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Multimedia Cases in Elementary Science Teacher Education: Design and Development of a Prototype

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Multimedia cases intend to bring about fundamental changes in teacher education by bridging the gap between theory and practice. The use of information and communication technology in multimedia cases is expected to create a powerful and flexible learning environment. Such a learning environment is in line with a constructivist vision of teaching and learning. This paper focuses on the rationale behind case-based instruction by describing the design and development of a prototype and addressing the justification of underlying design decisions. Moreover, the prototype is briefly outlined and formative evaluation results are presented.

Keywords: teacher education, multimedia/hypermedia, CD-ROM, innovation, design technology, evaluation/formative.

Introduction

This paper discusses the design and development of a prototype of a case-based interactive system, delivered via CD-ROM and the WWW for use in preservice teacher education. This prototype has been developed within the framework of the MUST-project (**MU**lti-media in **S**cience & **T**echnology). The MUST-project is a joint venture on behalf of three Teacher Education colleges, the National Institute for Curriculum Development and the University of Twente in the Netherlands. The MUST-project aims at developing multi-media cases for the professional development of prospective teachers in elementary science and technology education. The cases are meant to be implemented in all Teacher Education colleges in the Netherlands. Multimedia cases are considered to provide a powerful learning environment that stimulates and facilitates the prospective teachers' reflection on learning and teaching. They consist of a combination of edited videotapes of classroom events, as well as audiotaped information and text. The MUST developers employ a combination of evolutionary prototyping and deliberation in their approach. A prototyping approach is characterised by the cyclic process of design, development and formative evaluation of prototypes; while deliberation implies consensus building about design decisions by means of rational arguments in team discussions.

In the following two sections, the rationale between case-based instruction and multi-media cases in teacher education is described. Subsequently the design considerations and choices behind the MUST-prototype are presented, and this prototype is described. This article ends with an explanation why a MUST-case may be perceived as a constructivist

learning environment. Finally, the main results of a formative evaluation of the MUST-prototype as well as the project's future activities are briefly outlined.

Cases and case-based instruction

Cases

Cases and approaches to case-based instruction offer curriculum materials and pedagogies to alter teacher education. Although they may be new to teacher educators, written cases and case-based instruction have been popular in other professional development enterprises, such as law and medicine (cf. Lacey and Merseth, 1993). In general, cases intend to bring the complexity of professional practice into educational programs, and thereby bridge the gap between theory and practice. Until now, the vast majority of cases for educational purposes have had a written form. Cases are crafted in compelling narratives with a beginning, middle and end, and situated in a specific event or in series of events (J.H. Shulman, 1992). This definition has a rather general character, which enhances its applicability on many instances. However, it says nothing about, for example, the boundaries of a case. Should a case just tell the story of classroom events as they happen, or should a case be 'layered', i.e. so comments on these events (from the teacher, from students and/or from experts) form a part of the case. There is some controversy about whether or not to include experts' comments within the structure of a case. For instance, Merseth (1996) argues that those comments may inhibit the construction of knowledge by novices. When novices have read what "experts" say about the case, they may tend to abandon or suspend their own beliefs in favour of the "delivered wisdom" (p. 733). On the other hand, L.S. Shulman (1992) argues that, for example, experts' comments provide additional perspectives or lenses through which to view the events of the case. So, they add complexity and richness that gloss rather than simplifying or trivialising the events (p. 12). But both authors agree that no empirical research exists to support either of the two positions.

A topic that is not captured in J.H. Shulman's description of a case is the distinction between different types of (written) cases. On the contrary, Merseth (1996) divides cases into three main categories based on the different intentions behind their writing.

Firstly, cases as *exemplars* may highlight a principle, a theoretical point of view or an instructional technique (Sykes and Bird, 1992). Broudy (1990, p. 454) calls these cases "paradigm cases of professional practice." Secondly, another purpose of cases is to provide opportunities to *practice analyses and contemplate action*. These cases present problematic situations that require analysis, problem solving, decision making, and action definition. These cases are usually based on a real situation, which is portrayed in its full complexity rather than on an episode constructed to illustrate a point (Doyle quoted in Merseth, 1996). In this perspective, cases are an impelling force to informed action. Thirdly, cases can be perceived as *stimulants to personal reflection*. Merseth (1996) refers to those cases that are written for personal study and self-reflection. In these instances it is the act of case-writing that counts. Based on the case-writing by a professional-to-be, a

teacher educator acts like a coach and guides students to develop courses of action. So, case-writing fosters the ability to learn from experiences by means of reflection.

Advocates of cases in teacher education agree on one point: cases are powerful tools to encourage learning from experience, whether it is from the student's own experience or from the experience of others (Merseth, 1996). Which type of case (or combination) fosters teacher learning best is an issue as yet unresolved, because empirical research on cases in teacher education is limited.

Case-based instruction

The different purposes of cases and their design is one side of the coin. The other, equally important side is the way cases are incorporated in teacher education programs by means of case-based instruction. Case-based instruction is perceived as far better than teacher education programs dominated by the "twin demons of lecture and textbook" (L.S. Shulman, 1992, p. 1). "Case methods are expected to be more engaging, more demanding, more intellectually exciting and stimulating, more likely to bridge the chasms between principle and practice, and more likely to help neophytes to learn "to think like a teacher" (o.c., p. 1). Case-based instruction is also viewed as a means to stimulate cognitive flexibility, because of knowledge representations in multiple and context dependent settings (Merseth, 1996). In other words, instruction is anchored in the complexity of classroom teaching.

There is a growing body of evidence that cases function best in a learning environment wherein students have the opportunity to discuss alternative views and conceptions of the case. So, forms of collaborative group learning appear to be the optimal breeding ground to accomplish the full instructional potential of cases. It is no exaggeration to say that the claims of case-based instruction are far from modest. However, there are also possible disadvantages of case-based instruction (L.S. Shulman, 1992), which can be dealt with as follows:

- Cases are complicated, expensive and time-consuming to produce. An important issue is that richly described cases may lead to a cognitive overload if the reader must process too much information at one time. Good case development requires a careful design process including formative evaluations. The results of these evaluations should also provide information about contextual factors (such as the role of the teacher educator, the particular tasks of the students, the relation with other units in the program) that favour optimal use of the cases.
- Case-based instruction is a difficult teaching approach that requires teacher educators to be willing to invest longer periods of preparation time than is typical for most other methods. It also requires a change in beliefs and practice of many teacher educators: it removes them from the centre stage into a position of partnership with students. However, it is not clear by now how the professional expertise of a teacher educator should be incorporated in this partnership.
- From a perspective of content coverage, it must be admitted that cases are rather inefficient: little content is covered over rather long periods of time.

- Because of their episodic character, cases may inhibit students to critical generalisations and principles as the particularities of the narrative may overwhelm the general conceptions. However, one may say that such generalities do not have much value in the highly contextualized and ill-structured domain of classroom teaching. Nevertheless, the issue remains whether the learning experiences of a case can be transferred to other domains and especially to classroom practice.
- On the other hand, cases may be susceptible to overgeneralization. A single case may be so powerful that the students transform its apparent message into a rigid maxim.
- Last but not least, there is little research-based knowledge to found case design and the incorporation of case-based instruction in teacher education. Or as Grossman (1992, p. 237) puts it: "the development of case methods must be accompanied by a research agenda that seeks to illuminate what prospective teachers actually learn, and do not learn, from different genres of cases and the instructional methods that best support this learning."

From linear structure to hypermedia: multimedia cases

Until now, the vast majority of cases for educational purposes have been given written form.

Written cases are subject to a linear sequenced text structure. Hypertext, however, provides a non-linear environment for organising and displaying text. In such an environment, nodes of information are dynamically linked (McKnight et al., 1996). Stanton and Stammers (1990) give (partly empirically based) reasons why such an environment might be superior in supporting the learning process. They argue that non-linear information *adapts* to different levels of prior knowledge; *encourages* exploration; *enables* students to see a subtask as part of a whole task, and *allows* students to adapt material to their own learning style.

Hypermedia (or multimedia) can be perceived as an extension of hypertext. This concept refers to the integration of media such as audio, video, graphics, animation, spatial modelling and text, into one computer system (Cennamo et al., 1996; Jonassen and Reeves, 1996; Lacey and Merseth, 1993). Multimedia can stimulate more than one sense at a time and in doing so, may get and hold more attention (Jonassen and Reeves, 1993, p. 703). Particularly in teacher education, the use of video recordings of classroom teaching in multimedia cases seems to be very promising, because they may capture the similarity of events occurring in classrooms with greater accuracy than written text: "a picture is worth a thousand words." Kinzer (1997) paraphrased this maxim by saying that in order to capture the complexity of teaching one needs a thousand pictures.

Jonassen and Reeves (1996) have developed convincing reasoning as to why computers (and thus multimedia) should be perceived as cognitive tools for educational purposes. These tools refer to technologies that enhance the cognitive powers of human beings during thinking, problem solving and learning. In multimedia-based cognitive tools, information is not encoded in predefined educational communications that are used to transmit knowledge to students. Rather, such multimedia productions intend to actively

engage students in creating knowledge that reflects their comprehension and conceptualisation of information and ideas. In this way, multimedia cases fit into a constructivist vision of teaching and learning (Riesbeck, 1996).

From this constructivist perspective, multimedia cases offer ample educational advantages for (prospective) teacher learning (Bliss and Mazur, 1996; Cennamo et al., 1996; Fitzgerald and Semrau, 1996; Harfield, 1996; Nicais and Barnes, 1996) as they *stimulate* an active learning attitude in a learner-controlled environment; *yield* the possibility to revisit classroom events in order to make sense of them; *show* the cases from myriad perspectives; *offer* procedural support for instructional design and classroom teaching; *lessen* the gap between theory and practice, by giving practice a more profound and integrated position into teacher education programs.

Nevertheless, most disadvantages of case-based instruction mentioned in the previous section apply to instruction with multimedia cases as well.

Multimedia cases are even more complicated, expensive, and time-consuming to produce then written cases, however the former cases may not lead to cognitive overload, because the learners have more control over the type and amount of information they want to study. A distinctive feature of hypermedia systems is that learners are not hindered by information that does not make sense to them at a particular stage in their learning processes. Teaching with multimedia cases is an even more difficult teaching approach than teaching with written cases, because teacher educators must learn to handle the "technology factor". Moreover, there is not much experience with teaching approaches with dynamically linked information, that has, besides text, other representations of information in the form of moving pictures and stills. Multimedia cases may also have the disadvantage that little content is covered over a long period of time. However, one may say that this is not a disadvantage because in-depth knowledge is of more value than superficial content coverage. Working with multimedia cases may also overwhelm the students with all the rich details; they may not see the wood for the trees. And on the other hand, also multimedia cases may lead to overgeneralizations, even more than written cases, because video is more appealing then written text. Also the design and implementation of multimedia cases are not supported by firm research based knowledge, yet. Despite these possible disadvantages, multimedia cases may have the potential to fundamentally change teacher education by bringing classroom practice for analyses, reflection, and action purposes into the programs. Designers should be aware of the potential pitfalls and try to overcome them both in the structure of the cases and in their implementation in teacher education programs.

Design considerations in the MUST-project

Augmentation of the prior commitment

The choice for multimedia cases leads to subsequent decisions about the structure of case. In the MUST-project the cases (the prototype case and the cases to be developed) are *exemplars* of a more constructivist approach to elementary science. In order to avoid any

misunderstanding, these examples are not meant to be followed uncritically. On the contrary, they intend to stimulate reflective thought and communication. Moreover, examples are selected to show various ways of good quality science or technology education, and not to present 'one right way'. The cases will be designed in such a way that they provide ample opportunities for *practising analyses*, for *reflection* and for *contemplating acting*. In order to facilitate these processes the cases are layered. In particular, comments on the case from different perspectives, experts included, are meant to bring about internal cognitive conflicts (Levin, 1995) to stimulate students to in-depth processing of the information presented in the case.

Aim and functions of MUST-cases

The aim of the MUST-cases is to stimulate prospective teachers' pedagogical reasoning in elementary science and technology by situating learning in the complexity of classroom teaching. This is done in such a way that they can construct and reconstruct their knowledge base by means of personal and collaborative reflection in a community of practice. In other words, the cases intend "to foster the three Cs: complexity, constructionism and community" (Lacey and Merseth, 1993, p. 547).

The MUST-cases are intended to fulfil the following functions:

- to demonstrate exemplary teaching in the complexity of classroom teaching
- to stimulate reflection on pedagogical content issues;
- to support the design and implementation of high quality teaching;
- to provide a communication system for the exchange of ideas about science and technology teaching.

Design choices of the MUST-cases

McKnight et al., (1996) suggest conceptualising issues underlying the design of hypermedia systems in terms of four basic factors: the users, their tasks, the information space in which the task is being performed, and the environment or context in which all of these interact. Application of their suggestions to the MUST-project leads to the considerations presented below.

Users

In a multimedia system for teacher education, two user groups are to be distinguished: the teacher educators and the students. The computer skills in both groups vary from hardly skilled at all to very elaborated. This implies that the interface of the multimedia system must be very easy to handle without boring the more experienced users.

As far as the teacher educators are concerned, it must be recognised that there are differences in beliefs about quality science teacher education. The MUST-project favours flexibility of use of the multimedia cases and does not want impose a predescribed path on teacher educators. However, the view of the project team and their intentions will be communicated to the teacher educators by means of workshops, web-based communication and a teacher guide.

As far as prospective teachers are concerned, the MUST-project intends to develop multimedia cases that can be a challenging learning environment for students just starting the teacher education program, as well as for more 'mature' students.

Tasks

For teacher educators the use of multimedia cases will require a change in their current practice. Teacher educators need to act as coaches of students, and take their ideas as a starting point for the learning process. The MUST-project intends to support teacher educators by means of conferences, workshops and web-based aids. To a considerable extent this support is grounded in the implementation experiences of the teacher educators involved in the project.

In order to support the flexibility-of-use by both teacher educators and students, different types of assignments are part of the cases. And even more important, it is also possible for them to modify assignments and to add assignments to the cases. Both assignments are designed by the MUST-team, as well as modified and new assignments will be made public in a database on the MUST Web-site

Information space.

Actually, the question about the information space is about the boundaries of the case. In the MUST-cases a distinction has to be made between the CD-ROM-part and the WWW-part. At the CD-ROM-part the information space is limited to what the designers put into the case. The focus of the cases is on pedagogical content and on classroom management aspects in elementary science and technology. The reason for this focus is that research (also in the Netherlands) shows that lack of knowledge and skills in these areas is a hindrance to more innovative approaches to elementary science (Van den Berg, 1996). Within the WWW-component, the information base is rather "boundless" for two reasons. Firstly, the users are encouraged to add their ideas to the system and to communicate about them. Secondly, more general information about science and technology is added to the Web-site, such as the Dutch national standards for elementary science and technology, and general information about the MUST-project and the MUST-team.

Context

A rather large-scale reform of Dutch elementary teacher education has been planned and partly implemented to date. Two important aspects of this reform are to stimulate self-

directed learning of students, both individually and collaboratively, and the integration of Information and Communication Technology in teacher education programs. Within this context the Dutch government stimulates the use of multimedia. However, by now it is rather unclear what the policy will be with regard to the integration of those media in teacher education programs. So, the MUST-project also aims at contributing to a greater clarity of the possibilities and limitations of multimedia in the larger scale reform of teacher education in the Netherlands.

MUST-prototype

In order to facilitate a better understanding of the MUST project, a description of the prototype itself may be useful. Entering the program, users enter the main menu (pictured in Figure 1).

A star has been chosen as a metaphor for the interface, because it represents the nonlinearity of information. Additional reasons include the notion that "stars" are part of the science curriculum, and they are associated with "brightness." Clicking on the sun in

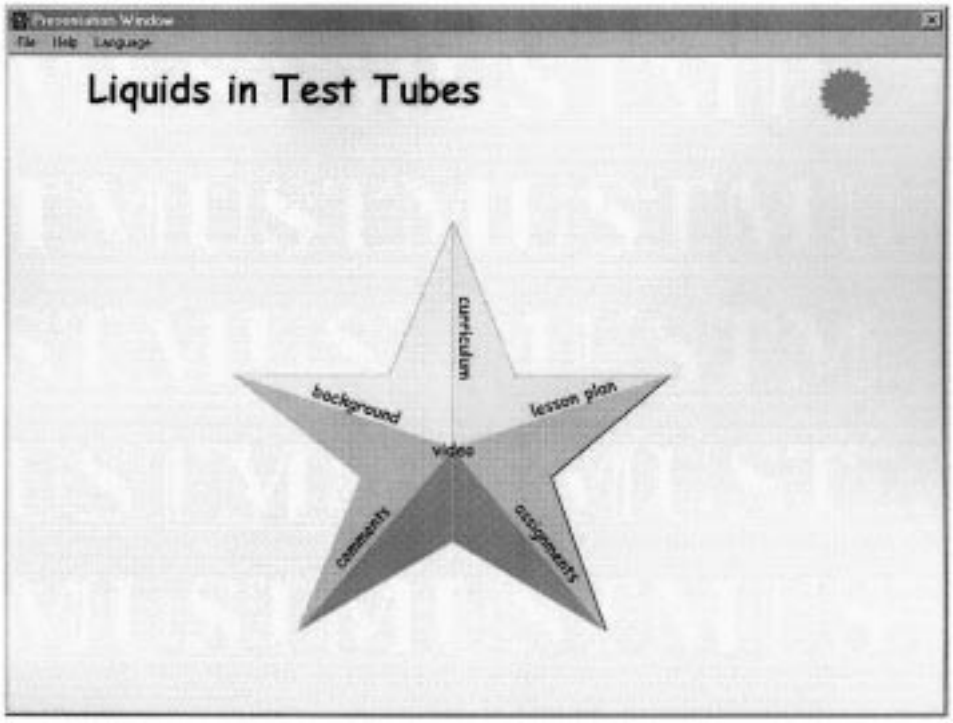

Figure 1. Main menu for the case.

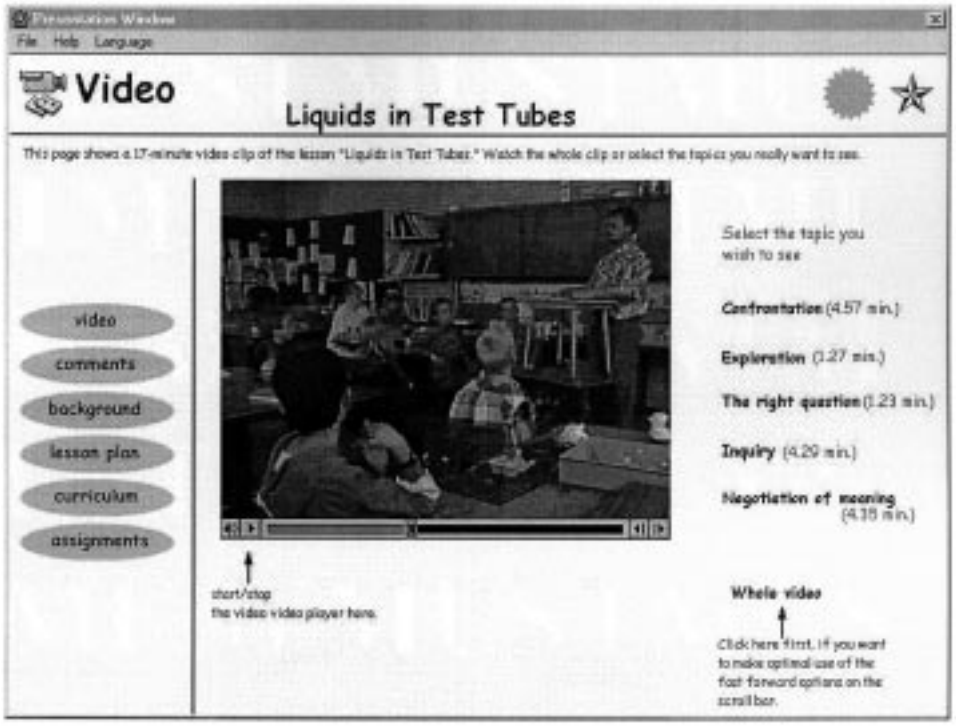

Figure 2. Video.

the right corner of the screen gives the user access to the MUST homepage (http://projects.edte.utwente.nl/crc/must).

Placing the video clip at the heart of the star emphasises that actual classroom teaching forms the core of the case. By clicking on the word, "video", the user enters the screen pictured in Figure 2.

Users may view the entire clip (17 minutes) from start to finish, or skip through sections by clicking on the particular lesson stage they are interested in.

Background information is presented in order to contextualise the classroom lesson (see Figure 3). This background information is intended to help the user to interpret the video. It provides factual information about the school, but also about the school's educational philosophy. The teacher page includes information about that teacher's view on student-centred elementary science. The class page contains some general information as well as authentic student work.

On the comments screen (see Figure 4), users may view and hear comments from various sources. The comments are given by the teacher in the video, by science teacher educators, generic curriculum specialists, and also by prospective teachers. These

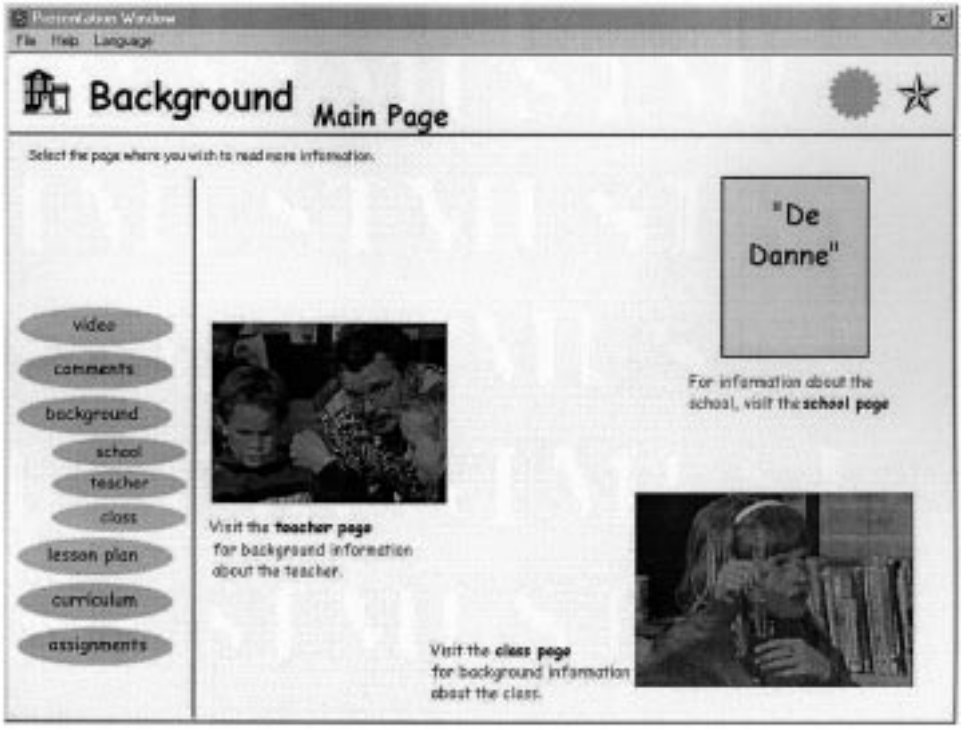

Figure 3. Background information.

comments may perplex students because differing views on the same lesson are expressed. By adding this type of information, the design team intends to encourage the users to formulate their own view on the lesson, and wants to reinforce the notion that there is no one correct answer when it comes to making classroom decisions.

On the curriculum page, users find information about how the lesson is related to the content areas for elementary science and how the lesson is related to the national standards in the Netherlands.

The assignment component offers various "learning routes" created for the future teacher. The general structure of such a learning route is as follows: (1) students are asked to *orient* themselves using the information on the CD-ROM; (2) students are asked to *analyse* and to *reflect* on the information; (3) a *practice* component in which students may apply what they have learned to prepare and to implement elementary science lessons during their internship; (4) students may complete extra assignments that are related to *more general issues* in elementary science and technology. Besides the more structured learning routes, students are also offered the opportunity to formulate their own learning questions and goals and to pursue according to those questions and goals.

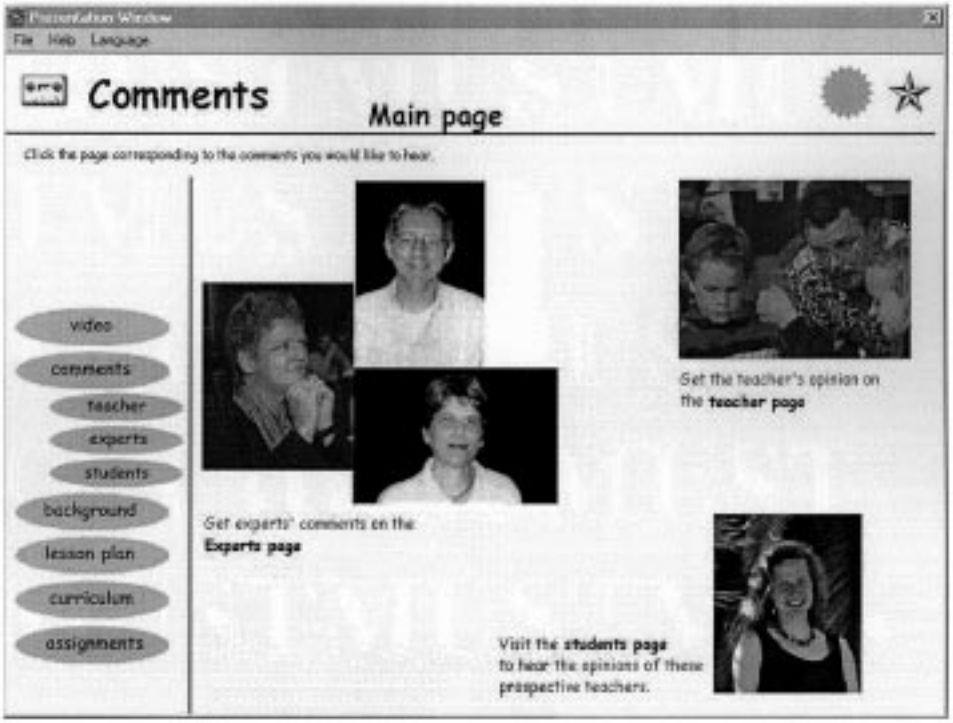

Figure 4. Comments.

Reflections and prospects

Constructivist learning environment

In this article we described the background and the development of multimedia cases as a constructivist learning environment (cf. Honebein, 1996). A first characteristic of such an environment is that learning is embedded in a *realistic and relevant context*. A non-scripted video of an elementary science lesson forms the core of the MUST-case. This video is both realistic and relevant for pre-service teachers. A second characteristic of a constructivist learning environment is that information is presented from *different perspectives*. Especially by including comments from the "video-teacher", experts, and future teachers this characteristic has been warranted. Moreover, in the "learning routes" students are stimulated to formulate and share their own views on the lesson. A third characteristic is that information is represented by *different modes*. This characteristic has been applied by using video and audio comments (also available in written form). Moreover, other modes of representation (text, stills, charts) are depicted by:

- different formats of lesson plans (complete, brief and custom);
- background information of the school, the teacher and the pupils;
- information about the science content of the lesson;
- information about how the lesson fits into the Dutch elementary science curriculum in terms of content areas and national standards.

A fourth characteristic of a constructivist learning environment is ownership and voice in the learning process by prospective teachers. This implies that they are encouraged to reflect on their knowledge construction processes and to take responsibility for setting goals and for pursuing learning tasks. In the formulation of the "learning routes" we tried to be sensitive to this principle. However, it must be noted that the way students work with MUST cases is not in the first place for the MUST-team to determine. Here the teacher educators are encouraged to explore applications within their own setting.

In sum, we may state that the MUST-prototype has characteristics that fit into a constructivist vision on teaching and learning. But, whether or not the full potential of a MUST-case will be realised depends on the way teacher educators implement the case into their programs.

Formative evaluations

The evolutionary prototyping approach of the MUST-project implies that formative evaluations are an integral part of the design process and that these evaluations are conducted relatively early in the design process. These evaluations are to be typified as micro-evaluations. In a micro-evaluation a small group of the target audiences uses (parts of) the materials outside classroom settings (cf. Nieveen, 1997). Several micro-evaluations have been conducted with the MUST-prototype. Students in their first and in their third year were participants in the evaluations as well as teacher educators. The results from the student evaluations are summarised below.

In general, students at teacher education colleges highly enjoyed working with the multimedia case. The reasons they mentioned can be summarised as follows:

- it is motivating to work in such a different way;
- it gives an illustration and also a clear impression of the difficulties of elementary science teaching;
- it allows for exploring questions about elementary science teaching.

As far as the different components of the CD-ROM are concerned they valued, not surprisingly, the video-clip most, because it offers them a picture of what an innovative elementary science lesson looks like in practice.

Students' reactions on the comments show some variation. Firstly, some tend to value the comments of the experts as more worthwhile than the other comments, as indicated by this response: *"you learn most from those comments"*. Another non-anticipated result is that some respondents who saw "their teacher educator" on the CD-ROM ignored the

comments of other experts. They seem to think that it is most important to know what their own teacher educator says about the videotaped lesson. Students who do not have the opportunity to consult the comments of their teacher educator pay equal attention to all expert comments, and elaborated more on the differences between them. There are also differences in the appreciation of comments of fellow prospective teachers on the CD-ROM. Some respondents enjoyed these comments very much, while others mentioned that comments of fellows are not very useful. As one stated: *"You cannot learn very much from those comments."*

The students appreciated the other three components (lesson plans, background information, and how that lesson fits into the overall curriculum). As far as the background information was concerned, they indicated an interest in more focused information regarding science education issues, and were less interested in more general information.

We not only asked students to give their opinion about the different components on the CD-ROM, but also to complete one of the assignments ("learning routes") related to the CD-ROM. The results of this part of the evaluation revealed that some students have problems with studying a virtual classroom lesson from different perspectives. They expected that the information on the CD-ROM would provide them with "correct" answers, and not with dilemmas to think about. One of the respondents formulated this point rather poignantly: *"Why not videotape a perfect lesson, then you don't need all those comments, and you know how to teach science lessons."*

In addition to the information regarding the educational value of the CD-ROM (summarised above), the results of the formative evaluations also provide detailed information for debugging and suggestions for technical improvements.

During their annual conference, 12 teacher educators attended a workshop in which the educational value of the CD-ROM was discussed. This discussion revealed that, although the reaction was positive, teacher educators experience problems with articulating how to integrate the multimedia case in their curriculum. This may be caused by their unfamiliarity with this medium.

Looking ahead

The case "Liquids in test tubes" is being used for prototype development and evaluation. At the moment (January, 1999), this case is being revised and improved. Further, two other cases are under construction: Outdoor Activities about Birds (for kindergarten); and a series of lessons on Colour and Light (for 11 and 12 yr-olds). Based on the experiences with and evaluations of the prototype, several improvements will be made. One of the most crucial issues in the coming period in the MUST-project will be the integration of multimedia cases in teacher education programs. In order to support this, a dynamic database will be developed in which teacher educators may find customised information about ways to incorporate MUST-cases into their curriculum. They will also be offered the opportunity to modify and add to the information in the database. This electronic support for and network of teacher educators will be accomplished by face-to-face interactions, such as conferences and workshops. This network of teacher educators is not seen as a

substitute for the opinions of student teachers. However, we believe that changes in beliefs and practices of teacher educators should have priority.

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