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Supporting reflective web searching in elementary schools

Bregje de Vries *, Hans van der Meij, Ard W. Lazonder

University of Twente, Department of Instructional Technology, Enschede, The Netherlands

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Abstract

In this contribution, two design experiments are presented in which reflective web searching is implemented in six elementary classrooms. Reflective web searching is viewed to comprise three steps: (1) develop ownership over search questions, (2) interpret and personalize web content, and (3) adapt web content into personally meaningful answers. A portal and a worksheet supported reflective web searching. A wide range of qualitative data, including observations, interviews and group products, was collected to gain insight in the emerging practices. The findings show that the portal and worksheet successfully contributed to the development of ownership, and the interpretation and personalization of retrieved information. Enabling children to search the web collaboratively further enhanced interpretation and personalization. The prototypes of both portal and worksheet were improved across the design experiments, and their success rates increased. Despite the improvements, the process of adaptation was not sufficiently supported by the portal and worksheet.

1. Introduction

Constructivist learning approaches emphasize the active role that learners play in their own development. In constructivist learning environments, learners are explicitly invited to activate their prior knowledge, and tailor new information to what they already know.

* Corresponding author. Present address: HAN University, Faculty of Education, P. O. Box 30011, 6503HN Nijmegen, The Netherlands.
E-mail address: bregje.devries@han.nl (B. de Vries).

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By doing so, new information becomes embedded in existing knowledge structures, and gains personal significance. Using the web in such constructivist learning environments demands that learners interpret the information they find by looking at web sources from their personal perspectives, and integrate new information with their prior knowledge frameworks. These prior knowledge frameworks consist of school knowledge (i.e., facts and concepts), as well as out-of-school experiences (i.e., stories, personal practices, attached feelings and appreciations), and 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). In other words, in constructivist learning environments it is emphasized that learners need to search the web *reflectively* by comparing owned concepts, facts, and personal experiences to new information, and starting a process of mutual adaptation. The aim of this project is to support students in being reflective web searchers by providing them a portal and a worksheet.

Reflective web searching involves three steps. The first step is *developing ownership* over a search question before the actual search is carried out. Imagine a sixth-grade boy named Roy, who is working on an essay about ancient Greek religion in a history class. Roy suddenly remembers an adventurous book he once read about a guy named Odysseus. He realizes Odysseus was an ancient Greek who believed in the gods and goddesses he is doing his essay on. What was it again that Odysseus did, and how did the gods and goddesses serve him? Roy wonders, and develops an interest in looking up some detailed information about the story of Odysseus. The particular search questions Roy poses later, when he actually starts searching the web, hence emerge from a personal memory, and a personal need to know. The importance of personal ownership over a question for motivation and perseverance, but also more fundamentally for the quality of the problem solving that follows, has been pointed out – more or less explicit – by many other researchers. For example, Dewey (1910) argued that thorough inquiry can only occur if the need felt for it is personal. Similarly, others have suggested that questions and subsequent inquiry should stem from a feeling of perplexity, and personal curiosity (Abrandt Dahlgren & Öberg, 2001; Van der Meij, 1998; Wells, 2000).

To support the development of ownership, we argue that it is necessary that web searching is carefully embedded in the context of a learning task. If web searching itself is the goal, and learners have to look up 'something' out of the blue or are presented with search queries by their teachers, perplexity and ownership are difficult states to arrive at. But if web searching is embedded in a learning task, learners will start to experience something, activate their prior knowledge frameworks, and this might give rise to puzzlement and personal needs to know. Only then learners can develop personally relevant questions they feel they own, and search the web reflectively. Other researchers have pointed out the importance of contextualizing web searching. For instance, based on findings from their study on web use in a sixth-grade classroom, Wallace, Kupperman, Krajcik, and Soloway (2000) conclude: 'In a more integrated information environment, in which use of Web resources was more closely tied to finding information as needs arose, one might expect to see different behavior from the same students. It would be interesting to carry on similar activities-letting students pose their own questions about aspects of the curriculum-in a classroom in which Web connectivity was available on a day-to-day basis and was one part of an environment of inquiry' (p. 101).

The second step in reflective web searching is the *interpretation and personalization* of new information while searching. New information has to be interpreted in light of the

search question that was formulated. In addition, the information should be personally understandable and relevant, and therefore has to be reflected upon from one's prior knowledge framework. In Roy's case, he might have formulated the following search question: 'Which gods and goddesses does Odysseus meet on his trip, and how do they help him?' He starts searching the web, and finds many relevant websites. While scanning and reading the information, Roy vividly remembers the excitement he felt about Odysseus' traveling, and how he had wondered if Odysseus would ever make it home, and see his wife again. One particular website named the gods and goddesses who directly helped or hindered Odysseus to get home. These are important, so it seems to Roy. Hence, in the process of searching and selecting information, Roy uses his prior knowledge and personal experiences with the Homer story to interpret new information, and make motivated choices about what he needs for his essay.

To interpret and personalize retrieved information, learners need to be able to search and select it first. Learners need many skills to search and select information, varying from knowing how to use a computer and search engine, to careful scanning and reading. Many studies have shown that elementary school children typically have difficulties performing these skills. They usually do not plan their searches, and prefer free browsing above keyword searching (Bilal & Kirby, 2002; Large, Beheshti, & Rahman, 2000; Schacter, Chung, & Dorr, 1998). When browsing, they get lost (Chiu & Wang, 2000). When using keywords, they use too broad or specific ones, and do not specify combinations of key words if needed (Bilal, 2002; Wallace et al., 2000). They also have problems with selecting information. They search quickly in many websites instead of thoroughly in a few ones (Bilal, 2001, 2002; Wallace et al., 2000). While most of these findings were obtained in American elementary schools, an observational study with Dutch children from the upper grades of elementary schools showed similar outcomes (Lazonder, Van der Meij, & De Vries, 2000).

With these problems children encounter in mind, we argue that a task-specific portal that helps pupils search and select relevant sources can support the interpretation and personalization of retrieved information. Jones (2002) states that spending lots of time on searching and locating relevant information comes at the cost of processing it. In her research on Internet inquiry projects in high schools, Jones provided students with links to relevant sources. As a result, the students allocated more time to processing the websites' contents. Other researchers also suggest using task-specific web environments and portals to facilitate searching, and the actual use of information (Bilal & Kirby, 2002; Greene & Land, 2000; Hoffman, Wu, Krajcik, & Soloway, 2003; Wallace et al., 2000).

The third step in reflective web searching is the *adaptation* of the interpreted and personalized information into a personal format after having searched the web. In the process of adaptation, information is translated and put into own words. The final answer expresses a personal understanding. Roy may have found the following information: 'The gods, goddesses, and creatures had supernatural powers that effected the lives of Odysseus, his crew, and family. Their actions proved to be powerful, beneficial, and deadly'. With his own knowledge about Odysseus' trip, and specific gods and goddesses that were mentioned in other websites, he formulates an answer: 'The Greeks believed that people really do not have much control over their own destinies at all. The gods were in control! At Odysseus' trip some important gods were: Zeus and Athene. Athene was in love with Odysseus, maybe that's why she helped him a lot. So they are just like humans too!' The answer reveals a personal understanding and appreciation of ancient Greek mythology, which Roy can use and apply in his essay.

To support adaptation, it seems crucial that Roy writes down his final answer. If the answer did not have to be written down, would Roy have formulated it? We therefore argue that providing learners with a worksheet for writing down question and answer creates opportunities for adaptation. The worksheet is expected to stimulate reflection on new information in light of the question, because the question is fixed and clearly visible. Seeing their question on the worksheet may prevent learners from the so-called 'question drift', i.e. the constant change of search goals when answers are not immediately found (cf. Land & Greene, 2000; Wallace et al., 2000). Using a worksheet for writing down the answer may also support learners to translate findings into own words instead of copying literal text from the source, as many researchers have found learners to do (Bilal, 2001; Schacter et al., 1998; Todd, 2000). And finally, the worksheet may help to connect the computer lab to the classroom, as the worksheet becomes the means of transportation of questions and answers between those places.

Summarized, we have argued that reflective web searching is an important capability in constructivist learning environments. Reflective web searching is viewed to comprise three steps in which the learner relates old knowledge and experiences to findings on the web, because he or she owns the question, interprets retrieved information, and adapts it into own wordings. To support reflective web searching with young web searchers, we propose a portal and a worksheet. In the following sections, research is presented in which an integrated learning environment for reflective web searching was developed and used in six elementary schools. The research commits itself to the intentions and procedures of Design-Based Research (e.g., Barab & Squire, 2004; Kelly, 2003). Two design experiments were conducted in which we implemented the portal and the worksheet. The design experiments sought to answer the following general research question: How do the portal and worksheet support reflective web searching in elementary classrooms? Derived from this general question, three specific ones will be answered: (1) How do the portal and worksheet support the integration of web use in the task and hence the development of ownership over the task?, (2) How do the portal and worksheet support the interpretation and personalization of retrieved information?, and (3) How do a portal and a worksheet support the adaptation of retrieved information into personally meaningful answers?

2. The first design experiment

2.1. Method

2.1.1. Participants

Four elementary classrooms (fifth- and sixth-grade) from different Dutch schools with a total of 28 small groups of 2–4 children participated in the experiment. Classrooms had variable access to the web with the number of computers ranging from 3 up to 15. One school used the computer regularly for word processing, e-mail, and the web. In the other schools, the web had not been used in lessons before. All teachers were familiar with the basics of using the web. The children varied in their experience with using the web at home. All schools had some experience with working in groups.

2.1.2. Materials

The *portal* (see Fig. 1) contained a single web page opening up to 110 websites divided in five task-related categories. The hyperlinks had meaningful names that indicated their

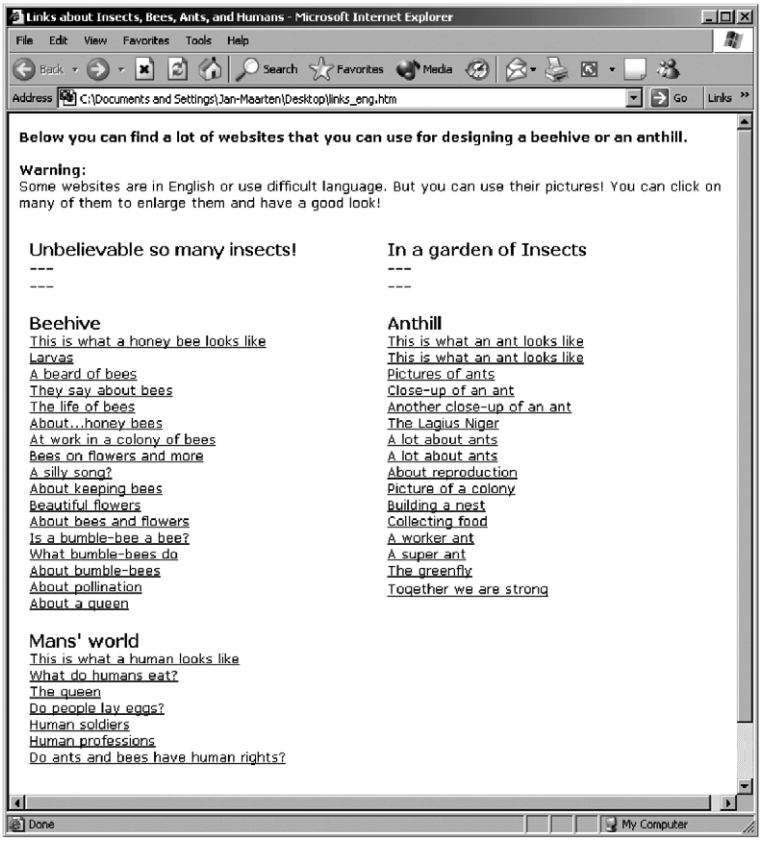

Fig. 1. First prototype of the portal.

general content (e.g., 'This is what a bee looks like'). A short introduction at the top warned for difficult words and foreign language (i.e., English). Simple browser buttons (e.g., Home, Back) were used to navigate between the portal and the web. MS Internet Explorer™ was used as a browser. The portal was set up as the default home page.

The *worksheet* (see Fig. 2) was an A4 paper containing two sections: 'Our question is', and 'Write down the answer you found below'. For each new web visit, one worksheet could be used.

Reflective web searching was embedded in a learning task in the domain of biology. For *six lessons* the children worked in groups on the design of a community of bees or ants. The groups designed a representation of such a community on a large paper that took the form of a concept map with drawings and written explanations. In the first lesson, the topic and portal were introduced and explored. In lessons two to four, the groups worked on their project. During these lessons, they used the web to answer self-generated questions as many times as they wanted. In lessons five and six, the groups prepared and gave presentations. In a face-to-face meeting with the teachers two weeks before the start of the experiment, the lesson materials were introduced and ideas, expectations, and practical issues related to web use were discussed.

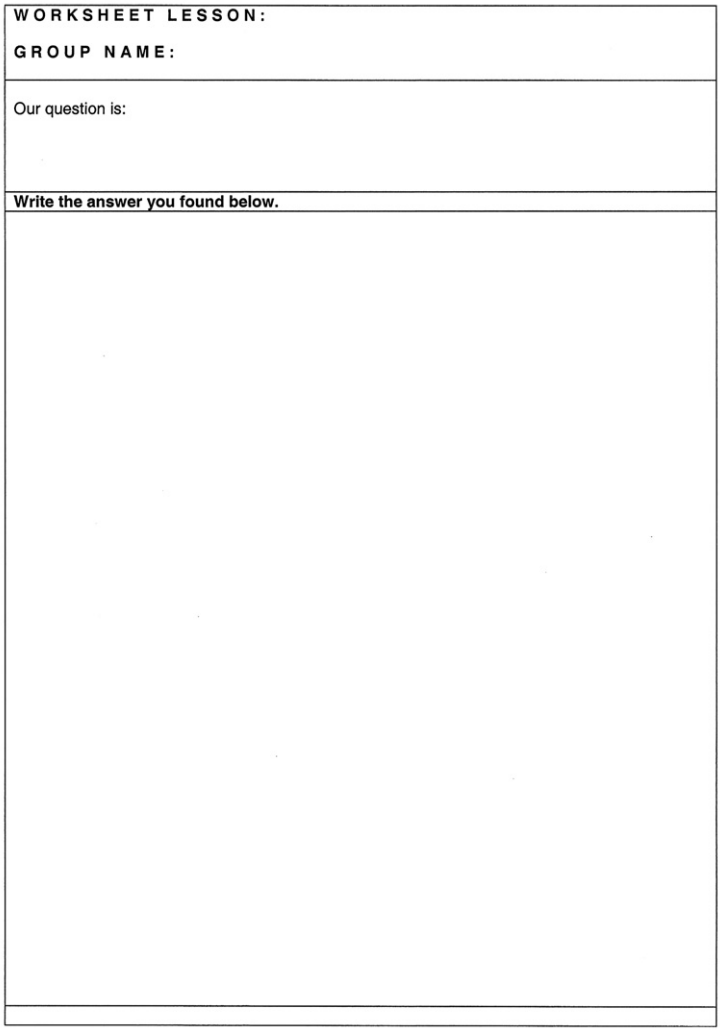

Fig. 2. First prototype of the paper worksheet.

2.1.3. Design and procedure

The experiment ran over six weeks, with one lesson of 2 h each week. To answer the research questions, different kinds of data were collected (for a more detailed description of the procedures followed, see also De Vries, 2004). To gain insight in the teachers' and children's ownership over the task, the lessons of two classrooms (14 groups) were observed. The observations concerned the teachers' introduction of the topic and learning task, and children's reactions to it. Special attention was paid to the prior knowledge, experiences and enthusiasm the children shared with each other in their whole class and group discussions, and to task divisions within the groups. Field notes were made describing the essence of the teachers' and children's dialogues and behavior during whole class discussions and group work. Informal evaluations were held with the teachers of those

classrooms after each lesson, and the teachers produced written evaluations of the lessons by writing down their experiences and comments on paper prints of the instructional designs of the lessons. Also, eight children randomly chosen from the two observed classrooms were interviewed after the fourth lesson. In a semi-structured interview, the children were asked to explain their appreciations of the lessons in general, and web use, the portal and the worksheet in particular.

2.1.4. Data analysis

To gain insight in the interpretation, personalization, and adaptation of retrieved information, the worksheets of all the groups in the two observed classrooms were collected. Next, the worksheets were coded in three steps. The questions were scored for task-relatedness (design/follow up question). After that, the answers were scored for question-relatedness (unrelated/related/related + extra). Finally, the answers were scored as adoption (i.e., literal copy) or adaptation (i.e., explicit interpretation by referring to prior knowledge and experience, or by adding appreciative comments). Interrater agreement was calculated for all steps, with Cohens kappa yielding, respectively .71, .66, and .90.

To gain insight in the collaborative process of developing ownership, interpreting, personalizing and adapting information, the interviews were transcribed, and field notes and observations were collected and summarized. Descriptive summarizations of the process of developing ownership, interpreting and adapting information were made for each classroom.

3. Results

Ownership: To successfully embed reflective web searching, a first prerequisite is that the teachers and children should enjoy the lessons and feel ownership over what they do. Both teachers and children reported that they did. In the informal and written evaluations, the teachers reported that the children were interested, and enjoyed working on the task. They observed a collaborative atmosphere within and between the groups. The teachers also valued the web use. They appreciated the independent, and collaborative way in which the children could work on their learning task. In the interviews, the children too evaluated the lessons positively. They reported being enthusiastic about the task, and about working in groups. They liked using the web to find answers to their self-generated questions. The following fragment illustrates this:

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

The observations of the whole class discussions and group work confirmed the evaluations of the teachers and children.

Did the children's enthusiasm lead to ownership over their search questions? In total, the 14 groups of the two observed classrooms generated 122 questions ($M = 8.7$, $SD = 5.0$). On average, each group posed 2.9 questions per lesson. The amount of questions posed per group per lesson illustrates that the web was only part of working on the learning task, and suggests that web use was successfully integrated in the environment as a whole. The children's motives to search the web were personal, and suggest a sense of ownership. The observations showed that search questions emerged from three personal

motives: enthusiasm to search the web, enthusiasm and curiosity about the topic, and uncertainty and lack of knowledge to complete the task. Especially the latter motive seems to be fruitful for reflective web searching, because (lack of) prior knowledge seems to play an important role here.

Close examination of the questions further supports the observation that in general the questions sprang from feelings of ownership. A majority of questions (82.0%) were follow-up questions that elaborated on forms and functions generated by the children in their designs. This indicates that they purchased search questions that were personally relevant to complete and improve their design products.

In one classroom, however, web searching was less integrated in the learning environment, because the groups were asked to pose their questions and visit the web *after* they had been working on their designs. The observations show that this separated scenario of web use resulted in a chaotic generation of questions at the end of the lesson, leading to lists of questions of which the whole group owned only some.

Interpretation and personalization: The portal played a critical role in helping children to select relevant information. Both the teachers and children reported that the portal helped them to select usable websites. The following fragments illustrate this:

> 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)

> 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, the firefly, there are a lot of them.
> (David, school 4, interview, lesson 4)

The children used the portal collaboratively, mostly in pairs. Both teachers and children reported benefits of searching together. The children frequently helped each other select information within and between groups. Moreover, searching collaboratively was beneficial for the interpretation and personalization of web sources as the children shared knowledge and personal experiences while sitting behind the computer together.

However, using the portal did not automatically lead to finding an answer to the question. An examination of the worksheets shows that most of the children's questions received no answers. In 61% of the cases, no information was found. In 8.1% of the cases, they wrote down unrelated information that was relevant to the task, but not to the question. Only in 30.9% of the cases, question-related information, sometimes with extras, was written down. Unsuccessful searching may have been caused by lack of ownership and focus in the classroom with the separated scenario. In this classroom, significantly fewer answers were found ($\chi^2(1,122) = 17.9$, $p < .01$) than in the classroom with an integrated scenario. In addition, the portal may have caused a limited amount of answers. Although the portal structured the search domain, not all websites in the portal were useful. The teachers and children reported that the English websites were too difficult, others were considered to be too detailed, specialized, or uninviting. In addition, the lists of websites presented in categories were experienced as overwhelming.

Adaptation: Examination of the answers on the worksheets shows a lack of adaptation, as most answers (75%) were literal adoptions, in which the children had copied information from the web source onto their worksheets without adding personal meaning to it. In only 12 answers, explicit personal understandings of retrieved information were written down. For example:

> 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)

Because the portal did not provide enough structure for children to successfully select and locate relevant web sites and information, the amount of adapted answers was expected to be low. This was not compensated by the worksheet. The worksheet was structurally used as a means of transportation of questions and answers between the computer lab and the classroom, but it did not stimulate the children to write down adapted answers instead of literal ones. Another factor that seems to have played an important role is the children's attitude and search strategy. The observations show that the children were impatient browsers. Although they seemed to improve their strategy across lessons reporting that they became more aware of having to read carefully for instance, their general attitude hindered the adaptation of retrieved information.

4. Conclusion

Reflective web searching was only partly realized in the first design experiment. The children used the web from their own personal motives feeling ownership over the task and over their questions. However, the interpretation and adaptation of retrieved information occurred infrequently. Three factors seem to have influenced a lack of reflectiveness. First, in one classroom using the web was separated from the task and this seems to have resulted in less ownership and subsequently less perseverance in locating answers. Second, the portal provided a structured search domain and relevant sources, freeing the children's time for discussion and interpretation. But it did not support locating information within websites. Third, the worksheet supported the transportation of questions and answers between the computer lab and the classroom, but did not stimulate the children to write down adapted answers.

In the second design experiment, the portal and worksheet were improved to raise the extent to which children locate, and adapt new information. The portal needed to support the location of relevant information better. Some researchers suggest that novices in a domain have difficulties navigating, because they lack an overview of the domain (e.g., Chen, Fan, & Macredie, 2006; Chiu & Wang, 2000; Hammond & Allinson, 1989). Supportive measures that are suggested are sitemaps, colour markings, and cues about contents. The portal was therefore rebuilt into a hierarchy of topics representing the domain. Colouring and icons were used to reveal content, and position the user's search path. The rebuilt portal was expected to lead to more answers.

The worksheet needed to support the adaptation of new information better. For that purpose, it was extended with a space inviting the children to explicate their prior knowledge in the form of provisional answers to be written down before the actual search is carried out. 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 explicate their prior knowledge. Provisional answers have been found to raise feelings of commitment, and help assess the information need (Van der Meij, 1990). In the context of the present research, articulating provisional answers was expected to further stimulate a sense of ownership, and lead to more adaptive answers.

5. The second design experiment

5.1. Method

5.1.1. Participants

Two sixth-grade classrooms from different Dutch elementary schools with a total of 16 small groups of 3–4 children participated in the experiment. Both schools had access to 10–15 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 lessons before. The schools had some experience with group work.

5.1.2. Materials

The *portal* (see Fig. 3) was rebuilt into a hierarchy of main topics (e.g., Insects, Mammals), and subtopics representing concepts in the domain (e.g., social living

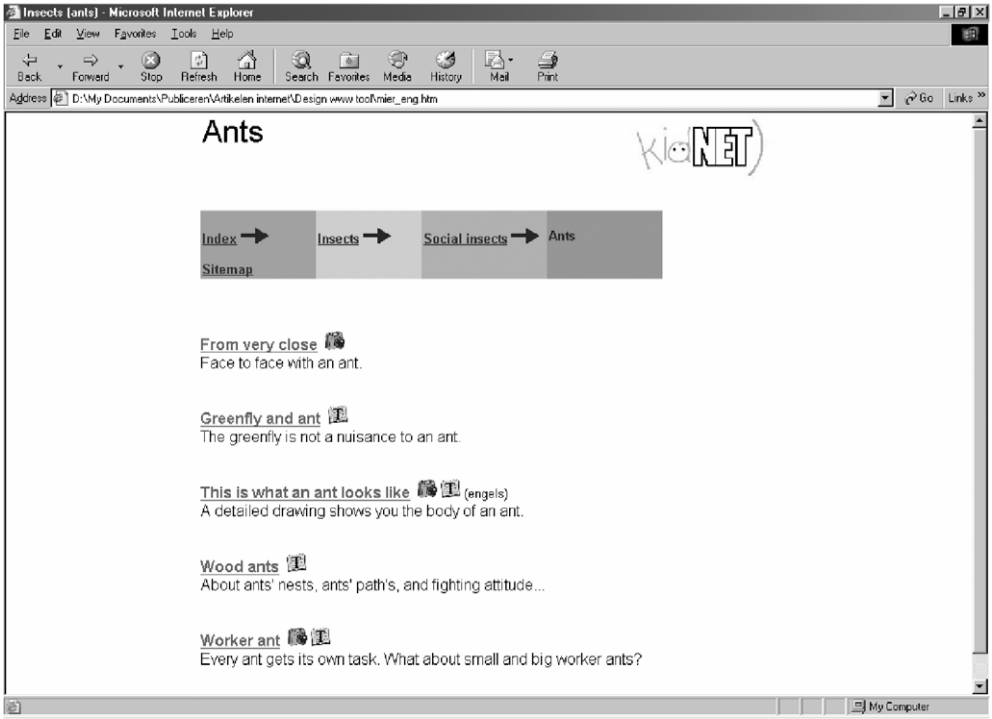

Fig. 3. Second prototype of the portal.

insects, solitary living insects). The hierarchy ran four levels deep. The portal contained 75 pages and about 246 links to websites. Additional support was given by a sitemap with a hyperlinked overview, a coloured and hyperlinked navigational bar on top of each page that displayed the search path, numbers in parentheses indicating the number of websites in a lower level, and icons indicating the type of information that could be found in websites (text/pictures; language). MS Internet Explorer™ was used as a browser. The portal was set up as the default home page (Fig. 4).

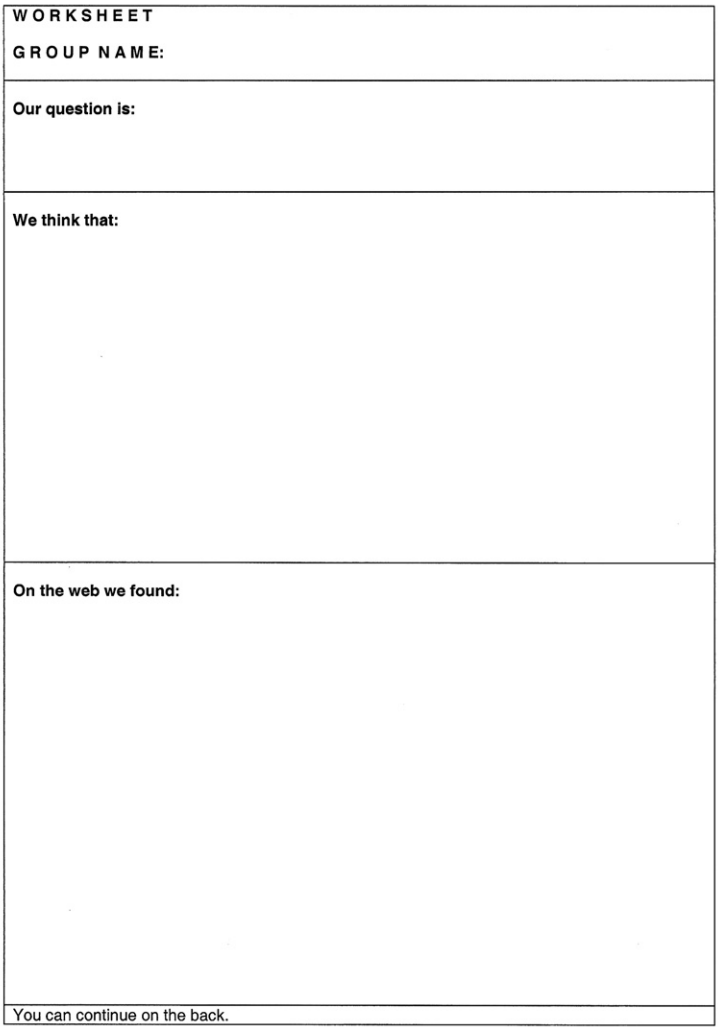

Fig. 4. Second prototype of the worksheet.

On the *worksheet*, a third section was added to write down provisional answers. The worksheet now contained three spaces to write down the question, the provisional answer, and final answer.

The *lessons* were almost similar to the first design experiment; only small adjustments were made to the lessons. More time was reserved for becoming familiar with the topic of insects, and the portal (lessons one and two). In lessons three to five, the children worked in small groups on their design project, using the web to find answers to self-generated questions. The groups presented their designs in the sixth lesson.

5.2. Design and procedure

The experiment ran for six weeks, with one lesson of 2 h each week. In individual meetings with the teachers before the start of the design experiment, the lesson materials were introduced and ideas, expectations, and practical issues related to web use were discussed.

Again, a broad range of data was collected. To gain insight in general ownership over the task and web use, as in experiment 1, whole class discussions were observed and field notes were taken. Informal evaluations and semi-structured interviews were held with the teachers to check the observations about the implementation of the lessons in general, and web use in particular. In addition, semi-structured interviews with seven of the eight children from the focus groups were held after the fourth lesson asking the children about their appreciations of the lessons in general, and web use, the portal and the worksheet in particular.

5.2.1. Data analysis

To gain insight in the interpretation, personalization and adaptation of answers, we collected the worksheets of all the groups, and coded their questions and (provisional) answers. As in the first design experiment, the questions and answers on the worksheets were coded in three steps. Interrater agreement was calculated for all steps, with Cohens kappa yielding, respectively .78, .72, and .75. The provisional answers were coded for their presence, length and mode (written, drawn, or combined writing and drawing).

To gain detailed insight in the collaborative process of developing ownership, interpreting, personalizing and adapting information, two focus groups (one in each classroom) were observed and audio taped during their work in the classroom and the computer lab. Their web visits were logged. Field notes were made, and the audio recordings were transcribed. The field notes and transcriptions were used to describe the collaborative process of reflective web searching.

6. Results

Ownership: The observations showed that in both classrooms, web use was successfully integrated in the learning task. In addition, the teachers and children reported in their interviews that they liked the lessons, and valued use of the web. The groups visited the web on their own initiatives whenever they felt the need. They owned their questions using the worksheet to write them down. Formulating provisional answers helped specify their need, as the following fragment illustrates. The focus group just posed the question 'How do bees make a beehive':

[4] Esther: We have to know ourselves how they do it
[5] Emily: A beehive is made of honey, isn't it?
[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?
[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)

In total, the groups ($n = 16$) posed 76 questions ($M = 4.8$, SD = 3.1). This is an average of 1.6 questions per group per lesson. Most questions were follow-up questions (70.9%), springing from generated forms and functions, and seeking to elaborate and specify. The groups came up with provisional answers for 92.1% of their questions. This indicates that they were motivated and able to express their prior knowledge. Most provisional answers were put in words varying in length from a single word (e.g., a numerical answer) up to 48 words ($M = 6.2$ words, SD = 7.3). Some contained drawings. Their nature varied, some expressing facts, whereas others gave expression to a line of reasoning:

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

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

Interpretation and personalization: In comparison to the first design experiment 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 fewer cases, only extra information was written down (2.6%). These findings suggest that the groups searched goal-driven, and succeeded more in locating relevant information. The observational data and web logs confirm that the focus groups searched goal-driven, scrolled pages, and took considerable time to read new information. They used the navigational bar next to general Browser buttons. Also, they pointed out hyperlink names, descriptions and icons to make navigational choices. The sitemap and Help page, however, were not used.

The audio recordings of the focus groups provide evidence for their frequent interpretation and personalization of information while searching. The children often read aloud and discussed what they saw. In these discussions, they frequently related the retrieved information to their prior knowledge and personal experiences, as the following fragment illustrates:

[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.

Adaptation: Did locating more relevant information, and interpreting and personalizing it also lead to more adaptive answers? Again, most answers were adoptions with only minor textual adjustments. Only 16 questions received adapted answers. Examination of these answers showed that although the provisional answers did not lead to more adaptations, they did function as a reference point for constructing them. For example:

Q: How many larvas are in a colony?
PA: 50.000.
FA: It was a little bit more... 550000000000000 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)

7. Conclusion and discussion

In general, the web is viewed to be a rich information source that provides new opportunities for active knowledge construction by learners. The web contains easily accessible sources to be browsed according to a user's preference. At the same time, it is recognized that having access to thousands of hyperlinked websites does not necessarily lead to active

learning. Salomon (1998) states: 'Access to avalanches of information, loosely inter-connected by threads of casual associations, does not facilitate turning the information into knowledge. And it is school's mission, particularly when colored by constructivist hues, to enable students to think and to acquire skills of intelligently handling information, not to drown them in it (p. 10)'.

Actively processing new information may be even more difficult for elementary school students, for whom reading and processing information, as well as searching the web, are relatively new. They are not yet used to activating their prior knowledge frameworks while reading and interpreting new information. In this paper, research was presented that set out to develop and implement an integrated environment for reflective web searching in elementary schools. Reflective web searching was viewed to comprise three steps: developing ownership over a question, interpretation and personalization of new information, and finally the adaptation of retrieved information into a personally meaningful answer. Two design experiments were conducted in which we embedded web searching in a learning task in the domain of biology. A portal and worksheet were developed to support reflective web searching in the groups.

The findings suggest that web searching was successfully embedded in the task. The groups used the web whenever they felt a need while working on their design projects. Their motivations to search the web varied from a general interest in the topic and web searching, to specific task-related uncertainties to be solved, but all suggest that the children felt ownership over the task.

The findings also show that, similar to what Jones (2002) and others have suggested, narrowing the search space by providing a portal can free learners from selecting relevant websites so that they can concentrate on locating and processing relevant information. Our results partly confirm this expectation. On the one hand, the portal seems to have helped the children to locate information. Two prototypes of the portal were tested in subsequent design experiments. The effects were different for the two prototypes. The portal in the first design experiment contained a wide range of websites organized into five task-related categories. This proved to be an easy to browse search space that, however, provided the children with too little structure. The children made short visits to many websites, did not scroll and read carefully, repeated searches, and only found answers to 30.9% of their questions. Their searching behavior resembles the behavior reported by other researchers leading to similar outcomes (cf. Bilal, 2000, 2001; Wallace et al., 2000). The portal in the second design experiment represented the domain with a hierarchy of topics. It provided the children with a conceptual representation of the domain (cf. Chen et al., 2006). Furthermore, the hyperlinks were accompanied by short descriptions, and indications of the amount and sort of information that could be found at a lower level. Thus, the portal provided the children with far more cues to base their navigational decisions on. This helped them to search goal-driven, and locate question-related information. The amount of answers increased dramatically, and is high in comparison to other studies (cf. Bilal, 2000; Schacter et al., 1998). We conclude that if a portal provides enough structure, it can indeed help children to locate relevant information, and at the same time not take away the feeling of having to search.

On the other hand, we found that only to a certain extent the children processed the information. They did interpret and personalize retrieved information in their talks while searching collaboratively. The children pointed out things to each other, associated new information with personal experiences, and expressed their appreciations. Other research-

ers have argued that using the computer collaboratively gives rise to discussions (e.g., Kumpulainen, 1996; Wegerif & Dawes, 2004). We conclude that reflective web searching occurred while searching and through talking. But once the final answers had to be written down, the adaptations were minimal. Most answers were literal adoptions with minor syntactical adjustments, and hardly any references to provisional answers.

Based on these findings, we conclude that to realize reflective web searching in elementary schools, a portal can successfully limit the search space, and provide young learners with a task-relevant overview of the domain in which they can locate and select new information according to their needs. In addition, a paper worksheet can help them to stick to their question, and relate questions to (provisional) answers. To further improve reflectivity, searching the web collaboratively appears to be a major stimulance. The group talk that evolves around the computer stimulates the interpretation and personalization of new information (cf. Lazonder, 2005). However, although a portal, a worksheet and collaboration seem helpful, additional support is needed to invite children to frequently adapt what they *find and think* into personally meaningful answers.

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