did not give much feedback to each other. In the waterplant-discussion, for instance, the group did not inform their partner group about their own waterplant-discussion nor about the other things they found out about waterplants.

The opportunities of the web

The children were enthusiastic and motivated users of the web. They formulated questions from their own motives. Some of these questions stemmed from an eagerness to use the web and a general curiosity towards the topic. Other questions stemmed from uncertainties that arose from working on the task. Most of the questions were follow-up questions. Hence, self-generated questioning was complementary to using the strategic design questions from the heuristic. As the children posed their questions, they articulated their prior knowledge in the form of provisional answers. Final answers were found on the web for a majority of the questions. The

following operational definition of reflective questioning with the web was derived from the studies:

‘posing follow-up questions based on immediate or delayed uncertainty and leading to adaptations of information during or after searching for the answer’

One of the reasons for choosing the web as a source for answering questions was its richness. The wealth of available information strongly motivated the children to use the web. At times they were flabbergasted by what they found. For instance, they loved the pictures that showed enlarged insects. But also textual information was found to be interesting. On one occasion, the children presented their designs in front of the classroom and one boy tried to explain how many insects there were on the whole earth and how important this was for human beings. He had found this information on the web in rather difficult words and now tried to explain these to the others. He stumbled over his words and sometimes used words whose meaning he did not grasp, but he successfully expressed his feelings about the information and perfectly translated his enthusiastic amazement to his peers. Instances such as these illustrate that the web functions as a source of inspiration.

There were also instances in which the children used the web to check their own thoughts. Since the children wrote down provisional answers, they were aware of what they believed the answer to be. On some occasions, the web confirmed their provisional answer and the children could write down that “What we found on the web is the same as what we thought ourselves”. These instances illustrate that the web can function as a source of confirmation.

Although the richness of the web motivated the children, most of the answers were copied and pasted onto their worksheets. There were few explicit interpretations or valuations of the information found. In other words, the children were focused on finding literal answers to their questions, as was the case in other research on children’s web searching (cf. Bilal, 2001; Wallace, Kupperman, Krajcik & Soloway, 2000). However, we also found that when formulating questions, giving provisional answers, and searching for relevant information, the children talked about their prior knowledge, the new information they encountered, and related experiences. Thus, although the children did not interpret the information on the worksheets, they did so in the processes leading to the answers. Showing adaptation was embedded within activities rather than within the products of learning.

Comparing e-mail and the web

In the general research problem that we recaptured at the beginning of this chapter, we asked ourselves how moments of reflection could be embedded in such a way that prior knowledge and new classroom experiences would become better integrated. The findings from the design experiments suggest that using e-mail and the web in the primary classrooms successfully created opportunities to activate, elaborate on, and recapture prior knowledge and new classroom experiences. Comparing the two further suggests that they did so in complementary as well as similar ways.

First, reflection-on-action with e-mail and reflection-in-action with the web seem to have contributed to the integration of prior knowledge and new experiences in different ways. In the web environment, the children were invited to look at their prior knowledge in light of new classroom experiences. In this reflective process, prior knowledge was the starting point for reaching personal understanding: (1) Using the heuristic was aimed at *activating* the prior knowledge. (2) Posing questions was aimed at *elaboration* on this prior knowledge. (3) Questioning with the web further prompted the *articulation and use* of prior knowledge while finding answers. In the e-mail environment, the children were invited to look at new classroom experiences in light of their prior knowledge. In this reflective process, new classroom experiences were the starting point for reflection: (1) Using the heuristic was aimed at the *activation* of prior knowledge. (2) Writing about the lessons individually and in groups was aimed at *evaluating* new classroom experiences and relating them to prior ones. (3) Reading and discussing received e-mails was aimed at *comparing* classroom experiences between groups.

Second, in the e-mail and web environment similar patterns of adoption and adaptation were found. The children *adopted* new information from freewritings and e-mails in the e-mail environment, and from websites in the web environment. They *adapted* information in their group talk evolving around the use of e-mails and websites. In the e-mail environment, the groups discussed freewritings during the composing process, and discussed received e-mails from the partner group. In the web environment the groups discussed their prior knowledge when formulating provisional answers, and they discussed new information and related old experiences while searching for a final answer. Research on computer supported collaborative learning can focus on the co-construction that takes place *between* groups or individuals collaborating at a distance (e.g., Kirschner, Buckingham Shum & Carr, 2003). The present findings suggest that research on computer supported collaborative learning can also focus on the co-construction that takes place *within* groups on 'one side of the connection'. The studies presented in this thesis indicate that the talking that evolved within the group is valuable. Other researchers too have suggested that it is useful to carefully

examine the group talk that evolves around using the computer (e.g., Kumpulainen, 1996; Wegerif & Dawes, 2004).

What could explain for the fact that the groups predominantly adopted information from writings and websites, whereas they mainly adapted within their groups? It is often argued that books have authority and that learners are inclined to believe what is in it and do not feel the need to make the information fit their personal needs. Likewise, Todd (2000b) suggests that the web is seen in an authoritative way. Thus, it comes as no surprise that the children mainly adopted information from the web. What is somewhat surprising, however, is that the children treated each other's freewritings almost in the same way. They did read but only shortly discussed these, and made only minor adjustments to create the content of their e-mails from the freewritings. It seems that the children *perceived* the freewritings as authoritative voices in the same way as they perceived e-mails and websites. A related explanation could be that the children are prone to adopt from *written* sources whereas they are prone to adapt in group *talk*. Other researchers have pointed out the complementary functions of talking and writing (Mason, 2001; Rivard & Straw, 2000; Wells, 2003).

Further research is needed to gain insight into how and why children perceive media in certain ways. What the present findings suggest, is that such research should not only focus on the actual interaction with the computer, but also on the processes that evolve around its use.

The personal nature of reflection

Generally, two traditions in research on reflection can be discerned (Nelissen, 1987). In both traditions, reflection is viewed as a way to give learners more control over their own learning, and to integrate new knowledge into existing structures. One tradition sees reflection as a metacognitive skill that is needed for self-regulated learning (e.g., Baird, 1986; Boekaerts, Pintrich & Zeidner, 2000; Brown, 1987; Van Hout-Wolters, Simons & Volet, 2000). In this view the object of reflection is the learning process and the goal of reflection is a conscious application of learning strategies. Initially, most of the research in this tradition took place in experimental settings. Later, research in educational settings followed. The second tradition views reflection as a learning function that is intertwined with other knowledge construction processes such as idea generation, hypothesis formulation, and testing (e.g., Dewey, 1910; Kolb, 1984; Schön, 1983). In this view the object of reflection is the problem that needs to be solved and the goal of reflection is to solve that problem and reach understanding.

The present research can be viewed in light of this second tradition. Based on Schön's theory of reflection, opportunities for reflection-in-and-

on-action were implemented in the classrooms. These moments of reflection were aimed at the development of *personal* understanding of a design task in the domain of biology. It was argued that to reach personal understanding children need to activate their prior knowledge and actively use this knowledge during the entire learning process so that new classroom experiences are related to it. Hence, *prior knowledge* and *classroom experiences* were at the centre of reflection. Here we explore what the nature of the children's prior knowledge and classroom experiences was.

In chapter one, prior knowledge was defined as "all knowledge learners have when entering a learning environment, and which is potentially relevant for constructing new knowledge" (Biemans, 1997, p.1). This is a rather broad definition that does not explain what is meant by 'all relevant knowledge'. Biemans gives a more specific interpretation of prior knowledge where he states that: "[...] 'prior knowledge', 'preconceptions', 'informal knowledge', 'naive theories', 'alternative conceptions', 'alternative frameworks', and 'original ideas' should be regarded as synonyms" (p.1). The research of Biemans was aimed at the activation of prior knowledge for the purpose of conceptual change. Hence, emphasis was put on conceptual or declarative prior knowledge.

In the classroom practices we observed, we found some evidence that the prior knowledge that children activated was only partly conceptual and cognitive. The children did use the design heuristic to activate conceptual prior knowledge. They did arrive at answers to the various questions on forms and functions on the basis of what they already knew or could infer. And they further questioned this prior knowledge by formulating follow-up questions, provisional, and final answers, all of which indicate an interest in developing conceptual knowledge.

However, the prior knowledge of children also consisted of unique personal experiences, and evaluations. The children recalled experiences from out of school life. Provisional answers contained lines of reasoning derived from related experiences (e.g., "We think they do it about the same way as human beings"). And the children connected new information to their experiences while searching for new information on the web (e.g., "I had that once in France, they fly around you in swarms"). In the freewritings and e-mails, children sometimes related new classroom experiences to prior ones from home (e.g., "And e-mailing seems funny to me. At home we don't have an e-mail address. So that's why I like it. For I have never done it so far"). Further signs of the importance and impact of personal experiences and evaluations comes from the classroom experiences that the children recaptured at the end of lessons. Although they had a conceptual component in the form of descriptions, and comparative and help-seeking questions, large parts of their stories were personal and affective. For instance, they assessed their own and other children's behavior (e.g., "Working in groups

did not go too well sometimes we also talked about some other things”), and expressed their appreciations of the learning task (e.g., “It was very fun and interesting!”).

The findings show that learners bring with them more than just conceptual knowledge. They also bring along their personalities. Two aspects of their personalities have become visible from the emerging practices: out of school experiences, and affective attitudes towards processes and products of learning. The findings show that these out of school experiences and affective attitudes do not function at the background, but are actively used to construct meaning. In the past, researchers have already drawn attention towards the active role that personal experiences play in the construction, storage and retrieval of meaning. For example, Bartlett (1932) pointed out that remembering is a process of active reconstruction based on, among other things, personal interests. Bruner (1990) pointed out that people construct narratives that are personally meaningful to make sense of everyday life. Because of the intertwinement of cognition and affect, Vygotsky (1934) argued that they should not be studied separately: “Their separation as subjects of study is a major weakness of traditional psychology since it makes the thought process appear as an autonomous flow of ‘thoughts thinking themselves’, segregated from the fullness of life, from the personal needs and interests, the inclinations and impulses, of the thinker” (p.8).

Based on our own findings, and in light of the thoughts of Bartlett, Bruner, and Vygotsky, we argue that definitions of prior knowledge should encompass the personal motives, experiences, and affective attitudes that learners bring with them and use to make sense of new information. Our research also suggests that existing approaches towards reflection are too cognitively oriented. Moments of reflection appear to be excellent opportunities not just for the activation of, elaboration on and recapturing of concepts and facts, but also for developing a personal understanding and appreciation of a learning task and domain. Although the research on reflection has been wide and diverse, not enough attention has been paid to its personal nature. Research on reflection has largely ignored the constructive role that personal motives, experiences and affective attitudes can play in learning. Only within socio-cultural theory a distinction has been made between intellectual and personal reflection (Nelissen & Tomic, 1996). Intellectual reflection concentrates on objective knowledge whereas personal reflection concentrates on the personal attribution of meaning to that knowledge. In the latter case, evaluative and appreciative questions such as ‘what am I doing’, ‘why am I doing it’, and ‘why am I doing it in this way’ become prevalent (Lompscher, 1999; Wardekker, 1998). More recently, the social nature of reflective processes has been recognized under the influence of socio-constructivist approaches towards learning (e.g., Kinzer, White,

Lin, Holmes, Kuhn, & Scardamalia, 2003). The present study hopes to contribute to a further investigation of learning and reflection in a line of research that recognizes its personal and social nature.

Structured freedom

Structured freedom has generally been recognized as an important guideline for the instructional design of constructivist learning environments. For instance, guided exploration has found to be more effective than pure discovery (e.g., De Jong & Van Joolingen, 1998; Mayer, 2004). Striking a balance between free navigation and guiding structure is an important problem that needs to be addressed when developing computer-based learning environments (e.g., Moonen, 1999). Besides a guiding principle for developing computer-based learning environments, structured freedom has been recognized as an approach towards developing constructivist learning materials in general. Lijnse (1995) argues that a constructivist perspective should make prior knowledge of learners the starting point for learning. However, most classroom practices realize a top-down instruction that gives children little room to start from their own knowledge and preferences. Lijnse therefore argues that seeking balance between top-down structure and bottom-up freedom is needed to reach constructivist learning environments in which learners can build on what they already know. In this thesis, instructional designs were developed that sought to invite children to bring in their prior knowledge and use this prior knowledge actively during the whole learning process. Finding a balance between structure and freedom was therefore an important consideration.

Central to the instructional design of the e-mail environment were a paper worksheet to write down the e-mail messages, and an individual exercise of freewriting. These instructional devices were developed, tested, and improved in the course of two design experiments. Initially, the worksheet tried to direct the process of reflection. For this purpose, it contained hints on what to share with the partner group. In some lessons, specific assignments were given in which the children were directed towards certain aspects of the design task. These directions did not work. The children hardly read and used the hints and assignments. The teachers tried to fill this gap by instructing the children in another direction that focused on questioning. Questioning was found not to be useful, because answers were received too late, among others. In the course of the first design experiment, freewriting was introduced in one classroom. This structured the teacher's and children's writing activities. The teacher could lead the children through several steps of reflective writing. As a result, the children engaged in reflection-on-action, individually and in their groups. In the second design experiment, freewriting was introduced to other schools and implemented in all lessons.

It became a structural part of reflective narration. We concluded that the freewriting exercise structured the act of reflective narration without disturbing the children's freedom to reflect on personally relevant issues. However, the achieved balance between structure and freedom was not entirely satisfactory. The process of composing group stories from individual freewritings was not implemented successfully in the schools. It was skipped, or developed rather chaotically. It was therefore concluded that more structure should be added to the composing process. Moreover, it was concluded that similar steps should also be added to the group process of reading and discussing received e-mails because we found that the groups hardly discussed these.

Central to the instructional design of the web environment were a portal and a paper worksheet. The portal was designed to support children in locating and selecting relevant websites and information. It provided a task-related search space, and structured the process of searching. The paper worksheet was designed to support children in formulating clear search goals in the form of questions, and in formulating personally relevant answers. Hence, it structured the process of questioning. The portal was improved in the course of the design experiments. The first prototype was a long list of addresses that did not structure the search space well enough. The children experienced this portal as an overwhelming list, and paid short and shallow visits to many websites to gain an overview of its content. This data-driven navigation took time away from the more important processes of reading and evaluating information. Therefore, a more heavily structured portal was developed that gave more indications about what information to expect. This portal supported goal-driven searching and helped the children to locate more answers. The worksheet was also improved. Although it functioned well as a transporter for questions and answers, it did not support the formulation of personal answers. Space for writing down a provisional answer was added to better structure the process of reflective questioning. The children successfully articulated their prior knowledge in provisional answers which raised their awareness of task-related uncertainties. Together, the portal and the worksheet found the right balance between structure and freedom.

Two issues evolve from these findings. The first issue is that the present data give insight in the questions of where to put structure and where to put freedom in learning environments. In the Learning-by-Designing tasks structure was process-related, whereas freedom was content-related. For instance, the design heuristic structured the children's thinking about form-function relationships without prescribing certain forms or functions. Furthermore, the fixed moments of reflection structured the lessons, but the children were left free in what to reflect on. In the web environment, the children could pose their own personally relevant questions emerging from

their own motives. And although the portal limited their search space, it still provided enough opportunities to follow personally relevant directions. In addition, the portal only introduced the children to the web. After clicking to a website they could follow the website's hyperlinks and leave the portal. Similarly, in the e-mail environment the children chose what to write about. They were free to talk about any task-related matter. Furthermore, they could dedicate parts of their message to personal communication with their partner group. In contrast, the processes of using e-mail and the web were heavily structured. Freewriting structured the process of individual and collaborative writing. The e-mail worksheet also structured collaborative writing and in addition, determined the way in which the e-mail software was used. For instance, the groups typed their messages in new e-mail windows instead of in reply-windows.

The second issue is that structuring the process instead of the content of learning seems to have helped the teachers to adopt a coaching role in which they provided freedom to the children. Freewriting consisted of several steps through which the children were led under the supervision of the teacher. Hence, freewriting became the instrument of the teacher to help the children focus on reflection without setting constraints to the content. The teachers now felt they could do something to help the children reflect. They were surprised by the reflective thoughts that the children put on paper. Similarly, in the web environment the worksheet was the tool with the help of which the teacher could organize the children's web use, lead children into reflective thinking, and keep an overview of the learning processes emerging. Thus, far from replacing the teacher, it is more and more recognized that the role of the teacher in organizing computer-based activities in the classroom strongly influences the kind of learning that emerges (e.g., Wegerif & Dawes, 2004). Freewriting, the portal and the worksheets added general procedures to the lesson plans through which the teachers could initiate, supervise and organize the reflective use of e-mail and the web without taking away the children's space for free and independent thinking.

Teaching an Adopt-Adapt strategy

E-mail and the web helped to establish learning environments in which the children were partly responsible for their own reflection. The children were left free in relation to the content of their reflections whereas structure was provided in the ways in which they were led into the processes of reflection. In the learning environment that was created the children applied a strategy that reflects this structured freedom: a strategy of adopt-adapt. Adoption and adaptation were found in both the e-mail and the web environment. In adoption, the children copied new information from

freewritings, e-mails, and websites. In adaptation, they discussed new information and fitted it to their own needs. Adoption seems to reflect the structure that the children experienced whereas adaptation seems to reflect their freedom to make their own personally relevant adjustments.

The adopt-adapt strategy was present in all classrooms implicitly. We already pointed out that at some points in the reflection process the teachers and children would have benefitted from more structure. For instance, the composing process developed rather chaotically or not at all in the e-mail environment. In the web environment, final answers were not interpreted but literally copied as they were found. Making the adopt-adapt strategy more explicit might help to further structure the reflection processes. A set of ground rules for collaborative reflection with ICT could be developed to optimize the use of the adopt-adapt strategy. Ground rules were developed and used in primary classrooms for the purpose of collaborative reasoning (Edwards & Mercer, 1987; Wegerif, Mercer & Dawes, 1999). These ground rules aimed at establishing a climate in which children reason together in an exploratory way (Mercer, 1994, 1996; Wegerif, 2000). The idea behind these rules was to make explicit what kind of dialogues are valued in collaborative reasoning and how they can be realized. Similarly, the adopt-adapt strategy might be taught as a set of ground rules for the collaborative and reflective use of e-mail and the web. Explicit teaching of the adopt-adapt strategy could make teachers and children more aware of the use they can make of external and written voices to create personal meaning.

Besides teaching the adopt-adapt strategy explicitly, providing opportunities for adoption and adaptation to occur should also be kept in mind. In the studies presented in this thesis opportunities were provided in two ways. First, different collaborative platforms were created. In the e-mail environment, the children worked in groups, prepared individually, and shared knowledge with a partner group. In the web environment, the children worked in groups, and sat behind the computer in pairs. In both environments, whole class discussions were held at the beginning and end of each lesson in which individual and group experiences were shared. Creating different collaborative platforms gives room to adopt between and adapt within platforms (cf. Brown & Renshaw, 2000; Dysthe, 1996; Mason, 1998). Second, different language-based activities, i.e. reading, writing, and talking, were combined. In the e-mail environment, reading and talking were central in the process of receiving e-mails, and writing and talking were central in the process of composing e-mails. In the web environment, talking and writing were central to the formulation of questions and provisional answers. And reading and talking were central in the process of searching for the final answer. Combining reading, writing, and talking supports adoption and adaptation between the different language modes.

Concluding remark

Children like to play and create. They are filled with imagination, spontaneous, easily express their emotions and seek social engagement. They like to move around and fancy a playful change of perspective. They are intuitive and curious. However, once they enter the school system they are easily led towards overemphasizing cognitive development. Schank and Cleary (1995) state that: "In their eagerness to fill students with knowledge, schools typically try to short-circuit the natural learning process. When we learn naturally, we start by developing an interest in what we are learning about. We try things out and get hands-on experience. We suffer expectation failures and we ask questions. Schools are not built around steps such as these. Instead, they try to cut the chase. They rush to present answers to questions students have not asked and generalizations about experiences students have not had" (p.11). Because schools try to cut to the chase, children may not be aware of the need to bring in their prior knowledge, and may not have much opportunity to do so. Furthermore, they may have limited chances to express their appreciations of the learning tasks and reflect on their own roles.

The studies that were presented in this thesis showed that e-mail and the web can provide opportunities for personal reflection. Their findings illustrate the richness of the prior knowledge that children bring to school, and of their personal views on new classroom experiences. We therefore hope that this study contributes to the ongoing discussion about the role of reflection in primary schools, stimulates the integration of reflective activities with ICT, and helps to emphasize that there is not a figure-ground relationship between the cognitive and the affective that foregrounds the cognitive, but that rather they are intertwined and truly interactive in the process of learning. In short, we hope to see more personal reflection in both educational theory and practice.

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Summary (English)

This thesis presents four design experiments in primary schools that address the following research problem:

How can reflection be embedded in the learning process to improve the development of personal understanding of a domain and learning task?

To explore this problem, deliberate moments of reflection are built into Learning-by-Designing tasks in the domain of biology. In the design tasks, children learn about nature ‘through the act of designing a biological system through guided reinvention’ by applying the form-function perspective. The design task is aimed at the activation and articulation of prior knowledge about the system to be designed for the purpose of further elaboration. In the studies presented in this thesis, solving the design task is supported by a domain-specific design heuristic, teacher guidance, and collaborative work in small groups. Deliberate moments of reflection are expected to strengthen the children’s awareness of their prior knowledge and their active use of it so that prior knowledge and new classroom experiences become better related. At these moments of reflection, children are prompted ‘to think about the process and product of designing by elaborating on and recapturing of prior knowledge and new classroom experiences’.

Two moments of reflection derived from Schön’s (1983) theory on the reflective practitioner are embedded in the design tasks: *reflection-in-action* and *reflection-on-action*. In the context of this study, moments of reflection-in-action aim at *elaboration* on prior knowledge and new classroom experiences, whereas moments of reflection-on-action aim at *recapturing* prior knowledge and new classroom experiences. Two language-based activities found in the research literature as being central to human cognition in general, and to reflection in particular, are chosen to give direction to these moments: *narration*, and *questioning*. Narration is implemented to reflect-on-action, and questioning is implemented to reflect-in-action. In addition, two technological means are chosen to further support the processes of reflective narration and questioning in the groups: *e-mail* and *the web*. E-mail and the web are readily available computer tools in primary schools that represent the two branches of ICT, i.e., information (the web) and communication (e-mail). Moreover, e-mail and the web seem to have promising characteristics that support reflection. To explore their appropriateness for reflection, four design experiments are conducted in which either e-mail is used to support reflection-on-action through narration, or the web is used to support reflection-in-action by questioning. The

following two research questions are derived from the general research problem:

- (1) *How does narration via e-mail support reflection-on-action?*
- (2) *How does questioning with the web support reflection-in-action?*

In chapter 1 of this thesis, the design tasks are introduced. Furthermore, it is argued that there is a need to embed deliberate moments for reflection. Using e-mail to exchange narrations, and questioning with the web, are proposed as ways to induce reflection. Moreover, a background to the methodological approach of the thesis is given. The studies are characterized as *explorative* and *descriptive*, and are committed to the general intentions and procedures of *Design-Based Research* (DBR). In DBR, studies are conducted in natural settings by implementing instructional designs and observing the emerging practices. The setup of DBR is characterized by design experiments that follow one another and aim at systematically adjusting aspects of the instructional design for the purpose of developing theory in naturalistic settings.

In chapter 2, the first design experiment is presented in which groups of children design ecosystems of self-chosen animals, and use e-mail to exchange narrations about the design task with a partner group at another school. The following two research questions are addressed: (1) *How can e-mail be implemented in the classrooms so that it engages children in reflective narration, and* (2) *What is the reflective nature of the narrations?*

Two primary classrooms with a total of twenty-four groups that are paired to exchange narrations with each other, participate in the design experiment. In each of six lessons, the groups send and receive an e-mail. Before the groups start working on their design, they receive an e-mail, and shortly discuss it. After working on their design, they send an e-mail. Writing an e-mail is supported by a paper worksheet on which the groups write their message before typing it on the computer and sending it away. Using the worksheet is expected to support collaborative writing in the classroom, and remove typing constraints from the process of reflection. In the course of the design experiment, several setups for the worksheet are tried out that vary the way they direct the process of reflection-on-action. A broad range of data is gathered to get a view on the implementation of e-mail in the classrooms, and on the reflectiveness of the children's narrations. The data are analyzed by looking at the classroom practices from three perspectives: the act of narrating, the rhetorical moves in the e-mails, and the stories told.

The findings show that an almost weekly e-mail contact is established between the schools. The groups are motivated to write to their partner

groups, and able to produce reflective stories. The e-mails have a classic letter setup in which personal ('We like football') and communicative talk ('Hello') dominate at the beginning and end of the narration, and design task related talk ('We have designed a fish's ecosystem') appears in the middle. The e-mail stories are further structured by the use of 'extended greetings', 'metatags', 'repetitive structures', 'enumerations', and 'spoken language items'. The structure and rhetorical moves present in the e-mails suggest that considerable effort is put in establishing and maintaining a shared collaborative platform between partner groups. The content of the e-mails is analyzed in an iterative process of categorization. The following operational definition of reflective narration is derived from this categorization: *'describing the process and product of designing, posing comparative and help-seeking questions, relating old and new experiences, and expressing assessments and appreciations'*.

Difficulties are also met. Initially, the groups focus on the exchange of questions and answers. These questions have a quiz-like character, and do not seek to compare or seek help, but rather to put the partner group to the test. These questions are considered not to be fruitful for reflection and the development of personal understanding. Hence, in the course of the design experiment, the instructions for reflection are extended by a freewriting exercise. The findings suggest that freewriting helps the children focus on reflection. Hence, a new question arises what would happen if freewriting is embedded into the lessons systematically? In addition, the groups hardly react on each other's narrations in their e-mails. Therefore, the need is felt to investigate the functionality of e-mail more closely by looking at the processes of reading and writing e-mails within the groups.

In chapter 3, the second design experiment is presented. Similar to the first design experiment, the second one aims at reflection-on-action through the exchange of narrations via e-mail in the process of designing an animal's ecosystem. Building on the findings from the first design experiment, the focus is on improving the richness of the stories by systematically embedding freewriting. In addition, we want to get a closer view on the low interactivity of the e-mail exchanges by exploring the group processes of reading and writing e-mails. The following research questions are addressed: (1) *How does freewriting support reflection-on-action when it is implemented in all the lessons, and* (2) *What is the reflective nature of collaborative narration?*

Three primary classrooms with a total of twelve paired groups participate. They send and receive one e-mail per lesson. Besides a paper worksheet to support the collaborative writing of messages, a freewriting exercise is implemented to support individual reflection. The freewritings are used as a source for composing a group e-mail. Data are gathered and analyzed in

similar ways as in the first design experiment. In addition, audio recordings of three focus groups are made in order to observe group processes more closely.

The findings show that freewriting is successfully implemented in the classrooms as it engages the children in individual reflective narration. The freewritings are then used to compose group e-mails. The e-mails contain rich reflective stories that describe and evaluate the design task from the children's personal perspectives. The unproductive posing of quiz-like questions disappeared from the e-mails. The findings also show that the teachers implement the composing process differently, and this strongly affects the entire process of reflective narration via e-mail. In two classrooms the children read and shortly discuss each other's freewritings and use parts of these to compose a group story. In the third classroom, the freewritings are pasted into the e-mail without making adjustments. As a result, the e-mails in this school are longer, structured differently, and contain more detail. In addition, the children in the other two schools develop a strong audience awareness during freewriting, and partly address their freewritings to the partner group. This audience awareness affects their motivation for freewriting, which decreases after the e-mail contact between two schools is disturbed.

The findings also show that the group talk surrounding the reading and writing of e-mails can contribute in important ways to the process of collaborative reflection, but often is rather short and shallow. In the process of collaborative writing, the children read and discuss each other's reflections, and become aware of individual differences. But they discuss the freewritings only briefly, and often while they are already writing the e-mail. In the process of reading received e-mails, the groups read and comment on it. However, only one instance is found in which the group extensively discusses the design task related content of the e-mail. Most of the comments concern personal and communicative talk instead. From the second design experiment, it is concluded that valuable discussion *within* groups can rise from e-mail communication *between* groups, but for this to occur frequently and extensively, more structure needs to be added to the processes of collaboratively reading and writing e-mails.

In chapter 4, the third design experiment is presented in which groups of children design communities of bees and ants, and use the web to find answers to self-generated questions. The following research questions are addressed: (1) *How can questioning with the web be implemented in the classroom so that the groups become engaged in reflection-in-action, and* (2) *What is the reflective nature of the questions and answers?*

Four primary classrooms with a total of twenty-eight groups participate in the design experiment. In three of the six lessons, the groups use the web for

questioning. The process of questioning is supported by a paper worksheet and a categorical portal. On the worksheet, the groups write down their questions and answers. Using the worksheet is expected to help the children focus on their information needs, and encourage the transformation of literal information into personally meaningful answers. The portal is used as an entry to the web, and provides one page with hyperlinks to websites divided in five task-related categories. The portal is expected to help the children locate relevant websites, so that more time is available for reading and interpreting new information. A broad range of data is gathered to get a view on the implementation of the web in the classrooms, and on the reflectiveness of the children's questioning. The data are analyzed by looking at questioning as a process taking place in three stages: perplexity, asking, and answering.

The findings show that the web is successfully implemented in the lessons by the teachers, but in different ways depending on the amount of computers available. In the two classrooms with only a few computers connected to the web, an 'integrated scenario' is found in which questioning and designing are intertwined activities. In these classrooms, groups take turns at the computer and are allocated limited time to search for answers. In the two classrooms that have a higher number of computers at their disposal, it is possible for all groups to visit the web at the same time. Hence, the teachers divide the activities of designing and questioning with the web. This is called a 'separated scenario'. In all classrooms, the groups are motivated to pose questions and visit the web. They pose questions from different motives. On the one hand, they emerge from a general eagerness to visit the web, and an unspecified curiosity about the topic. On the other hand, questions emerge from task-related uncertainty. Most of the questions that are posed are follow-up questions that seek to elaborate on already generated biological forms and functions. Furthermore, most of the answers that are formulated on the worksheets are literal adoptions from websites. A few answers show explicit interpretations of the information found. Based on these findings, the following operational definition of reflective questioning is derived: *'posing follow-up questions based on task-related uncertainty, and leading to adaptations of information'*.

Questioning with the web appears not to be reflective in all stages. The difficulties are found in the stage of answering, as a majority of questions do not receive an answer, and most answers are adoptions that do not articulate personal meaning. Several factors may be responsible for this. First, the separated scenario shows an unreflective pattern of questioning in which lists of questions are produced after instead of during working on the design task. As a result the groups lose focus when searching answers. Second, the portal is experienced as an overwhelming list of websites that hardly supports goal-driven searching. Third, perplexity is not always task-related,

and this may have caused a lack of feeling the need to adapt information into personal answers. Therefore, improvements to the instructional design are proposed that focus on establishing an 'integrated scenario' in the classrooms, supporting the stage of answering by structuring the portal more heavily, and extending task-related perplexity. Moreover, a need is felt to explore the group talk surrounding the process of questioning to see if further adaptation of new information takes place there.

In chapter 5, the fourth design experiment is presented. Similar to the third design experiment, the fourth one aims at reflection-in-action through questioning with the web in the process of designing communities of bees and ants. Building on the findings from the third design experiment, the focus is on improving the stage of answering. In addition, we want to get a closer view on the group talk surrounding the formulation of questions and answers. The following two research questions are addressed: (1) *Does the articulation of provisional answers lead to delayed perplexity and more adaptations in the stage of answering*, and (2) *What is the reflective nature of collaborative questioning?*

Two primary classrooms with a total of sixteen groups participate. To support the stage of answering, the worksheet and the portal are improved. The worksheet contains a third space for writing down a provisional answer before the web is visited. Formulating provisional answers is expected to increase the children's awareness of their information needs, and encourage the formulation of personally meaningful answers. The portal is changed into a hierarchical search space with anchors for searching such as a navigational bar, short descriptions, and icons indicating information type. Data are gathered and analyzed in similar ways as in the third design experiment. In addition, audio recordings of two focus groups are made to observe group processes more closely.

The findings show that an 'integrated scenario' is realized in both classrooms. The groups pose questions and visit the web whenever they feel the need while working on the design task. The same motives for questioning emerge as in the third design experiment, for instance curiosity and uncertainty. A closer view on the emergence of questions in the two focus groups, however, shows that uncertainty plays a role at different moments. Sometimes, uncertainty is raised by the design task. Yet at other times, it becomes visible when a provisional answer is formulated. Hence, *delayed perplexity* is raised in the process of formulating provisional answers. Furthermore, the portal successfully helps the groups to locate relevant information as an answer is found to a majority of questions. However, again most of the answers are adoptions rather than adaptations. A closer examination of the group talk surrounding web searching suggests that although groups hardly adapt written answers on the worksheets, they

do discuss new information while they are searching. The focus groups read aloud and point out relevant information, frequently discuss its meaning, and relate new information to personal experiences. Similarly to the e-mail studies, these findings illustrate that the group talk surrounding the formulation of questions and (provisional) answers can contribute in important ways to the process of collaborative reflection. Based on the findings, the operational definition of reflective questioning is adjusted into the following definition: *'posing follow-up questions based on immediate or delayed uncertainty, and leading to adaptations of information during or after searching for the answer'*.

In chapter 6, an overview of the four design experiments is presented and some issues that came forth from the data are further discussed. The main purpose of the present studies was to engage children in thinking about their prior knowledge and new classroom experiences in order to improve the development of personal understanding. It is argued here that a prerequisite for such reflection to take place is that the children have a feeling of *ownership* of the task, find the task *relevant*, and are willing to take *control* over their own learning.

First, we conclude that the diversity of activities, children's appreciation and prior knowledge of the topics, and the structured freedom of the design tasks are important factors that give ownership and control to the children, and increase the relevancy of the task.

Second, we conclude from the first and second design experiment that using e-mail resulted in reflection on a wide range of task-related issues. The children reflect on the process and product of designing, both individually and in their groups, and sometimes relate these to prior experiences. In addition, they frequently reflect on their own roles in the learning process by the expression of assessments and appreciations. Writing to a real audience motivates the children, and creates opportunities for sharing and comparing thoughts.

Third, we conclude from the third and fourth design experiment that the web helps to establish a motivating climate for questioning. The groups pose follow-up questions that complement use of the design heuristic as they seek to elaborate on forms and functions that are generated by using the heuristic. Furthermore, the web creates opportunities for reflection because the children articulate prior knowledge in the form of provisional answers, and discuss information while searching for answers.

In examining the results of the four design experiments from an overview perspective, it is additionally concluded that e-mail and the web encourage reflection on prior knowledge and new classroom experiences in opposite ways. In the e-mail environment, the emphasis is put on the *new classroom experiences* and these form the starting point for relating them to prior ones.

In the web environment, the explication of *prior knowledge* is the starting point for seeking new information. Furthermore, by comparing e-mail and the web it shows that in both the environments similar patterns of *adopting* and *adapting* are present. Adoption takes place *between* groups and sources, whereas adaptation occurs *within* groups. The studies presented in this thesis hence indicate that the group talk that evolves around computer use is valuable.

Third, we examine the kind of reflection that emerged in the classrooms. It is argued that in contrast to two traditional views on reflection in the field of educational research, i.e. reflection as a metacognitive skill, and reflection as a learning function, the findings from the present studies suggest a view on reflection that emphasizes its *personal* character. It is related to reflection as a learning function, because it views the process of reflection as intertwined with the process of knowledge construction. But in addition, it emphasizes that learners reflect in unique and personal ways in which the cognitive and affective are intertwined. The studies illustrate how e-mail and the web can provide opportunities for personal reflection. *Structured freedom* and teaching an *adopt-adapt strategy* are suggested means to create these opportunities in future classrooms.

Summary (Dutch)

In dit proefschrift worden vier design experimenten gepresenteerd die zijn uitgevoerd in de basisschool en het volgende probleem onderzoeken:

Hoe kan reflectie worden geïmplementeerd in het leerproces zodanig dat de ontwikkeling van een persoonlijk inzicht in een domein en leertaak erdoor wordt bevorderd?

Deze vraag is onderzocht in een reeks van vier studies waarin momenten van reflectie zijn ingebouwd in lessen natuuronderwijs. De lessen zijn opgezet volgens de Leren door Ontwerpen benadering waarin leerlingen leren over de natuur door bestaande biologische systemen te herontwerpen volgens in de natuur en biologiewetenschap geldende principes, zoals het vorm-functie perspectief. De ontwerptaken zijn erop gericht de voorkennis van leerlingen te activeren en deze kennis uit te breiden met nieuwe inzichten. In de studies die in dit proefschrift beschreven staan, wordt het ontwerpen ondersteund door een ontwerpheuristiek, leerkrachtbegeleiding, en het werken in groepjes. De verwachting is dat momenten van reflectie in deze ontwerplessen de leerlingen zal helpen zich bewust te worden van de voorkennis die ze tot hun beschikking hebben en actief kunnen gebruiken om nieuwe ervaringen opgedaan tijdens de lessen persoonlijke betekenis te geven.

Twee reflectiemomenten ontleend aan de theorie van Schön (1983) over reflecteren in de beroepspraktijk worden ingebed in de ontwerptaak: *reflectie-tijdens-handelen* en *reflectie-op-handelen*. In de hier gepresenteerde studies zijn de momenten van reflectie-tijdens-handelen gericht op het *uitbreiden* van voorkennis en nieuwe ervaringen, terwijl de momenten van reflectie-op-handelen gericht zijn op het *samenvatten* van voorkennis en nieuwe ervaringen. Twee reflectieve activiteiten staan centraal: *vertellen*, en *bevragen*. Vertellen is gericht op reflectie-op-handelen, bevragen is gericht op reflectie-tijdens-handelen. Daarnaast zijn twee technologische middelen ingezet om deze activiteiten vorm te geven en te ondersteunen: *e-mail* en *het web*. E-mail en het web zijn twee technologische middelen die tegenwoordig in de meeste basisscholen volop aanwezig zijn. Bovendien representeren ze de twee hoofd takken van computertechnologie (ICT): informatie (web) en communicatie (e-mail). Ook lijken e-mail en het web over eigenschappen te beschikken die geschikt zijn voor reflectie. Om deze vermeende geschiktheid te onderzoeken, worden vier design experimenten uitgevoerd waarin of van e-mail gebruik wordt gemaakt ten behoeve van vertellen over de leertaak, of van het web ten behoeve van het bevragen van de leertaak. De

volgende twee onderzoeksvragen die zijn afgeleid van het algemene onderzoeksprobleem staan centraal in de design experimenten:

- (1) *Hoe kan vertellen via e-mail reflectie-op-handelen ondersteunen?*
- (2) *Hoe kan bevragen met het web reflectie-tijdens-handelen ondersteunen?*

In hoofdstuk 1 van dit proefschrift worden de leertaken, die zijn opgezet volgens de Leren door Ontwerpen benadering, gepresenteerd. Ook wordt beargumenteerd dat het wenselijk en nodig is momenten in de les te reserveren voor reflectie. Het gebruiken van e-mail voor het uitwisselen van vertellingen over de lessen, en het gebruik van het web voor het zoeken van antwoorden op eigen vragen, wordt voorgesteld om die momenten van reflectie verder in te richten. Naast deze algemene opzet van de lessen, wordt de methodologische achtergrond van de in dit proefschrift gepresenteerde studies toegelicht. De studies kunnen gekarakteriseerd worden als exploratief en beschrijvend, en passen in de richtlijnen van ontwikkelingsonderzoek, ook wel *Design-Based Research* (DBR) genoemd. Een centrale gedachte van Design-Based Research is dat onderwijsproblemen onderzocht moeten worden in de praktijk waarin ze zich voordoen zodat aan realistische oplossingen en praktijkgetrouwe theorie-ontwikkeling gewerkt kan worden. De algemene opzet van DBR ligt in een opeenvolging van zogenaamde design experimenten die doelen op een systematische aanpassing van onderdelen van de te ontwerpen leeromgeving zodat elke aanpassing fungeert als een experimentele setting.

In hoofdstuk 2 wordt het eerste design experiment gepresenteerd. In dit experiment ontwerpen groepjes leerlingen ecosystemen van zelf gekozen dieren en gebruiken e-mail om verhalen over hun lesbevindingen uit te wisselen met een partnergroepje op een andere school. De volgende onderzoeksvragen staan centraal: (1) *Hoe kan e-mail worden ingebed in de klas zodanig dat het leerlingen uitnodigt tot reflectieve vertellingen, en (2) Wat is het reflectieve karakter van hun vertellingen?*

Twee basisschoolklassen met in totaal vierentwintig groepjes nemen deel aan het experiment. De groepjes uit de verschillende klassen worden aan elkaar gekoppeld om e-mails uit te wisselen. In elke les sturen en ontvangen de groepjes één e-mail. Voordat ze beginnen te werken aan hun ontwerp, ontvangen ze een e-mail en bespreken deze kort. Nadat ze hebben gewerkt aan hun ontwerp, schrijven ze een e-mail terug. Het schrijven van de e-mail wordt ondersteund door een papieren werkblad waarop de groepjes in de klas hun bericht schrijven voordat ze dit op de computer intypen en verzenden. De verwachting is dat het werkblad ervoor zorgt dat het hele groepje betrokken is bij het schrijven van de e-mail. Ook kan het ervoor zorgen dat ze tijdens het reflecteren en opschrijven van hun reflecties nog

niet bezig hoeven zijn met typen, wat voor veel leerlingen nog moeilijk is en veel aandacht vereist. In de loop van het design experiment zijn verschillende werkbladen uitgeprobeerd die varieerden in de wijze waarop en de mate waarin ze richting gaven aan het reflecteren. In het experiment zijn verschillende soorten data verzameld om inzicht te krijgen in de implementatie van e-mail in de klas, en de reflectiviteit van de vertellingen. De data zijn geanalyseerd aan de hand van drie perspectieven op vertellen: de handeling van het vertellen, de retoriek van de vertellingen, en de inhoud van de vertellingen.

De scholen realiseren een bijna wekelijks e-mail contact. De groepjes zijn gemotiveerd voor het schrijven van berichten aan hun partnergroepjes en in staat om over de les te schrijven. De e-mails zijn opgezet zoals een brief, met op de communicatie (bv. "Hallo") en persoonlijke kennismaking (bv. "Wij houden van voetbal") gerichte inhoud aan het begin en einde van de e-mails, en inhoud gerelateerd aan de ontwerptaak (bv. "We hebben de leefomgeving van een vis ontworpen") in het midden. De e-mailvertellingen zijn gestructureerd door 'uitgebreide begroetingen', 'metatags', 'herhalende structuren', 'opsommingen', en 'gesproken taal'. Deze karakteristieke retorische eigenschappen in de e-mails laten zien hoe een deel van de berichtgeving is gericht op het vestigen en onderhouden van een samenwerkingsverband op afstand. De taakgerelateerde inhoud van de e-mails wordt verder geanalyseerd in een iteratief proces van categorisering. De uiteindelijke categorisering laat zien dat de groepjes de lessen beschrijven en evalueren. Uit het experiment wordt de volgende operationalisatie van reflectief vertellen afgeleid: *'het beschrijven van het proces en product van ontwerpen, het stellen van vergelijkende en hulpzoekende vragen, het relateren van oude en nieuwe ervaringen, en het uiten van beoordelingen en waarderingen'*.

In het experiment worden ook problemen geconstateerd. Aanvankelijk richten de groepjes zich op het uitwisselen van vragen en antwoorden in plaats van het uitwisselen van reflectieve vertellingen. De vragen die de partnergroepjes elkaar stellen zijn quiz-achtig, en dienen niet om tot een vergelijking te komen of hulp te zoeken, maar om de partnergroep te testen. We beschouwen deze vragen als niet reflectief en niet gericht op het ontwikkelen van een persoonlijk inzicht in de leertaak en het domein. Daarom worden in de loop van het experiment de instructies voor het reflecteren uitgebreid met een individuele oefening 'vrij schrijven'. Na het invoeren van deze oefening in twee lessen van één school blijkt dat de leerlingen zich meer richten op het vertellen over de les en minder op het stellen van quiz-vragen. Uit het eerste design experiment vloeien de volgende vragen voort: In hoeverre verbetert het reflectieproces als vrij schrijven wordt ingebed in elke les? En omdat de partnergroepjes wel e-mails uitwisselen maar nauwelijks op

elkaars e-mails reageren, doet zich de vraag voor wat er in de groepjes gebeurt tijdens het schrijven en lezen van e-mails.

In hoofdstuk 3 wordt het tweede design experiment gepresenteerd. Net als het eerste experiment richt dit tweede experiment zich op reflectie-op-handelen door middel van het uitwisselen van vertellingen via e-mail gedurende zes lessen waarin groepjes een ecosysteem ontwerpen. Voortbouwend op de resultaten van het eerste design experiment, richt dit experiment zich vooral op de invloed van het vrij schrijven op de reflecties. Bovendien willen we een gedetailleerder zicht krijgen op de interactieve processen die zich in de groepjes voordoen terwijl ze gezamenlijk e-mails lezen en schrijven. De volgende onderzoeksvragen staan centraal: (1) *Hoe ondersteunt vrij schrijven reflectie-op-handelen wanneer het wordt geïmplementeerd in alle lessen, en (2) Wat is de reflectieve aard van het gezamenlijk vertellen?*

Drie klassen doen mee in het onderzoek met een totaal van twaalf groepjes. Deze groepjes verzenden en ontvangen één e-mail per les. Behalve een papieren werkblad dat het gezamenlijk schrijven in de klas ondersteunt, wordt vrij schrijven ingebed in de lessen voorafgaand aan het gezamenlijk schrijven van een e-mail. Er worden op dezelfde manier data verzameld en geanalyseerd als in het eerste design experiment. Bovendien worden er audio-opnames van drie focusgroepjes gemaakt om een beter inzicht te krijgen in de groepsprocessen rondom het lezen en schrijven van e-mails.

Vrij schrijven wordt succesvol geïmplementeerd in de drie klassen en zet de leerlingen aan tot reflecteren op de les. De individuele schrijfsels dienen als bron voor het componeren van een groepsverhaal. Op basis van de schrijfsels worden rijke reflectieve verhalen geproduceerd die de lessen beschrijven en persoonlijke evaluaties onthullen. Het stellen van quiz-vragen komt niet meer voor. Ook laten de resultaten van het onderzoek zien dat het proces van e-mails componeren op basis van de schrijfsels door de leerkrachten verschillend wordt ingericht. In twee klassen lezen de leerlingen elkaars schrijfsels en bespreken deze kort. Daarna gebruiken ze delen uit de schrijfsels om een e-mail van te maken. In de derde klas worden de schrijfsels zonder verdere verandering in een document geplakt en als attachment verzonden. Bijgevolg zijn deze e-mails langer, hebben een andere structuur, en bevatten meer details over de les. In de andere twee scholen, staat het individueel vrij schrijven meer en meer in het teken van het e-mailen met de partnergroep, en delen van de schrijfsels worden al tot de partnergroep gericht. Dit is van invloed op hun motivatie voor vrij schrijven wanneer halverwege de lessenreeks het e-mailcontact met de partnerschool tijdelijk wordt onderbroken.

Uit het experiment blijkt ook dat de groeps gesprekken rondom het lezen en schrijven van e-mails belangrijk zijn in het proces van gezamenlijk

reflecteren, maar dat ze vaak nogal kort en oppervlakkig gevoerd worden. In het proces van gezamenlijk schrijven lezen en bediscussiëren de leerlingen elkaars schrijfsels en worden zich daardoor bewust van individuele verschillen. Maar de discussies zijn kort, en vinden vaak plaats tijdens het schrijven van de e-mail. In het proces van e-mails lezen, zien we iets soortgelijks. De groepjes lezen de e-mail en geven commentaar, maar het commentaar is kort en heeft vooral betrekking op de lengte en de persoonlijke zaken die erin genoemd staan. Er wordt slechts één geval gevonden waarin de groep uitgebreider discussieert over een taakgerelateerd aspect uit de ontvangen e-mail. De conclusie van het tweede design experiment luidt dat waardevolle discussie kan plaatsvinden *binnen* groepjes voortvloeiend uit een e-mailcontact *tussen* groepjes. Meer structuur in de groepsprocessen van schrijven en lezen is nodig om deze potentiële reflectiemomenten vaker en beter tot hun recht te laten komen.

In hoofdstuk 4 wordt het derde design experiment gepresenteerd. In dit experiment ontwerpen de groepjes bijen- en mierenkolonies en gebruiken het web voor het zoeken naar antwoorden op eigen vragen. De volgende onderzoeksvragen staan centraal: (1) *Hoe kan vragen stellen met het web worden ingebed in de klas zodanig dat het de groepjes uitnodigt tot reflectie-tijdens-handelen, en (2) Wat is het reflectieve karakter van de vragen en antwoorden?*

Vier klassen nemen deel aan het experiment met in totaal achtentwintig groepjes. In drie van de zes lessen gebruiken de groepjes het web. Het proces van bevragen wordt ondersteund met een papieren werkblad en een categorische portaalsite. Op het werkblad noteren de groepjes hun vragen en antwoorden. De verwachting is dat het werkblad hen zal helpen gericht te blijven op hun vraag, en persoonlijk relevante antwoorden te formuleren. De portaalsite biedt een ingang naar het web door middel van een enkele webpagina met daarop tientallen hyperlinks ondergebracht in vijf taakgerelateerde categorieën. De portaalsite zal hen helpen relevante websites te vinden, zodat er meer tijd beschikbaar komt voor het lezen en beoordelen van informatie. Verschillende soorten data zijn verzameld om inzicht te krijgen in de implementatie van het webgebruik in de klassen, en in de reflectiviteit van het vraagproces. De data zijn geanalyseerd aan de hand van een model van bevragen bestaand uit drie fasen: perplexiteit, stellen, en beantwoorden.

De resultaten laten zien dat het webgebruik succesvol is geïmplementeerd in de klassen, maar op verschillende manieren, afhankelijk van het aantal computers met internetverbinding die de leerkrachten tot hun beschikking hebben. In de twee klassen waar slechts enkele computers aanwezig zijn, wordt een 'geïntegreerd scenario' gerealiseerd waarin vragen stellen en ontwerpen geïntegreerde activiteiten zijn. In deze klassen gaan de groepjes

omstebeurt naar het web en krijgen beperkt de tijd om antwoord op hun vraag te zoeken. In de twee klassen waar voldoende computers aanwezig waren om alle groepjes tegelijk achter de computer te laten, wordt een 'gescheiden scenario' gerealiseerd, waarin het ontwerpen gevolgd wordt door vragen stellen en webbezoek. Ongeacht het gerealiseerde scenario zijn de leerlingen in alle klassen gemotiveerd om vragen te stellen en het web te bezoeken. Ze stellen hun vragen vanuit verschillende motieven. Enerzijds ontstaan vragen vanuit enthousiasme voor het web en een algemene nieuwsgierigheid voor het onderwerp. Anderzijds ontstaan er vragen vanuit taak-gerelateerde onzekerheden. De meeste vragen die gesteld worden zijn volgvragen die doorvragen op met de heuristiek gegenereerde biologische vormen en functies. De meeste antwoorden die opgeschreven worden op het werkblad zijn adopties die bestaan uit gekopieerde informatie. Enkele antwoorden vertonen expliciete betekenisgeving. Uit de resultaten wordt de volgende operationalisatie van reflectief bevragen afgeleid: *'het stellen van volgvragen gebaseerd op taak-gerelateerde onzekerheid, en leidend tot adaptaties van informatie'*.

Het proces van bevragen is niet reflectief in alle fasen. De moeilijkheden lijken vooral te zitten in de fase van antwoorden, want een overgroot deel van de vragen wordt niet beantwoord en de meeste antwoorden zijn letterlijk overgenomen van websites. Verschillende factoren zouden hiertoe bijgedragen kunnen hebben. Ten eerste, het gescheiden scenario lijkt niet succesvol. De groepjes produceren lijsten van vragen nadat ze aan de ontwerptaak gewerkt hebben, en lijken hun focus op al die vragen te verliezen in de fase van antwoorden. Ten tweede, de portaalsite wordt ervaren als een overweldigende lijst mogelijkheden die niet veel houvast biedt voor het doelgericht zoeken. Ten derde, de perplexiteit is niet altijd taakspecifiek. Als de motivatie voor het stellen van een vraag ongedefinieerd enthousiasme is, vervalt wellicht de behoefte het antwoord in eigen betekenisvolle bewoordingen te formuleren. Gebaseerd op het derde experiment, wordt daarom besloten de lessen dusdanig aan te passen dat een geïntegreerd scenario zal worden gerealiseerd in de klassen. Bovendien moet de fase van antwoorden verder ondersteund worden door een betere portaalsite, en door taakspecifieke perplexiteit in de leerlingen aan te wakkeren. Daarnaast is evenals in het tweede design experiment een behoefte ontstaan om in meer detail te kijken naar de groepsprocessen rondom het formuleren van vragen en antwoorden. Een mogelijkheid is dat daar meer adaptatie plaatsvindt dan op de werkbladen zichtbaar is.

In hoofdstuk 5 wordt het vierde design experiment gepresenteerd. Evenals in het derde experiment, richt dit experiment zich op reflectie-tijdens-handelen door middel van bevragen met het web tijdens het ontwerpen van kolonies van bijen en mieren. Voortbouwend op de resultaten

van het derde experiment, ligt de focus op het verbeteren van de fase van antwoorden. Bovendien willen we een beter inzicht krijgen in de groepsgesprekken rondom bevragen. De volgende onderzoeksvragen staan centraal: (1) *Leidt de articulatie van voorlopige antwoorden tot vertraagde perplexiteit en meer adaptaties in de fase van antwoorden, en (2) Wat is het reflectieve karakter van het gezamenlijk bevragen?*

Twee klassen met in totaal zestien groepjes nemen deel aan het onderzoek. Om de fase van antwoorden verder te ondersteunen, worden een verbeterd werkblad en portaalsite aangeboden. Het werkblad bevat nu ook een derde vak waarin de leerlingen vooraf aan het webbezoek een voorlopig antwoord op hun vraag formuleren. De verwachting is dat het formuleren van voorlopige antwoorden leerlingen bewuster maakt van hun voorkennis en informatiebehoefte, en leidt tot meer aanpassingen van de gevonden informatie. De portaalsite wordt uitgebreid tot een hiërarchische zoekruimte met extra ondersteuning voor het zoeken in de vorm van onder andere een navigatiebalk, korte omschrijvingen, en iconen die het soort informatie aanduiden. Data worden verzameld en geanalyseerd overeenkomstig het derde experiment. Daarnaast worden audio-opnames gemaakt van twee focusgroepjes om een nader inzicht te krijgen in de groepsprocessen rondom het vragen stellen.

Uit de resultaten blijkt dat een geïntegreerd scenario wordt verwezenlijkt in beide klassen. De groepjes stellen vragen en bezoeken het web wanneer ze daar tijdens het werken aan hun ontwerp behoefte toe voelen. De vragen ontstaan uit dezelfde motieven als in het derde experiment, dus zowel uit een algemeen enthousiasme als uit meer taakgebonden onzekerheden. Daarnaast blijkt dat onzekerheid ook later in het proces van vragen stellen een rol kan spelen, namelijk tijdens het formuleren van een voorlopig antwoord. Een *vertraagde* perplexiteit wordt veroorzaakt wanneer tijdens het formuleren van voorlopige antwoorden leemtes in de voorkennis duidelijk worden. De portaalsite ondersteunt het zoekgedrag met meer succes. De meeste vragen krijgen een antwoord. Maar weer bestaat het merendeel van de antwoorden uit adopties van websites zonder verdere interpretatie. Wel blijkt dat tijdens het zoeken naar het antwoord de leerlingen achter de computer nieuwe informatie bespreken, en voorkennis en persoonlijke ervaringen inbrengen om deze nieuwe informatie betekenis te verlenen. De leerlingen lezen nieuwe informatie hardop, wijzen naar relevante passages, bediscussiëren wat er staat, en relateren nieuwe informatie aan persoonlijke belevenissen. Net als in de experimenten met e-mail lijken de data er op te wijzen dat groepsgesprekken rondom webgebruik een waardevol onderdeel zijn van het gezamenlijk reflectieproces. Gebaseerd op de resultaten, wordt de operationalisatie van reflectief bevragen als volgt geherformuleerd: *'het stellen van volgvragen voortkomend uit onmiddellijke of vertraagde*

onzekerheid, en leidend tot adaptaties van informatie tijdens of na het zoeken naar een antwoord'.

In hoofdstuk 6 wordt een overzicht van de vier design experimenten gepresenteerd en worden enkele opvallende resultaten besproken. Het hoofddoel van alle design experimenten was de leerlingen te betrekken in het nadenken over voorkennis en nieuwe ervaringen zodat deze gerelateerd raken en leerlingen ruimte krijgen om een persoonlijk inzicht in de leertaak en het domein te ontwikkelen. Voorwaardelijk voor zulke reflectie is dat leerlingen het gevoel hebben dat ze de taak *bezitten*, dat de taak *relevantie* voor hen heeft, en dat ze ook daadwerkelijk de *controle* over het leerproces krijgen.

Ten eerste concluderen we dat de diversiteit aan activiteiten die in de lessen plaatsvinden, de waardering van de leerlingen voor het onderwerp en de voorkennis waarover ze beschikken, en de gestructureerde vrijheid in de lesplannen in belangrijke mate bijdragen aan de authenticiteit en zelfstandigheid van de leerlingen, en aan de ruimte voor reflectie.

Ten tweede concluderen we uit het eerste en tweede design experiment dat het gebruiken van e-mail heeft geresulteerd in reflectie op een breedheid aan taakgerelateerde onderwerpen. De leerlingen reflecteren op het proces en product van de ontwerptaak, zowel individueel als in hun groepjes, en relateren nieuwe ervaringen aan oude. Bovendien reflecteren ze op hun eigen en elkaars rol in de lessen door middel van het beoordelen en waarderen van processen en producten. Schrijven voor een echt publiek werkt motiverend, en geeft gelegenheid gedachten te delen en te vergelijken binnen en tussen groepjes.

Ten derde concluderen we uit het derde en vierde experiment dat het web een motiverend klimaat voor het stellen van vragen vestigt in de klassen. De groepjes stellen volgvragen die aanvullend zijn op het gebruik van de heuristiek. En in het proces van vragen stellen en (voorlopige) antwoorden formuleren, articuleren de leerlingen hun onzekerheden en hun voorkennis, en bespreken nieuwe informatie.

Als we de vier experimenten overzien, concluderen we niet alleen dat e-mail en het web gelegenheid bieden voor individuele en gezamenlijke reflecties, maar dat ze dat ook op tegengestelde wijze doen. In de e-mail omgeving zijn *nieuwe ervaringen* uitgangspunt voor reflectie en wordt voorkennis aan deze nieuwe ervaringen gekoppeld. In de web omgeving is juist de *voorkennis* het uitgangspunt en leiden onzekerheden in de voorkennis tot het zoeken naar nieuwe informatie. Een vergelijk tussen de beide omgevingen laat bovendien zien dat ze ook overeenkomsten hebben, want in beide omgevingen worden gelijke patronen van *adoptie* en *adaptatie* gevonden. Adoptie vindt plaats *tussen* groepjes en bronnen, en adaptatie

vindt plaats *binnen* groepjes. De design experimenten illustreren de waarde van groepsprocessen rondom computergebruik.

Tot slot beschouwen we de soort reflectie die ontstond in de leeromgevingen. In contrast met twee bestaande traditionele opvattingen over reflectie in onderwijskundig onderzoek, namelijk reflectie als metacognitieve vaardigheid, en reflectie als leerfunctie, ontvouwen de huidige design experimenten een kijk op reflectie die het *persoonlijke* karakter benadrukken. Deze kijk op reflectie past in reflectie als leerfunctie, omdat zij reflectie ziet als een proces dat verbonden is aan kennisontwikkeling en tegelijkertijd daarmee plaatsvindt. Maar het voegt daaraan toe dat leerlingen reflecteren op eigen en unieke wijzen door middel van het inbrengen en expliciteren van persoonlijke ervaringen en evaluaties waarin het cognitieve en affectieve sterk door elkaar heen lopen. De design experimenten illustreren hoe e-mail en het web gelegenheid creëren voor persoonlijke reflectie. *Gestructureerde vrijheid* en het expliciet maken en onderwijzen van een *adoptie-adaptatie strategie* zijn mogelijke middelen waarmee in toekomstige klassen zulke gelegenheden opnieuw gestalte kunnen krijgen.