Educative curriculum materials for the integration of writing and science in elementary schools

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Abstract

This paper describes how five teachers perceived and operationalized the curriculum embodied in one set of educative materials, with limited additional professional development. All 25 class sessions were observed during the enactment of a five-lesson curricular module on clouds and precipitation, which was designed to facilitate pupils writing about science. All teachers showed less of the suggested teaching practices. Nevertheless all teachers focused most on those practices that were considered most important by the designers, viz. student collaboration and student thinking processes. Teachers were very positive about the possibilities of learning more about integrating writing and science through educative curriculum materials. Further study is necessary to understand what teachers learned from the experience and how this may have affected their practice for the longer term.

Keywords: curriculum materials; science teaching; design research

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Introduction

Classroom implementation of curriculum reform is notoriously problematic. As Cuban (Cuban, 1992, p. 236) notes, "…the refrain is always the same: 'frontal' teaching, traditional instruction, teacher-centered instruction, conventional teaching – the value-charged code words differ, but the habits of teachers persist." Similarly, so do the habits of innovation designers. In a triumph of optimism over experience, we continue our efforts toward curriculum improvement through carefully-shaped teacher and school development programs; more robust curricula; and clearly articulated standards. Yet, just as teachers find it challenging to apply theoretical knowledge in practice, so too, do innovators struggle to operationalize what we know about curriculum improvement.

Research and experience alike have taught us much about approaching teacher professional development in the context of curriculum reform. For example, active teacher autonomy in professional development is critical (Burbank & Kauchak, 2003). In terms of curriculum reform, a pre-requisite for exercising autonomy is that the need or desire for change must be experienced by the teachers concerned. As with teacher learning in general, professional development in the context of curriculum change must offer teachers opportunities for in- and out-of-classroom learning. Toward facilitating the adoption of new ideas into one's own educational setting, situated learning is necessary as it helps anchor new experiences in real-world situations (Elmore & Burney, 1999; Fullan, 2001). In combination with situated learning, it can also be important to create opportunities for experiences away from the daily setting that allow teachers to 'break set' and explore new ideas free from immediate classroom pressures (Putnam & Borko, 2000). Both in and out of the classroom, teachers must be given time and opportunities to build and integrate knowledge and skills (Davis, 2004; Loucks-Horsley, Hewson, Love, & Stiles, 1998). Doing so must be facilitated by organizational support (Guskey, 2000) as well as pedagogical support in classrooms.

By far the dominant form of classroom support used by teachers worldwide is the textbook. Traditionally textbooks and/or teacher guides have been designed to help implement curricula. However, recent attention is also being given to the value of materials that are specifically designed to help teachers learn through enactment of the curriculum (Ball & Cohen, 1996). Researchers are just beginning to investigate the contributions of curriculum materials designed to support teacher learning (Callopy, 2003; Davis & Krajcik, 2005; Remillard, 2000), referred to by Davis and Krajcik as "educative curriculum materials."

The potential of educative materials

Curriculum materials regularly play powerful roles in shaping teaching practice as well as practitioner ideas about teaching and learning. Where both curricular autonomy and affordable resources are present, teachers have been known to spend great time and effort identifying and obtaining curriculum materials for their classes (cf. Grossman & Thompson, 2008). Curriculum materials are designed to help teachers better enact the curriculum in practice (Ball & Cohen, 1996). By contributing to teacher understanding, they can help facilitate curriculum implementation. Materials can support teacher learning by offering support for: understanding and implementing innovative intentions (van den Akker, 1988; 1998); pedagogical shaping of pupil activities (Brophy & Alleman, 1991; Singer, Marx, Krajcik, & Chambers, 2000); integrating technology in lessons (Voogt, 1993; Keursten, 1994), stimulating reflection (Davis & Krajcik, 2005); subject matter understanding (Ottevanger, 2001); and classroom management techniques (McKenney, 2001). The use of high-quality materials has been shown to facilitate curriculum implementation (van den Akker, 1988; Keursten, 1994; Voogt, 1993). However, high-quality materials may be more the exception than the rule. For example, research has shown that many textbooks and teacher guides often fail to help teachers understand the rationale for teaching suggestions or how to examine student work and thinking (Ball & Cohen, 1996; Valencia, Place, Martin, & Grossman, 2006).

Realizing the potential of educative materials

Given the powerful potential of educative materials to support curriculum implementation through teacher learning, it seems fitting that researchers are now exploring how to unlock that potential. Ongoing efforts target the development of guidelines for high-quality curriculum materials for elementary science education (Roseman & Koppal, 2008; Shwartz, Weizman, Fortus, Krajcik, & Reiser, 2008), especially for culturally and linguistically diverse populations (Lee & Buxton, 2008). Davis and Krajcik (2005) have developed design heuristics for educative materials. Their design heuristics are organized around pedagogical content knowledge (PCK) for science topics; PCK for scientific inquiry; and subject matter knowledge. Each heuristic maps out what the curriculum materials should provide for teachers; how the curriculum materials could help teachers understand the underlying rationale for the recommendations; and how teachers could use the ideas in their own teaching. In order to support teachers in implementing curriculum innovations, Van den Akker (1998) states that curriculum materials need to incorporate procedural specifications – that is concrete how-to-do suggestions for those parts of the innovation that are new for teachers and yet not part of their normal routines. Another important function of educative curriculum materials is that they should prompt reflection. To do this, materials should trigger decisions about how to proceed. This can be achieved by containing space and support for curricular decision-making. According to Remillard (2000), texts should be much more “unfinished” than they currently tend to be; they should be incomplete without teachers’ input. Encouraging teacher engagement with the materials relates to what Davis and Kracjik (2005) refer to as “increasing the teacher pedagogical design capacity” which can lead to improved quality of local adaptations. Finally, the long and frustrating history of curriculum reform has taught us that materials alone will not yield the level of professional development necessary to implement new curricula (Loucks-Horsley, Hewson, Love, & Stiles, 1998; van den Akker, 1998). For curriculum innovation to have a fighting chance, alignment must be demonstrated among supportive materials and teacher professional development, while preferably also harmonizing with curriculum standards and large-scale assessment practices (McKenney, van den Akker, & Nieveen, 2006). This is so difficult to achieve, that it rarely happens. In fact, even when materials are mandated, surprisingly little on-site support can be present (Valencia, Place, Martin, & Grossman, 2006).

Materials as a catalyst for change

The interaction of teacher (content and pedagogical) knowledge, context and materials is situated and complex (Valencia, Place, Martin, & Grossman, 2006). To fully understand how a teacher makes use of educative opportunities embedded in materials, the beliefs that constitute the teacher’s identity need to be considered in relation to the beliefs that are targets of change through professional development (Callopy, 2003). This is because teacher beliefs and knowledge play a critical role in how materials are used (Ben-Peretz, 1990; Valencia, Place, Martin, & Grossman, 2006). New teachers tend to follow materials with higher degrees of fidelity, only experimenting with adjustments as their confidence and competence grow (Grossman & Thompson, 2008). The same has been said for more experienced teachers working with the early implementation of substantially new curricula (Van den Akker & Voogt, 1994). In both cases, the materials serve more as 'life preservers' in earlier stages and more as 'option menus' in later stages of familiarity with a particular curriculum.

In examining the complex relationship between teacher knowledge, beliefs and contexts with regard to curriculum implementation, Ottevanger (2001) likens the use of materials to a catalyst in a chemical reaction. Since curriculum change usually requires investment of additional time and energy, teachers must overcome an enormous activation barrier before new curricula will really work for them in the classroom. In a chemical reaction, reactants must also cross the activation barrier in order to form new products. This barrier can be overcome by an increased input of energy, or by the use of catalysts to actually lower the activation barrier, itself. For a catalyst to act properly, it is established based on a clear understanding of the intended function, and of the local conditions in which it will be put to work. Catalyst development usually requires several cycles of testing and refinement. The next section discusses the context of this study, a curriculum improvement initiative featuring the design and development of educative materials to serve as catalysts, lowering the activation barrier and facilitating the use of technology to engage primary school pupils in writing about science.

The LiST project

This Language in Science Teaching project was established to develop an integrated curriculum for writing and science for elementary school. The three driving factors behind the project's inception were: (1) writing instruction in Dutch primary schools is considered weak; (2) very little time is given to teaching science in Dutch primary schools (one hour a week is not uncommon); and (3) technology , digital graphing organizers in particular, might help to link writing and science.

The LiST project can be characterized as design research (cf. McKenney, van den Akker, & Nieveen, 2006), in which flanking research informed the iterative design and development of curriculum materials. The design and development of the 'writing and science language in science' materials was conducted by a multidisciplinary team, consisting of: two primary school teachers (one newer, one very well-seasoned); a professional curriculum developer (content area: language); a pre-service teacher educator (content area: science); and two curriculum researchers (with expertise in technology and teacher learning). In different stages of the project, assistance was also given by (in total) six undergraduate students in the field of education, mainly to conduct formative evaluations of draft materials. Toward the start of the project, the team deliberated on topics that would lend themselves to the integrated curriculum, while also being standard elements in the national curriculum. The project team chose to address the topic: weather, because this topic offered ample opportunities to practice different text types and to address elements of the national elementary school science curriculum. Three modules were designed, each containing a teacher guide and student materials. The modules addressed the following weather-related themes: temperature; air and air pressure; clouds and precipitation. Before and during the design of curriculum materials, the team deliberated on the kinds of classroom interactions that would be desirable; and how these might be stimulated through the materials.

Formative evaluations were undertaken throughout the design and development of the materials. The first two modules of materials (temperature; air and air pressure) were trialled by five teachers from two schools. Two of the teachers were those in the design team. The formative evaluations were geared toward answering the following three research questions: (1) "What are the *pupil and teacher perceptions* of the weather-themed language-in-science materials?; (2) How *practical* are the weather-themed language-in-science materials for *pupils and teachers* to use?; and (3) How could the weather-themed language-in-science materials be *improved*?" Data were collected through classroom observations; interviews with both teachers and learners; and questionnaires administered to both teachers and learners. The evaluation findings yielded specific insights (useful for fine-tuning individual lessons and modules) as well as generic improvements (for the series as a whole). Adjustments were made in the first two modules and the lessons learned informed the design of the third module: clouds and precipitation. The summative evaluation of the clouds and precipitation module provided the setting for the study described in this article.

While the content naturally differed, the clouds and precipitation module shared characteristics of all the writing-and-science modules. The module contains a paper-based teacher guide with digital video examples of the experiments, as well as paper-based and digital student materials for five lessons of 60 minutes each.
The teacher guide:

- Articulates the rational for the writing-and-science approach and describes the underlying learner-centered pedagogy;
- Explains the science concepts to be addressed, beyond the level of conceptual development expected by the learners;
- Explains the writing process, and the pedagogical support that is expected from teachers;
- Describes the conceptual development pathways for both science and writing; and links these steps to the individual lessons;
- Describes the way digital graphical organizers can be used to support science conceptual development and the writing process;
- Demonstrates and explains the experiments that are incorporated in the materials (DVD);
- Lists vocabulary to be developed, classified as language either related to general purposes (e.g. measure, dew, mist); science content (e.g. volume, air pressure, stratus clouds, condensation); and reasoning skills (e.g. second, because, if…then);
- Offers teachers 'what to expect' scenarios; along with ideas on how to handle learner reactions;
- Provides procedural specifications for each of the six lessons; these are divided into introduction, body and conclusion;
- Offers a rubric to assess learner's writing products.

The student materials consist of:

- Worksheets to guide the experiments (paper-based)
- Note taking support (paper-based & digital): Templates of (digital) graphical organizers were developed to support learners in sentence/ paragraph construction of their writing during the experiments.

The materials endeavor to engender teaching practices that facilitate the attainment of the (language and science) content-related goals, through interactions that are consistent with the learner-centered pedagogical vision. Based on a literature study (Jonker, 2008) seven elements were considered essential for a learner-centered pedagogical vision in an integrated science-writing curriculum. Specifically, the materials strived to stimulate teaching practice in which teachers:

- Stimulate learners to reflect on their prior knowledge;
- Demonstrate and support thinking processes in learners;
- Create an authentic and meaningful learning process;
- Stimulate social interaction and collaboration among learners;
- Jointly (teachers and learners) reflect on the learning process at the end of lessons;
- Stimulate learners to make notes and discusses them;
- Tailor new information to the level of the learners;

The adopted learner-centered vision assumed that the teacher acted as an active coach for the students during the lessons. This implied that (s)he engaged the learners in the lesson topic and encouraged them to be active learners. Particularly at the start of the lesson it was expected that the teacher in an interactive discussion with the whole class sets the scene, so that learning can occur. At the end it was expected that the teacher in an interactive classroom discussion recapitulated what was learned.

Research Questions

The study described here focused on teacher behaviors during the use of the materials, together with the causes for those behaviors; in so doing, salient characteristics of the teachers themselves and the settings in which they work were also examined. Data were collected to answer the following two main research questions:

- *To what extent were teachers showing the teaching practice that was suggested by the curriculum materials?*
- *How did teachers reflect on their experience in implementing the curriculum materials*

Methods

Participants

The two schools participating in the study are typical Dutch elementary schools: the curriculum is offered in separate subjects, the teachers use the textbook as the main resource for teaching, and during the week time is scheduled for children to work independently on tasks they have to finish. All five grade 5 and 6 teachers participated in the study. They were not involved in the development of the materials. Two teachers were young and did not have much teaching experience. The other three were experienced teachers. All teachers were not used to offering an integrated writing and science curriculum. On average students have 6 hours per week instruction in language arts (mother tongue), of which about 1-11/2 hours is spent on writing (generating texts). One hour per week is spent on science education. As in most Dutch elementary schools the teachers are not very experienced in science education (Meelissen & Drent, 2008). The teachers in school I have an interactive whiteboard at their disposition. The teachers in school II can use a beamer when they want to use the computer in their classroom. In each classroom three computers are available for students, who use the computer on average 1-2 hours per week. The teachers in school I jointly prepared the lessons. They met each week for about 11/2 hours to adapt and discuss the lessons. The teachers in school II prepared the lessons by themselves. It took them each week about 11/2 to 2 hours.

Table 1 Background information teachers and classes

	Teachers	*Yrs of experience*	*Sexe*	*Number of students*	*Grade level of students*
School I	Alan	2	Male	27	5
	Bob	18	Male	24	6
	Chris	20	Male	22	6
School II	Diana	11	Female	27	5
	Ed	3	Male	14	6

Instruments

Observation checklist 'Actual teaching practice'

To be able to determine to what extent teachers' classroom practices reflected the suggested teaching practice essential elements of the intended classroom practice were formulated. These essential elements were made operational in a classroom observation checklist and validated by an expert. Similar instruments were used in other studies (van den Akker & Voogt, 1994) to determine the extent of alignment between expected and actual teaching behaviour. In Table 2 the essential elements of teaching practice are presented together with sample items from the classroom observation checklist, and sample observations. Data were collected by observing teachers teaching the integrated science-writing lessons. The researcher took notes during observation of a lesson and marked the time necessary for each part of the lesson (orientation, body, conclusion). Immediately after each lesson the researcher used his notes to fill in the observation checklist.

Table 2 Components of expected teaching practice, sample items of suggested

Components of expected teaching practice	**# items**	**Sample items of suggested teaching practice**
Stimulate learners to reflect on their prior knowledge. (10 items)	10	The teacher asks the learners general questions about what they know about the water circle. The teacher recalls the new words that were learned in the previous lesson.
Create an authentic and meaningful learning process (	5	The teacher learner's experiences with the weather to illustrate concepts. The teacher brings attributes to the classroom that are related to clouds and precipitation
Tailor new information to the level of the learners.	6	The teacher attunes his instruction to learner's ideas. The teacher checks whether the learners understand new information
Demonstrate and support thinking processes in learners.	25	The teacher asks the learners for causal explanations. The teacher thinks aloud to demonstrate his thinking process
Stimulate social interaction and collaboration among learners.	33	The teacher helps student groups that have questions about the assignment. The teacher checks whether pairs of students are on task
Stimulate learners to make notes and discusses them.	13	The teacher encourages students to complete their notes The teacher discusses the notes of the learners at the end of the lesson.
Jointly (teachers and learners) reflect on the learning process at the end of lessons.	12	The teacher evaluates the lesson with the learners. The teacher summarizes what was learned in this lesson

Twenty five lessons taught by the five teachers were observed and videotaped. For each item in the observation checklist the observer scored '+','+/-', and '-', which was later transcribed to 2, 1, and 0 points respectively. The total score was expressed in percentages of the maximum score. The first lesson of each teacher was observed by two observers. Cohen's kappa was 0.71. Based on these observations some items of the instrument were slightly adapted.

Observation list 'Teacher questioning'

Next to the overall observation of the teaching practices of the participating teachers, also the orientation and the closure of the first four lessons were observed. The focus of this observation was the type of questions teachers asked to engage learners and elicit their thinking. A distinction was made between questions that asked students to report about what had happened *(report)*, questions used to check what had been done *(control)*, and questions that invited students to think *(constructive)*. Table 3 presents a description of these three types of questions.

Table 3 Description of three types of questions

Question types	**Description**
Report	The teacher asks what has been discussed in the (previous) lesson
Control	The teacher asks if the learners understood and/or are able to reproduce what they have learned
Constructive	The teacher asks questions which help learners to construct new knowledge (interpretations, solutions, causal relations, predictions)

Interview

An interview scheme was developed to determine teachers' experiences with the use of the curriculum materials in classroom practice. The development of the interview scheme was based on Doyle and Ponder's (1977-78) view on the practicality ethic of teacher decision making and had items related to instrumentality, congruence and cost. Instrumentality refers to extent which the teachers experience the curriculum materials as supportive for lesson preparation and execution. Congruence reflects the extent to which the innovation which is reflected in the curriculum materials is aligned with teacher routines and beliefs. Cost is the teachers' perception of the efforts a teacher has to put into the innovation and the benefits the innovation yields. Table 4 presents sample questions of the interview scheme. With each teacher an interview was administered immediately after the lessons were given.

Tabel 4 Sample questions of the interview scheme

Instrumentality	Did the curriculum materials offer clear information about the integration of science and writing in the lessons? Which information was most useful? Which information was lacking? What was challenging in preparing and implementing the lessons?
Congruence	Did you consider enough alignment of the curriculum materials and the science and writing curriculum in your school? How much was the pedagogical approach expressed in the curriculum materials attuned to your way of teaching?
Cost	How do you experience the trade off between your efforts and the benefits of the curriculum materials?

Procedures
Teachers received a one-day introduction into the curriculum materials. After that they implemented the materials in five 50-60 minute lessons. In school I the teachers prepared their lessons collaboratively. This was not the case in school II. Observation and interview data were collected by undergraduate students. Of the 25 lessons the first lesson of each teacher was observed by two research assistants. The remaining lessons in school I were observed by a research assistant and the remaining lessons in school II were observed by the other research assistant. The research assistant who observed the lessons in school I also conducted the interviews with the five teachers. The research assistants provided the schools also with the laboratory equipment necessary for the experiments.

Results
Time
It is shown in Figure 1 that the teachers had difficulties in completing the lesson in the time suggested by the materials Particularly Chris en Bob used much more time to complete a lesson. All teachers used more time for the body of the lesson, where they had to carry out the experiments. In the interview all teachers expressed that they were not used to having the children doing experiments in their lessons. Bob, Diana and Chris also used more time for the orientation part. Alan, Ed and Diana did not use enough tiome to finalize the lesson and to look back on what was learned.

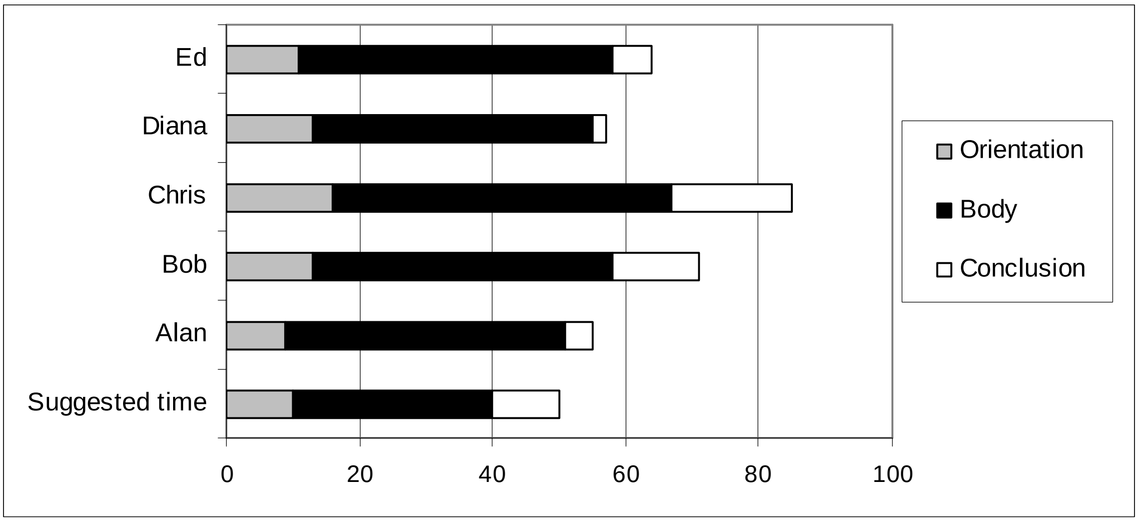


Figure 1. Suggested and average time per lesson (in minutes, per teacher)

Suggested and actual teaching practices

Figure 2 provides an overall impression of the teaching practice that was suggested by the curriculum materials. Figure 2 does not provide information about the time spent to these practices, but give information whether certain practices (as expressed in the items of the checklist) occur. Table 5 gives some examples of practices the teachers demonstrated during the lessons.

Table 5 Components of suggested practice and examples of observed teaching practice

Components of suggested teaching practice	Examples of observed teaching practice
Stimulate learners to reflect on their prior knowledge;	Ed asks: What comes up when you think of the weather (Lesson 1) Diana asks about the notes the learners had written down in the previous lesson (Diana, Lesson, 2) Alan and Bob recapitulate the water circle by using the concept map (lesson 4) All teachers ask the students characteristics of a 'well-written' text (lesson 5)
Create an authentic and meaningful learning process;	Alan, Bob and Chris ask learners about sports in the winter and the differences between snow (skiing) and ice (skating) (lesson 3). Alan and Chris refer to the weather forecast on television to introduce measuring precipitation (lesson 4)
Tailor new information to the level of the learners;	The teachers give additional instruction to groups that were not able to do the experiments on their own (Alan, Chris, Diana, Ed, lesson 4)
Demonstrate and support thinking processes in learners;	Bob and Chris ask learners to make connections between the words in the concept map and to express in sentences these connections (lesson 2) Diana asks to link the attributes of the experiment for rain making (a mirror, ice cubes, hot plate, water kettle) to the water circle (lesson 2) Chris and Ed ask learners to predict the amount of drops on a coin. Chris and Ed also ask for predictions for coins of different sizes (lesson 3)
Stimulate social interaction and collaboration among learners;	All teachers walk around and help pairs of students when necessary (lesson 3)
Stimulate learners to make notes and discusses them	Chris and Ed ask learners to copy the concept map to their notes and make additions (lesson 1) Ed tells the learners to make notes about learners' observations during the instrument (lesson 2) Bob and Chris ask learners to read aloud their notes about the experiment of water drops on a coin and en to compare their notes with their predictions (lesson 3) Bob, Chris and Ed tell students that they can use their notes for their final report (lesson 5)
Jointly (teachers and learners) reflect on the learning process at the end of lessons;	Chris evaluates the lesson with the learners (lesson 3) Alan and Ed recapitulate what was learned (lesson 4)

The suggested practice shows the distribution of the different practices across the curriculum materials. As can be seen the majority of the suggested teaching practices focused on stimulating social interaction and collaboration between the learners and on demonstrating and supporting thinking processes in learners. Least emphasis was put on adapting new information to the level of the children and on creating authentic and meaningful learning processes. All five teachers showed less of the suggested practices than was suggested, with Bob, Chris and Ed showing considerably more of the suggested practices than Alan and Diana. All five teachers paid most attention to learner's collaboration followed by encouraging and supporting thinking processes, as was also suggested in the materials. Joint student and teacher reflection at the end of the lesson was done less than was suggested. This is probably due to the fact that the teachers, Ed, Diana and Alan in particular, felt that they were running out of time. All five teachers had considerable attention for stimulating children's prior knowledge. This is also reflected in the time they spent on orientation (Figure 1). After all, stimulating prior knowledge usually is an activity at the start of the lesson. Ed and Alan did not attune the topic of the lesson to the learner's daily experiences (create authentic and meaningful learning practices), while Diana did not do much to adapt new knowledge to the level of the learners.

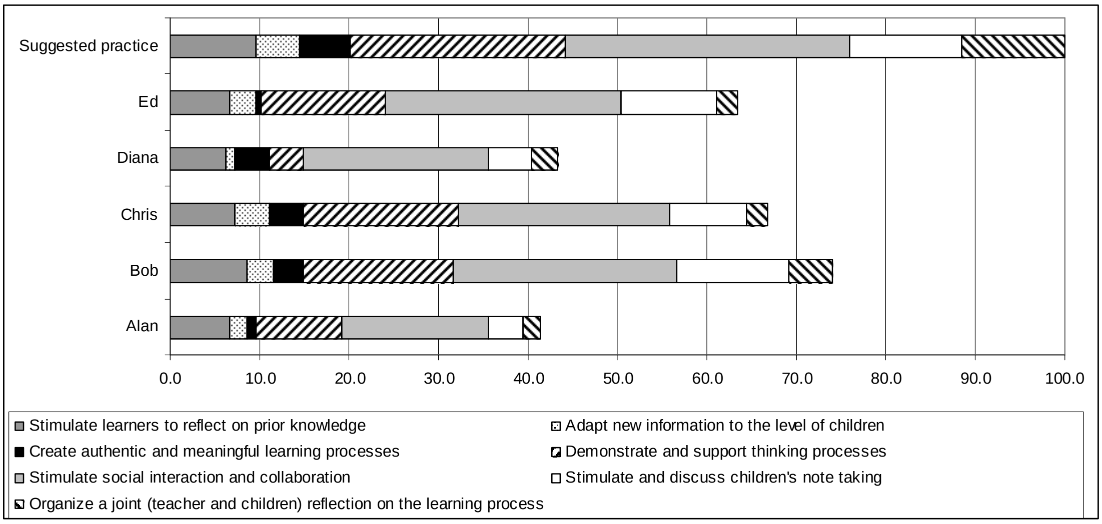


Figure 2. Suggested and actual teaching practices (in %)

Type of questions

To get a more in-depth understanding of the way teachers and learners interacted at the start and the closure of the lesson we decided to focus on the type of questions the teachers used as a way to stimulate engagement and knowledge building in learners. Table 6 provides examples of different types of questions the teachers used. Figure 3 presents the amount of questions that were posed.

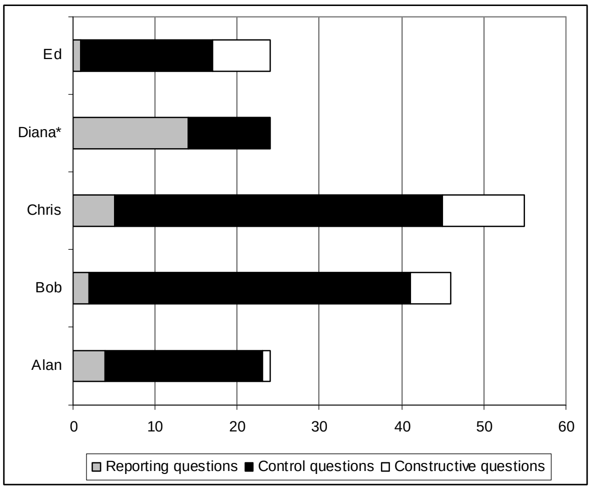
Table 6 Examples of the different types of questions

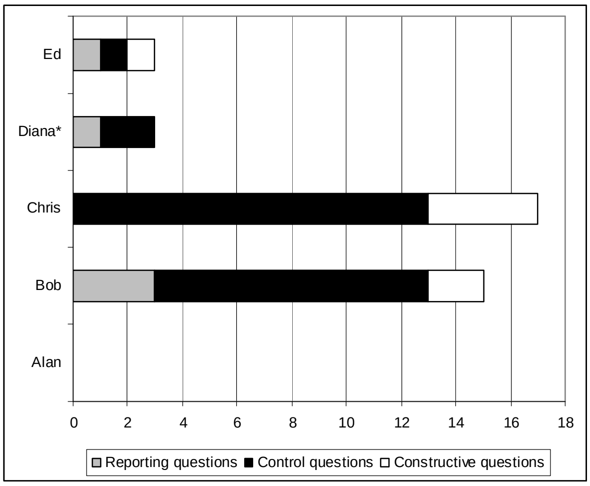
Type of questions	*Orientation*	*Closure*
Report questions	What was the topic of the previous lesson?	What did we discuss this lesson?
	What were your notes?	
Control questions	How do clouds originate?	
	What is the water circle?	Can you read aloud your notes?
	What is important to write in your note book?	What has changed in our concept map?
Constructive	Ice crystals differ. How come?	What do you think can we still change our concept map?
	Which words can you use to connect these words?	How can you formulate this more clearly?

The results in Figure 3 show that teachers asked much more questions during lesson orientation than during lesson closure. Also teachers differed a lot in the amount of questions they posed to the learners, with Chris and Bob asking many more questions than the other teachers, which also explains that they needed so much time (Figure 1). Alan did not even ask questions to the learners at lesson closure. It is remarkable that

all teachers used mostly control questions and not the constructive kind of questions that was expected.
Figure 3. Number of questions per teacher and per type during lesson orientation (a) and lesson closure (b). Note: due problems with the video not all Diana's lessons could be observed

Teacher reflections





According to all five teachers the curriculum materials provided clear information about what was expected. They appreciated to introductory workshop, as an additional source of information about the ideas of the lesson materials, and how they were made operational in the curriculum materials. Chris expressed his opinion as follows:

> *' After the workshop and reading the curriculum materials it was cristal clear to me how to integrate writing and science and how the emphasis on science decreases and on writing increases during the five lessons'*

Although the ideas were clear they did not find it easy to bring the curriculum in practice. Again Chris

> *'You can prepare the lesson, but in practice things are often different, and then you have to act immediately'*

The teachers reported that they needed a lot of time for the experiments during the lessons and that they then did not allow themselves to pay attention to writing. Similar to the teachers, the teachers also noticed that their learners needed to get used to the different approach. According to Ed

> *'They (the learners) are more involved with the experiment than in writing their notes'*

As a result the note taking was done at the end of the lesson, or was skipped at all. Despite the time needed for the experiments the teachers found it important to keep them. As Alan said it

> *'Children always like experiments, that should be kept, or even expanded'*

Grade 6 teachers found the experiments about the water circle a little too easy for their students. Particularly because the topic has been studies already in grade 4.
The teachers particularly liked the note taking templates that were made for the children. According to Diana

> *'I liked the note taking templates. It was well thought out. In the beginning children found it difficult to use, because they had to formulate sentences by themselves' (and not to fill in the gap,, where they were used to, authors)*

Most of the teachers used the paper-based templates with children instead of the digital templates, because of the insufficient ICT infrastructure. In school I teachers used digital graphical organizers with the interactive whiteboard to elaborate the concept map during whole classroom sessions.

Despite the time they needed to prepare the lessons (11/2 – 2 hours per week) all teachers were very positive about the way writing and science were integrated in the curriculum. They (and the children) appreciated the science experiments, which they usually don't do. Bob and Chris found it a challenge to do something different. Diana felt very uncertain in the beginning, but this disappeared after a while. Ed said that he needed a lot of time to understand the science part. According to the teachers the curriculum materials helped them to practice a new approach that was very different from their normal practice. However, to incorporate the materials in their school curriculum further adaptation is needed.

Discussion

In this study, five teachers from a ordinary elementary school in the Netherlands used educative curriculum materials in which writing and science were integrated. The curriculum materials had adopted a learner-centered pedagogical approach. The integration of writing and science was new to the teachers. In addition they particularly experienced the science part as new. They had never conducted experiments in the classroom, and were also not very familiar with the physics content of the lessons. The teachers perceived the materials as supportive for practicing this new approach to writing and science and appreciated the materials very much. Nevertheless, they had difficulties in carrying out the curriculum as expected by the curriculum designers. All teachers needed more time to cover the curriculum content. They used too much time for the start of the lesson (orientation), and as a consequence had too little time to jointly reflect on the lesson at the end. The teachers differed in the amount of practices they demonstrated during the lessons, but all showed less practices than were suggested by the materials. However in the distribution of practices they did not differ too much from the distribution that was suggested in the materials. All teachers focused in particular on learner collaboration and on student thinking processes. Yet, it was disappointing that teachers were hardly able to ask constructive questions to learners during the start and the closure of the lesson. The teachers very much appreciated to be involved in the project. They described it as a positive experience. However more needs to be learned about what these teachers learned from working with the curriculum materials for their own learning, and what aspects of the materials they took to their own practice. Follow up interviews (after 1½ years) will be conducted to further explore the impact on teacher learning and on curriculum implementation.

When it comes to curriculum innovation, there is growing attention for new partnerships that combine the perspectives of researchers, designers, teachers and sometimes even pupils (Könings, Brand-Gruwel, & van Merriënboer, 2007; Linn, Davis, & Bell, 2004). The LiST project team experienced the combination of researcher, designer, subject matter expert and teacher perspectives as both powerful and productive. The materials created by this team were shaped by classic views of mutual adaptation (McLaughlin, 1976) and curriculum enactment (Snyder, Bolin, & Zumwalt, 1992), in which teachers are viewed as natural constructors of curriculum (cf. Ben-Peretz, 1994). This study helped identify choices teachers make when enacting LiST materials, which is useful toward further improvement of the guidance offered to teachers. It also provides an example of how classroom materials can be collaboratively developed through a design-based research approach.

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