Celebrate

Learning objects in classroom settings

A report of 13 case studies conducted in Finland, France, Hungary, Ireland and United Kingdom

CELEBRATE WorkPackage7

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I Introduction

The classroom case studies were conducted in five countries, Finland, France, Hungary, Ireland and United Kingdom, during spring 2004. Classroom case studies were an independent study of the CELEBRATE project, but they are also connected to the overall evaluation process. By classroom case studies it was possible to reach teachers' and students' concrete practices, and to evaluate the use of learning objects (later: LOs) in a real teaching and learning sequences. The study as a whole represents an exploratory multiple case study (Yin, 1989), and it also has some characteristics of a design experiment (Brown, 1982).

The focus of the case studies was in the use of LOs as a part of the educational activities and practices in primary and secondary classrooms. The learning tasks, students' activities and teacher's support are important elements of the learning situation to investigate, in order to better understand the possibilities to develop LOs that support advanced learning and teaching practices. The goals of the classroom case studies were following:

- To test LOs as part of as various pedagogical practices as possible, in order to get experiences and understanding about what kinds of LOs best support the development of learning culture;
- To examine the interrelatedness of the pedagogical practices and the characteristics of LOs;
- To better understand the possibilities and challenges that teachers experience in using LOs in advanced pedagogical practices;
- To analyse the learning activities and the use of LOs from the point of view of knowledge and expert-like features in knowledge processing;
- To produce ideas and recommendations for developing LOs.

This report is descriptive: we try to give examples of using various kinds of LOs in classroom practices. Although researchers used common guidelines (Ilomäki & Lakkala, 5.2.2004) for conducting the case studies, national researchers were responsible for the accomplishment, analysis and evaluation of their cases. Because the possibilities for research varied in the countries, the case studies have considerable differences. Some of the cases were observed during the overall teaching and learning sequence, including lessons with as well as without LOs. Some cases report observations of single lessons, during which LOs were used. In the majority of the cases, teachers have used LOs created by publishers, but a few cases examine teaching and learning units, during which teachers used LOs created by themselves with a special template.

The school cultures and practices as well as the level and use of technology varied in the countries of the classroom studies. The original idea was to investigate, especially, so called “advanced pedagogical practices”, but actually the studies were carried out in various learning settings and various pedagogical approaches.

In broad outlines, pedagogical goals and approaches can be differentiated on those which 1) emphasise an acquisition of knowledge by individual learners (in a passive or in a active manner depending on the approach); 2) emphasise participation on authentic activities and collaborative ways of doing things; 3) emphasise learning as something where external knowledge objects (“artefacts”) are collaboratively developed and modified for subsequent use (see Hakkarainen, Palonen, Paavola & Lehtinen, 2004). The first of these approaches (the knowledge-acquisition perspective) is easily connected to traditional way of understanding education where recalling of knowledge is emphasized. Two other approaches have challenged this view by emphasizing participation to certain kinds of activities, or collaborative and systematic creation of some knowledge objects. “Advanced pedagogical practices” relates to the participation and knowledge-creation approaches of learning and the use of ICT (see e.g. Law, Lee and Chow, 2002; Kozma, 2003; Ilomäki, Lakkala and Lehtinen, 2004). Such practices can be described by the following features:

- Teaching and learning change from teacher-centered to learner-centered, supporting student's ownership and active involvement;
- Instead of concentrating on fact-based learning, more general skills and abilities are emphasized in relation to learners’ understanding and activities. Students should become self-regulatory, reflective, and critical learners;
- Human beings construct ideas and things collaboratively and in social interaction; meanings and interpretations of things are negotiated socially. Also learning should be based on collaboration, dialogue, discourse to develop interaction and collaboration skills.
- School-learning should take authentic problems more into account and teach how to solve authentic, open-ended, and ill-defined problems within complex, real-life environments, and sustained working processes.

In the CELEBRATE project, for example, the following features were outlined to make concrete such advanced pedagogy related to the development of learning objects: activating prior knowledge; giving multiple representations; supporting conceptual change; visualisation of thinking; giving the possibility to deal with the complexity of the content; giving expert models and guidance; and supporting collaboration that is directed to thinking and explaining (Ilomäki, Jaakkola, Lakkala, Nirhamo, Nurmi, Paavola, Rahikainen & Lehtinen, 2003).

Closely linked to the pedagogical features mentioned above is expert-like activity with knowledge. In learning activities, such a kind of approach to knowledge means, for example, to trigger students to develop knowledge, to compare various perspectives, to weigh evidence, to defend own viewpoint, etc. The 'knowledge' presentation should then, for example, give various points of views to the topic, support the use of procedural and silent knowledge, give metaknowledge, present

authentic knowledge, and help to integrate practical and theoretical knowledge (Ilomäki & al., 2003).

By concentrating on "advanced" practices we wanted to avoid results that describe only technical problems, the problems of ICT applications of novice teachers, or the teachers' need to have more experience, as many reports often present. In some of the cases this approach was not possible to follow, because not all teachers had enough skills and experience about ICT. However, this brought more variety to the overall picture of the cases, and also addressed the crucial importance of the high quality of technology in authentic classrooms.

The cases were selected both based on teachers volunteering to take part and on the research interests. The case studies investigated the phenomena of using LOs in primary as well as in secondary level classrooms, and from that point of view the school level in single cases is not important. Similarly, the cases are conducted in various school subjects. We believe that the experiences of using LOs are transferable to several subjects, and to all school levels.

The validity of the study is based on how well these cases represent reality in schools. The cases give a rich picture of classroom life; however, they concentrate on schools and teachers that were experts in the pedagogical use of ICT, or at least interested in developing such expertise. From that point of view these cases represent active, technology-interested schools and teachers. Although each case is unique, they share several common features related to the use of technology and LOs. These common results are presented in national and cross-country conclusions.

We want to thank all the researchers who conducted the studies, as well as all participating teachers for their efforts and valuable contribution.

Espoo, Finland, 20.10.2004

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II THE CASES

The case studies were conducted in Finland, France, Hungary, Ireland and United Kingdom. The national cases were guided by a working paper (Ilomäki & Lakkala, 5.2.2004). However, the execution of the case studies differ somewhat from each other. In the Finnish case studies, the 'case' consisted of a larger working sequence or a pedagogical unit: one teacher and his/her students conducted one teaching and learning sequence, which concentrated on one topic or theme and which had a certain goal. The study examined the whole sequence, including the use of the LO. The French cases consisted of one lesson to four lessons. The three Hungarian case studies consisted of cases of different length: a collection of observations of special days which was organized around LOs, a longer period of which four lessons were observed and of one case of two lessons. Both the Irish and English case studies consisted of one lesson during which the LO/LAs were used.

The whole study consisted of 13 cases. Table 1 presents a summary of the general features of the cases.

Table 1. A summary of the general features of the cases

Title of the case	***School level***	***Age of students***	***Number of students***	***School subject***	***Length of the case (weeks * lessons/week***	***Number and type of LOs used***
Finland						
Case 1 Are you a healty eater?	primary	11 to 12	31	Natural sciences	5 * 1-2 lessons	1 (Exploration)
Case 2 Do you know how to eat?	lower secondary	13 to 14	21	English	3 * 3 lessons	1 (Exploration)
Case 3 Senses and the brain	lower secondary	15 to 16	17	Biology	3 * 2 lessons	9-10 (Information source & Drill-and-practice)
Case 4 Multiple-intelligence and learning objects	upper secondary	16 to 17	16	Health education	6 * 1-2 lessons/week + virtual discussion 3 weeks	2 mainly (Tools, Exploration & Guide); evaluation of several others (mainly Drill-and-practice)
France						
Case 5 Water cycle	primary	10-11	9+9 (two groups)	Natural sciences	2 * 2 lessons	1 (Information source, Drill-and-practice)

Title of the case	*School level*	*Age of students*	*Number of students*	*School subject*	*Length of the case (weeks * lessons/week*	*Number and type of LOs used*
Case 6 Bread making	lower secondary	11-12	15+15 (two groups)	Biology, natural sciences	2 lessons with 2 classes	2 (Information source & Drill-and-practice)
Case 7 Exploring the comparative form	lower secondary	11-12	20	English	2 * 2 lessons (55 min each)	7 (Drill-and-practice)
Case 8 Relations	primary	10-11	11	Mathematics	1 lesson	1 (Drill-and-practice)
Hungary						
Case 9 Energy	primary	13-14	18	Natural sciences + history and geography	4,5 lessons in one day	20 many kinds
Case 10 Waves	secondary	14-15	24	Natural sciences	4 of 13 lessons in 6,5 weeks	9 + DB templates
Case 11 Interactions of people and environment	secondary	15-16	22	Biology	2 lessons	6 (Drill-and-practice, made by DB templates)
Ireland						
Case 12 The Spreading of the HIV Virus	secondary	16-17	10	Biology	1 lesson	1 (Drill-and-practice)
UK						
Case 13	primary	11-12	19	Natural sciences	1.5 hours	3 (Drill-and-practice)

The case studies are presented by providing, at first, an overview of the case, in order to help the reader understand the case better. This is done by describing the overall context of the case, explaining what happened during the teaching and learning sequence, and giving the teacher's evaluation of the sequence. After this follows the researchers' analysis of the pedagogical approach, and the use and account of the learning object in the described case.

Finnish cases

Case study 1 Are you a healthy eater?

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1. An overall description

School 1 is an ordinary elementary school, located in a suburb of City of Espoo. There are about 500 students in the school (aged 6 to 13), and 26 teachers. Jupperi school participated in Celebrate-project as one of the pilot schools, and the teacher of this case study was the organizer of the Celebrate pilot use in the school. All teachers use ICT for their teaching, and the skill of the teachers is rated from medium to high.

The male teacher of this case study had 21 years of teaching experience, and he has used ICT for 16 years with pupils. He is active also outside the school and he belongs to an ICT expert teacher team of the City of Espoo. He trains other teachers to use ICT at the local level, he has participated in special training about ICT, and he participates, for example, in national conferences about ICT. He can be regarded as a key teacher in ICT also on local level.

The school has an ordinary technological infrastructure typical for a Finnish school. There are 30 computers, which means about 18 students per one computer. This is somewhat less than national average in elementary level. All computers have a high-speed Internet connection. Single computers are located in classes and in the library and there is also a computer room, which is small and cramped. In the computer room (used also for the CELEBRATE experiment) there are 18 computers. Teachers reserve in the autumn a regular time once a week in the computer room for their class. Besides that, there are some additional hours, which can be reserved during the school year.

The case study was conducted with a class of 5th grade (11 years old), primary school pupils in Finland studying natural sciences. The learning object used was Terveellinen ateria (Healthy meal) and it is available at http://www.edu.fi/oppimateriaalit/terveellinenateria/. The type of the learning object can be regarded as an **Exploration**, according to the Celebrate Application Profile or metadata. In Figure 1 is presented a main screen of the LO.

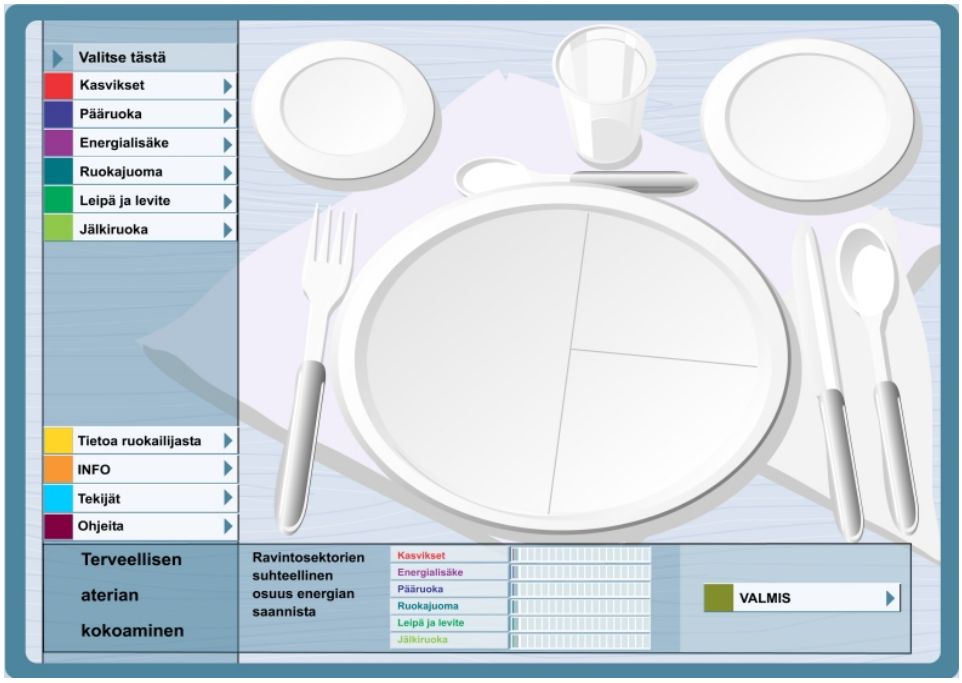

Figure 1. The main screen of the Terveellinen ateria (Healthy meal) learning object.

The goals of the teaching and learning sequence defined by the teacher were:

- To get pupils to understand the principles of a healthy diet
- To help them to reflect on their daily eating, even to help them make some changes to it.

2. The structure and phases of the learning/teaching sequence

The whole process was conducted over a five-week period. First, the pupils visited the school's lunch room, where the canteen manager talked about the school meals for around 20 minutes, and the pupils were then given a leaflet about healthy food. This provoked some discussion later in the class. After this lesson, the teacher sent an e-mail to parents about the project. Next, an introduction to the tasks for the students took one lesson (45 minutes). The pupils were guided to keep record about their meals for nine days. They got a simple template for this, made by the teacher, and the task itself was carried independently at home. Parents were requested to sign a diary daily, in order to follow the pupil's daily meals. In the third lesson the school nurse visited the class and spoke about healthy meals for 45 minutes.

After some days (the first possible day at the computer class), the pupils started to use the learning object itself (Healthy meal) in two groups, because there was room only for half of the class at the same time. The computer lessons were on Thursday mornings. The pupils used the learning object by applying the data that they had recorded on their personal meal diaries. The LO calculated the nutrition values of the meals, and gave the value and a visual image of it as feedback. At the computer class,

the pupils also worked independently, at their own pace and made their own decisions, for example, as they substituted one dish with another (the missing dishes in the learning object). They asked for help, and helped each other in a natural way, but everyone was responsible for conducting his/her own work.

The computer work was slower than the teacher had expected; it took five lessons, which meant five weeks. (The class had a possibility to use the computer class once a week for two hours.) Because this was an elementary class, the teacher reminded the pupils every now and then during other lessons about the need to update the food diary.

3. The teacher's evaluation of the learning/teaching sequence

The teacher was rather satisfied with his design. The only improvement he mentioned afterwards was the timing of the sequence; he would shorten the students' record keeping time for meal diary to five days. The teacher thought that the LO was easy to use, although he mentioned also some shortcomings, which are mentioned in the LO section.

4. An analysis of the pedagogical approach of the case

Nature of activities

The overall working process was structured by the teacher. He decided pupils' activities, and he was all the time the key person in the class; he gave the overall structure for the process, and within this structure, the pupils worked individually.

The pupils kept records about their own eating habits for 9 days. They used a simple template for that, and were independently responsible for keeping the record at home. At the computer class, the pupils also worked independently, in their own pace, and made own decisions, for example, as they substituted a dish with another (the missing dishes in the learning object). They asked for help, and helped each other in a natural way, but everyone was responsible for conducting his/her own work.

The content of the sequence was based on the pupils' own, authentic data; they reflected their own behaviour. We may suggest that this ownership was one reason for the active and good working atmosphere that the researcher observed in the classroom.

Nature of knowledge processing

There were several expert-like features in how ´knowledge´ was processed during the working process.

1) The teacher gave several perspectives to the content: the expert model in the learning object, the canteen manager and the nurse of the school.

2) The LO presented the content through several means, that is, the knowledge was presented from various angles (picture, text, numeral and graphical results of calories, etc.);

3) The knowledge that the pupils processed was authentic and meaningful;

4) The knowledge produced by the students (the content of the food diaries) was important, not only in itself, but as a source and means for further learning (in mathematics).

The responsibilities/roles of the teacher and the students

The teacher was the designer and organiser of the working process, and he structured the overall working sequence. He helped pupils in problems with the computers and gave technical advice; for example, he demonstrated the use of the CELEBRATE portal and the LO so well and clearly that the pupils managed well even during the following lessons. It was interesting that the teacher didn't really teach the content of the lesson; it was left to two other school-related experts and to the learning object.

The pupils were responsible for reflection and designing the product (the learning diary and its evaluation) themselves.

5. The evaluation of the learning object

The learning object had several roles: First, it was ***a tool*** for the pupils to study and which allowed them to reflect on their own eating habits. This was the main use during the process. It was also an ***assessment model*** and ***information source*** and thus gave ***an expert model*** about what constitutes a healthy meal. However, the learning object didn't "force" the pupils to do anything, for instance, compare own ratings to those of the program. In this sense it was an open tool. The learning object was also ***an exploration area***, in which pupils checked the nutritive value of meals.

Advantages of the learning object

Content: the knowledge (data, mechanisms and feedback about healthy eating) was provided through several means, which made it easy to understand.

Functions: the learning object was easy to use, which means that the 5th grade pupils (and the teacher) had no problems to use it technically. They also went to CELEBRATE demo portal independently, and selected the learning object after seeing the process once. The LO design was also clear and visually attractive.

Problems of the learning object

The content: the number of choices was too limited and also somewhat astonishing: several typical and common Finnish dishes were missing. It was not possible to write a personal explanation or a note on the result that the LO gave, and users had to choose one of the ready-made dishes. The teacher solved this by advising pupils to choose something similar.

Functions: it was not possible to write any additional information (e.g., a name, or a date) to the constructed meal, which made the use of the learning object less flexible. There was only one printer in the class, and the teacher had to be standing and delivering the prints to pupils, who then tried to check if they had a correct print. In this case the teacher solved the problem by helping the pupils to find the correct prints but he couldn't do much else; for instance, he had not time to guide the pupils in the content questions. Within time, the teacher organized the printing by following the printing order on his computer screen, which helped the situation somewhat.

It was not possible to save one's own notes. In order to get the work "saved", it had to be printed out. It would have been useful if pupils could have saved their work electronically in order to continue with their work later.

Case study 2 Do you know how to eat?

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1. An overall description

School 2 is an ordinary secondary school, located in a suburb of the City of Espoo. It consists of both lower- and upper-secondary grades. There are about 400 students in the school (aged 13 to 19; 250 in lower-secondary and 150 in upper-secondary level), and 40 teachers. School 2 participated in the Celebrate-project as one of the pilot schools. Most of the teachers use ICT for their teaching, and the skills of the teachers are rated from medium to high.

The female teacher of this case study had 20 years of teaching experience, and she had used computers for about 12 years in teaching. During the spring, the teacher participated in two long-term, in-service trainings for teachers ('Learning objects and network pedagogy' and 'Network pedagogy for subject teachers'). The teacher applied the same instructional design in a 9th grade group, and used that design as a project work for her training. She can be regarded as an advanced teacher in ICT in school level.

The school has an ordinary technological infrastructure typical for a Finnish school. There are 50 computers, which means about 9 students per one computer. All computers have a high-speed Internet connection. The computers are located partly in two computer rooms (10 and 15 computers), and partly in several other classrooms, especially in upper-secondary level (a few computers in each). The teachers can reserve the computer rooms rather easily when needed.

The case study was conducted on the English language lessons of a 7th grade (13 years old) group in lower secondary school. The students had studied English in school for almost five years. According to the teacher, the general learning skills of this student group was not very high. The teacher had conducted the same teaching and learning sequence with another, "more high-level" teaching group (according to the teacher) in another 7th grade group before this.

The learning object used was Healthy meal, which is available at http://www.edu.fi/oppimateriaalit/healthy_meal/. It is the same LO as in Case 1, but in English (see Figure 2). The type of the learning object can be regarded as an **Exploration**, according to the CELEBRATE Application Profile or metadata. An English textbook had a big role in the teaching and learning sequence: There were three paragraphs that dealt with the issues of food and nutrition, and an essential part of the students' activities in the whole teaching and learning sequence was working with the texts in them by doing oral or written exercises. The whole sequence included 4.5 lessons related to the learning object, and 5 lessons related to the textbook. All along the students collected vocabulary for their note books.

Figure 2. The main screen of the English version of the Healthy Meal LO.

The goals defined by the teacher were:

- Learning food and nutrition oriented vocabulary.
- Using acquired language skills as well as information on nutritional values and recommendations in a context directly linked to the pupils' own health and well being.
- Social interaction among students.
- Getting feedback on the effectiveness of preliminary work via the degree of usefulness of each student's own notebooks.

2. The structure and phases of the teaching and learning sequence

The unit was conducted over a three-week period, involving three 45-minute lessons per week.

In the first lesson, the teacher orientated the pupils to the new unit by telling them that they would study vocabulary related to food and nutrition; this topic was covered in a textbook paragraph. She explained that in this unit, each pupil would make their own vocabulary, but that the pupils could show their competence also by an oral presentation. She told them that they will study the vocabulary at a more advanced level than usual, since the vocabulary of the LO to that they would use is more advanced than the pupils of this age usually study at school (the LO is not particularly created for lower-secondary level or English language learning). The teacher presented the general guidelines for the whole sequence and for the final work using a

slide. After that, the teacher distributed some pictures of food and meals and asked the pupils to start collecting food vocabulary. The teacher drew a mind map in the black board including the main categories of food vocabulary (vegetables, milk products etc.). The pupils were asked to add words under the main classes highlighted on the black board and to write the main categories as titles in their notebooks. The collection of words under the main categories was given also as home work. At the end of the lesson, the teacher asked the pupils to return their seats, and the class listened together to a song named "Eat it" played on a tape recorder.

In the second lesson, the teacher divided pupils into five groups, each of which was responsible for one or two main categories of the food vocabulary. In the groups, the pupils shared the words that each pupil had collected in their note books. After that, one or two students from each group wrote the words of their group's food category to a cumulative list on the blackboard. During the group work, the students were also instructed to add words from blackboard to their personal dictionary in the note book. They did that till the end of the lesson.

The next five lessons were more traditional language teaching lessons, including, for instance, practicing pronunciation, grammar lectures, pair discussions, and doing exercises from the textbook. Only the last of these lessons was observed.

The following two lessons took place in a computer room. In the first lesson, the students practiced using the Healthy meal LO. At the start of the lesson, the teacher gave instructions about finding the LO, and assigned the students to work in pairs and to try all choices for constructing healthy meals. There were some technical problems: the mouse of two computers did not work, and the pupils using those computers moved to other groups. The teacher fetched new mice from another computer room. The teacher handled these technical problems smoothly and peacefully, and, eventually, all the pupils had gone through the choices in the LO. When pairs of pupils had completed this activity, they were asked to start planning their final work. In the second lesson, the student pairs elaborated their final work (either a healthy meal recommendation, a dictionary, or a piece of drama) using computers and the LO. The students asked some questions about using the LO but, generally, they appeared to manage with it very well. The pupils' technical problems were related mainly to the XP operating system, which was new for them.

The last (tenth) lesson was in a regular classroom. First, the teacher went through all the pairs asking the state of their final work. Two groups had not completely finished the work. Then, seven student pairs presented their final work orally in short (1-3 minute) presentations. There were two dramas (fictional persons talking about healthy eating), three meal recommendations (printed from the LO), and two dictionaries presented. At the end of the lesson, the teacher asked the pupils about their experiences in using the LO. The pupils said that it was useful; it helped them learn the vocabulary, because it was so concrete and combined pictures and text.

3. The teacher's evaluation of the teaching and learning sequence

The teacher was especially satisfied with the students' motivated and active working, and their capability to succeed in accomplishing a challenging task that they were faced with during the sequence. The only improvement that the teacher mentioned concerning the design of the sequence related to timing and scheduling.

The teacher thought that the LO was easy to use, and a good knowledge source in English lessons; it suits students in various levels if supported with vocabulary. The teacher speculated that the content may require localisation if used in other countries.

4. An analysis of the pedagogical approach of the case

Nature of activities

The sequence included various kinds of successive activities through which the pupils studied food and nutrition vocabulary from several points of view, individually and collaboratively. Each lesson was planned to include certain activities. The activities supported, for instance, the activation of prior knowledge (collecting words), multiple perspectives (reading text chapters, practicing pronunciation, exercises, pictures and text in the LO, writing and sharing dictionaries etc.), collaboration (group tasks), and creation of knowledge (own dictionary and final works), and authentic tasks (the dictionary was made as a personal tool for using the LO).

Maybe it is typical for language teaching that students' work consists of multiple smaller activities that promote practicing of language skills from several viewpoints. The sequence described above can be seen to include two main components within each other: typical and traditional language learning parts following the textbook, plus more open-ended part including advanced-level usage of vocabulary using the LO, creating own dictionaries, and making the final works.

Nature of knowledge processing

There were several expert-like features in how ´knowledge´ was processed during the working process.

1) The LO gave an expert-like perspective to the content: the vocabulary was more advanced than the pupils of this age usually study at school. It gave the students an extra challenge, which the teacher used to motivate the students to collect and learn new vocabulary;

2) The learning object presented the content with several means;

3) The pupils were assigned to make their own personal dictionary. Through the dictionary, the students were processing knowledge for their own use, and they had to take personal responsibility of the usefulness of their work for subsequent use. It gave them ownership to the content to be learnt, and the elaboration of the dictionary was a continuing, integrative process during the whole sequence;

4) The pupils were promoted to share their expertise and knowledge of food vocabulary by collaborative tasks,

5) The pupil pairs were allowed to choose the type and content of their final work themselves, which supported pupils' ownership of the task, and enabled multiple perspectives to the knowledge.

However, the sequence also included elements that were related to the textbook and were practiced partly separately, although the context was related to the theme of nutrition (e.g., the grammar exercises: "You should eat less salt.", or "If I ate all that, I'd be fat in a week."). Maybe it could have been possible to integrate, for instance, practicing of the grammar or pronunciation also with the authentic texts written by the pupils in finals works.

The responsibilities/roles of the teacher and the pupils

The teacher was the designer and organiser of the teaching and learning sequence. The teacher gave the pupils good guidelines about the goal and structure of the whole sequence of lessons at the beginning and also guided the pupil groups during the activities in the classroom; she walked around from one group to the other and discussed the groups' work quietly without disturbing other groups.

The pupils were individually responsible for creating their own dictionary. The teacher explained to pupils several times that it was important to spend time making a good personal dictionary because it would then be an extremely useful resource when they came to use the Learning Object. The pupils also worked in pairs and were responsible for the creation, completion and presentation of their final work.

5. The evaluation of the learning object

The learning object had two roles: First, it was an ***information source*** for pupils in their study of food and nutrition vocabulary. Then it was an ***expert model*** for using advanced-level vocabulary in a context simulating an authentic situation.

Advantages of the learning object

Content: The knowledge (= vocabulary) was given via several means, which facilitated learning and remembering. The language was used in an authentic and complex context, which provided a more expert-like situation for learning vocabulary than using only the textbook.

Functions: The LO was easy to use, which means that the 7th grade students (or the teacher) had no problems using it technically. The teacher thought that the LO was good and well made.

Problems of the learning object

There were no explicit problems in using the LO, maybe because the content of the LO (nutrition and health) as such was not critical in this case; the main goal was to learn English vocabulary, not nutritional issues as such.

Case study 3 Senses and the brain

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1. An overall description

The case study 3 was conducted in the same school (School 2) as Case 2. The female teacher of this case study had about 15 years of teaching experience, and she had used computers for about 10 years in teaching, but not very much. She had ordinary ICT skills, but needed help with more advanced technical issues (according to her own description). She can be regarded as an ordinary level teacher in ICT.

The case study was conducted with a group of 9th grade (15 years old) pupils in Finland studying Biology. According to the teacher, the overall competence of this student group was not high, and there were also difficult social problems inside the classroom community.

Several Learning Objects from multiple sources were used in the case:

a) Four LOs from a Finnish LO bank that included LOs for several school subjects. The type of these LOs can be regarded as **Drill-and-practice**, according to the CELEBRATE Application Profile or metadata.

The structure of the eye: http://www.perunakellari.fi/silma.htm (see Figure 3)

The vision: http://www.perunakellari.fi/nako.htm

The ear: http://www.perunakellari.fi/korva.htm

The nervous system: http://www.perunakellari.fi/hermosto.htm

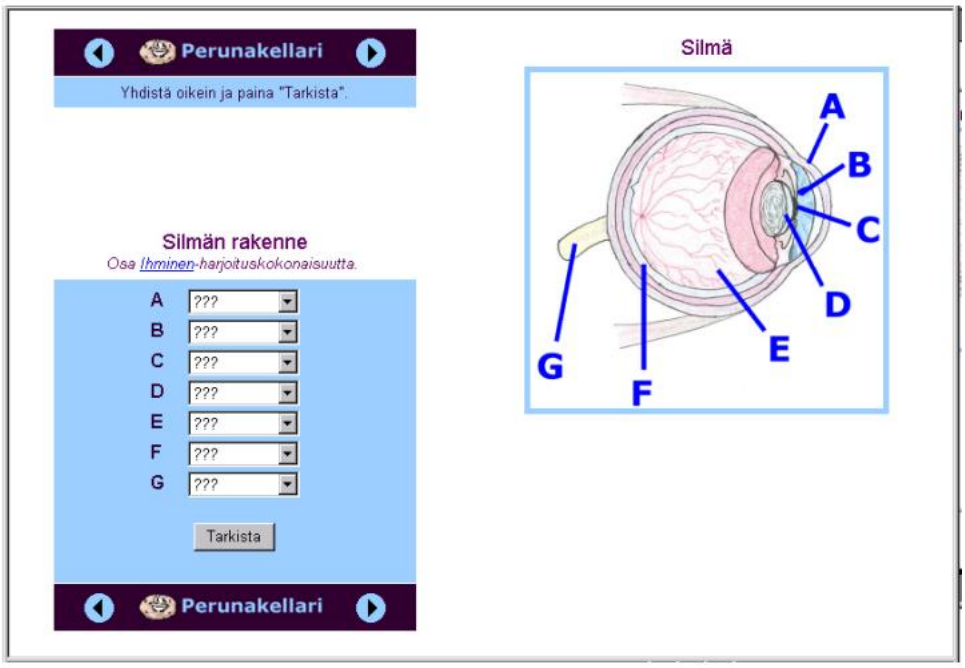

Figure 3. Drill-and-practice LO about the structure of the eye.

b) Hypertext materials from the Web (in Finnish). The type of these LOs can be regarded as an **Information source**, according to the CELEBRATE Application profile or metadata.

The structure of eye: www.nkl.fi/yleistie/tietopaketti/kalvo3.htm

The structure and functioning of brain: www.biomag.hus.fi/braincourse/L1.html

c) LOs from the CELEBRATE demo portal (in English)

The ear - sensory cells (the type of this LO is **Information source**, see Figure 4): http://celebrate.ls.no/english/animations/science/orets_sanseceller.swf

The eye - sensory cells (the type of this LO is **Information source**; similar as The ear LO):

http://celebrate.ls.no/english/animations/science/oyets_sanseceller.swf

The Human brain (the type of this LO is **Drill-and-practice**; you should put the names of the brain sections in the right places):

http://celebrate.ls.no/English/Animations/Science/hjernespill_enkel.swf

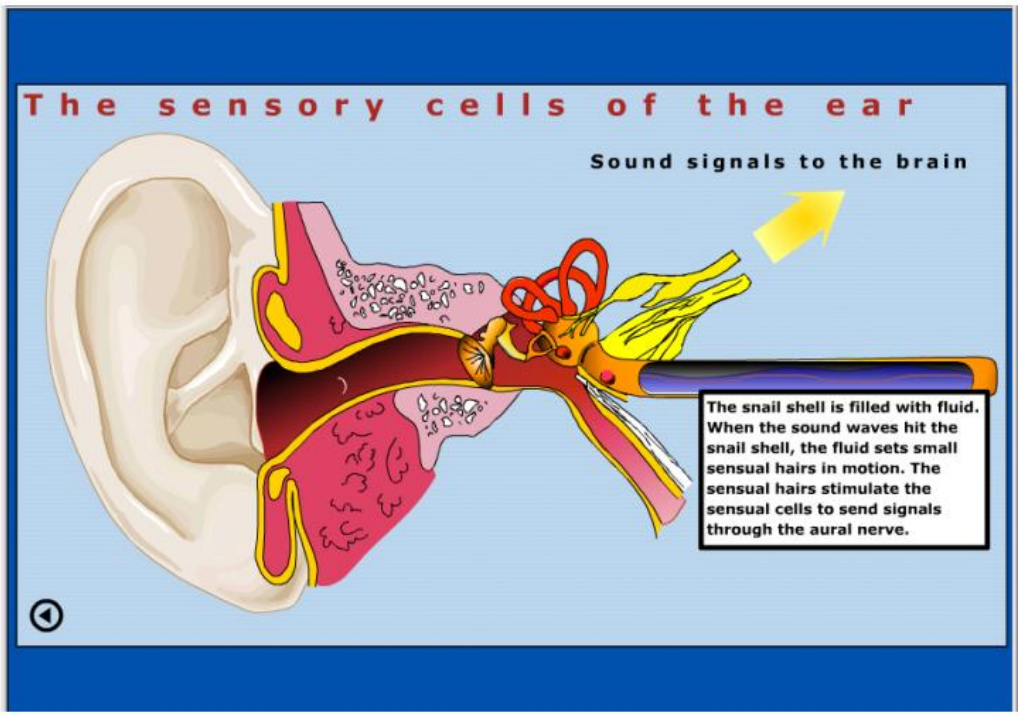

Figure 4. One screen from The ear – sensory cells LO.

The teacher made four papers, including tasks about the parts and functioning of the eye, ear, and brain, and instructions for how to carry out a piece of research. In addition, the students used their biology school books, and there were plastic models of the eye, the ear, and the brain available in the classroom. For the final work, the students also searched for information by using the Google search engine.

The goals defined by the teacher were following:

The students will learn the basic issues (presented also in the school book) about the structure of the eye and ear, the origin of sensation, and general outlines of the functioning of various parts of the brain.

2. The structure and phases of the teaching and learning sequence

The unit was conducted over a three-week period, involving two 45-minute lessons per week.

The first lesson took place in the biology classroom, in which there were four computers. The pupils were divided into five groups, and the teacher asked the groups to take one computer, and start working with either the eye, the ear or the brain tasks and related LOs. Three pupil groups went to the computers, but two groups had nothing to do (the teacher had originally assumed that they would have also had the geography classroom available with four computers). Therefore, the teacher gave

those groups separate instructions to start planning the research work. The first task was to create a research question that interested the group about any topic that related to the functioning of the senses or the brain. One group took the free computer in the biology classroom, and used Google for information search. The other group went with the teacher to a computer classroom. When the teacher came back, she walked around the classroom and guided each groups separately. After finishing the first task, two groups (working with the ear and the brain LOs and tasks) changed computers with each other, and started the new tasks. When the group that had made the tasks about the eye was finished, they started to plan their research work after getting instructions from the teacher.

In the second lesson, the computers in both biology and geography classrooms were in use (adjacent classrooms). The teacher ordered the pupils to continue their group tasks. All students went to the biology classroom, and one group went to the geography classroom to do the tasks about the ear only after the teacher guided them to do so. The pupils did not seem to be sure about what to do, where, and in which order. The teacher walked round the groups and gave guidance for each group separately. After a while, the teacher gave two groups a practical task that involved preparing a frozen eye of a pig, and to recognise the parts of eye from it. Because the preparation made some boys feel sick, they could not look at the preparation, which was made by two girls. The pupils of the other groups filled in their task papers, partly with the help of the LOs, partly by copying answers from other students' papers. Some pupils just walked around.

In the next two lessons, the pupil groups worked on their research work, using Google and writing a text document about their research question. In the first lesson, some students still completed the tasks paper. The second lesson was in the computer classroom which had nine available computers. After the groups' document was ready, the teacher ordered the groups to save it in a project folder in a common server. There was some technical problems in the saving (the XP operating system was new in the school), but eventually all groups succeeded in saving their research work document on the server.

In the last (fifth) lesson, each group commented the work of one other group by loading the document from the server, and writing their comments at the end of the document. Also the teacher commented on each document after the lesson. There were, in all, five documents from the following subjects: How UV-radiation affects the eye, Dystonia, Autism, Schizophrenia, and Psychosis. The documents were 1 to 2 pages long. About half of the lesson was reserved for that; and then the teacher started a new teaching sequence on another topic.

3. The teacher's evaluation of the teaching and learning sequence

The teacher thought that the students were motivated to conduct most of the tasks during the sequence, and thought that especially the problem-based task was

important because it required students' own elaboration. After the first lesson, the teacher mentioned that the LOs appear to have promoted concentration and thinking: After the second lesson, she evaluated that the novelty effect of the LO usage had decreased.

4. An analysis of the pedagogical approach of the case

Nature of activities

The activities in this case study were a mixture of highly-structured, fact-oriented tasks, hands-on lab activities, and an open-ended, problem-based task. The various tasks and activities did not integrate very well with each other, especially the fact-oriented tasks and the use of the LOs did not relate directly to the problem-based task. All the working was planned to be very collaborative, because the pupils worked in groups during the whole sequence, and the groups also commented on each other's work. The idea was good but, in practice, the organization of group work into various activities seems not to work very well, and the students were apparently not always sure, what was expected from them, which can be concluded from the students' questions and wandering around the classroom during the lessons. Apparently there were too many different elements included in a short period. Although the idea of some tasks was good, the time for each task was too short to get the tasks well conduced.

Nature of knowledge processing

There were some expert-like features in how ´knowledge´ was processed during the working process.

1) The pupils were assigned to make their own report in groups, based on their own research question under the main topics.

2) The pupils used authentic information sources from the Web in the research-like task.

3) The pupils had a possibility to compare the conceptual knowledge about the parts of the eye to a real parts of a pig's eye.

However, the sequence also included tasks (especially related to the LOs), in which knowledge was presented in a very factual manner, and the pupils just copied the right answers from the materials, from textbook or from each others' papers.

The responsibilities/roles of the teacher and the pupils

The teacher was the designer of the tasks and organised the groups in the teaching and learning sequence, and she had prepared task papers beforehand for the tasks. The teacher also actively guided each pupil group separately during the activities in the classroom. However, the teacher did not give pupils very clear structure or orientation for the whole sequence, and that caused some confusion during the lessons.

The pupils were in groups responsible of filling in the task papers and making their question-driven report.

5. The evaluation of the learning objects

The learning objects had two roles: First, they were ***information sources*** for pupils in their study of the parts and functionality of the eye, the ear and the brain. Then they were ***sources of evaluation,*** with which the students were supposed to check the rightness of their answers in the task papers.

Advantages of the learning objects

Content: The knowledge was given in several means (pictures, text, animation, drill-and-practice tasks).

Functions: The LOs were easy to use, which means that the 9th grade pupils (or the teacher) had no problems in using them, but they were also very simple LOs.

Problems of the learning objects

The learning objects that were available in the Celebrate portal (or in the Finnish LO bank) for the topic, were pedagogically rather low level drill-and-practice LOs or narrow information-source LOs presenting only some facts or concepts, which was mentioned also by the teacher in a meeting before the case study. Therefore, the LOs did not help the ordinary teacher to apply more high-level tasks and activities; on the contrary, they promoted the fact-oriented knowledge processing approaches. The CELEBRATE LOs about the eye, the ear, and the brain were also in English, which was a little problematic according to the teacher. There were also other LOs of this topic in the CELEBRATE portal but the English vocabulary in them was too advanced for the students and they were not selected.

Case study 4 Multiple-intelligence and learning objects

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1. An overall description

School 4, an upper secondary school, is located in a rural community at the Finnish metropolitan area. In a national assessments, the school has been ranked among the 10 best upper secondary schools (in Finland the information about school assessment is not public.) There are about 160 students in the school (aged 16 to 19), and 25 teachers. The school participated in Celebrate-project as one of the pilot schools, and the teacher of this case study was the contact teacher in the Celebrate pilot use. Some of the teachers have used ICT in education, and the ICT-teacher estimated the level of the teachers' ICT skills as from medium to high.

The male teacher of this case study had about 20 years of teaching experience, and he had used ICT for about 12 years with pupils. During the recent years he has especially used virtual discussion and collaboration tools. He is active also outside the school; he has been training other teachers on national level about using ICT in education, and he has been developing ICT-based learning material. He can be regarded as a pioneer of ICT usage in education. He can be regarded as a national-level actor in ICT in education.

The school has an ordinary technological infrastructure typical for a Finnish school. There are 60 computers together with a lower-secondary school, which means about 5 pupils per one computer. All computers have a high-speed Internet connection. The computers used in this case are located in a room, which is small and cramped. In the room, there are about 20 computers for the pupils and one for the teacher.

The case study was conducted with a 1st grade (16 years old), upper secondary group of pupils in Finland studying health education. The learning objects used were the following:

a) *IQ-Learn*, a combination of a tool, en exploration and a tutorial for self-reflection made in Helsinki University (the type of this LO can be regarded as a **Tool, Exploration** and **Guide**, following the CELEBRATE classification, although it was not a CELEBRATE LO): http://iqform.edu.helsinki.fi/iqlearn/ (see Figure 5). Anybody can use IQ-Learn for free after ordering themselves an own user account.

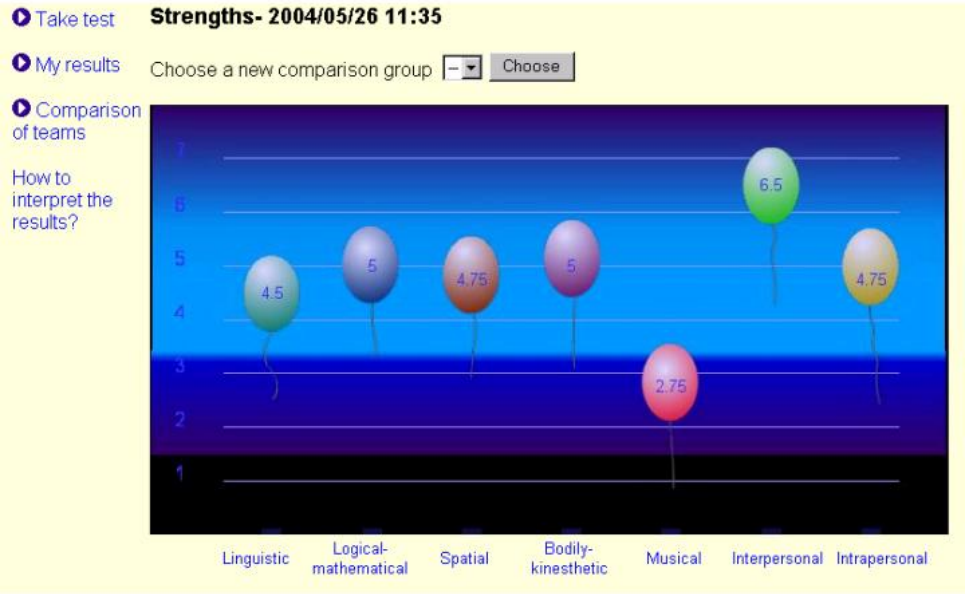

Figure 5. An example of the result screen of the IQ-Learn.

b) *Mind Manager*, a commercial program for creating mind maps (the type of this LO can be regarded as a **Tool,** following the CELEBRATE classification, although it was not a CELEBRATE LO): http://www.mindjet.com/.

c) Several (dozens of) learning objects in the CELEBRATE Demo Portal; they were of various types, mainly **drill-and-practice** type: http://demoportal.eun.org/celebrate_dp/index.cfm,

The pupils also searched learning materials by using the Google search engine, and used *Ryhmix* groupware, which includes, e.g., threaded discourse tools and documents sharing facilities.

The goals defined by the teacher were the following:

- The students will learn to observe that there are different kinds of intelligence, and everyone is gifted in some ways; areas of strength can be developed, and the students' understanding of multiple-intelligence strengthens their self-confidence.
- A practical goal of the case study was to test if the CELEBRATE DemoPortal and the CELEBRATE learning objects can be used independently by students, and to let them evaluate the usefulness of the learning objects themselves. (In this sense the case was interesting and unique; in the other Finnish case studies the teachers chose and organized the use of the CELEBRATE learning objects.)

2. The structure and phases of the learning/teaching sequence

The overall working process was structured by the teacher. The working process was divided into two phases: an intensive face-to-face working period (mainly) during one week and a longer virtual period, when students continued the discussion in network environment for three weeks. Before the sequence, the teacher briefly oriented the students to the topic by describing the upcoming period. This happened just before the pupils went on holiday for a week.

First two lessons (2 x 45 minutes). The work started with a teacher's presentation as an introduction. After that the pupils started to test themselves with an IQ-Form test to find out their strong areas of intelligence. They continued the work by making an individual mind map about themselves using Mind Manager. At the end of the double-lesson, the pupils wrote the first notes in the virtual discussion forum concerning the question "How could I develop my strong area?". They also started to search for any LOs from the CELEBRATE DemoPortal (and later from whole web with search engines) that would be useful for developing their intellectual capacity; they continued this activity during *the third lesson*. The teacher had selected several potential CELEBRATE LOs for the search to help students in the beginning, but he encouraged the students to use also the whole DemoPortal as an LO library. The pupils linked the learning objects to the virtual discussion forum and commented on them. During *the following two lessons* the pupils were advised to complete the first mind maps with the new ideas and comments, which they have got during the process, and to connect the mind maps to the virtual discussion forum. The pupils also continued the virtual discussion.

After the face-to-face period, the pupils continued the discussion for three weeks in the virtual forum. At the end of the course, four weeks after the first lessons, there was a lesson for a summary of the process (*the last lesson*). This final lesson involved an external expert (a teacher of psychology) who first gave a short introductory lesson about research into intelligence including what are the modern conceptions and applications of intelligence and how intelligence is measured. After this, all students, alone or in pairs, gave a presentation about each of the areas of intelligence. Some of them also presented how the mind maps reflected their own ability and strengths. All the outputs were evaluated at the end of the course. The network discussion constituted 50 % of the final grade, and the remaining 50 % came from the final exam.

3. The teacher's evaluation of the teaching and learning sequence

The teacher was satisfied with the design, although he thought that students' time could be saved so that the teacher seeks good LOs ready for the students. He also described that through this experience he had understood that LOs can be a good extensions to network learning, which he regarded the most important. But the teacher

also speculated that there is a need for more complex and pedagogically more elaborate LOs, especially for secondary schools.

4. An analysis of the pedagogical approach of the case

Nature of activities

The teacher was the designer and the organiser of the process; he gave printed guidelines for the working sequence, he had pre-structured the discussion forum topics, he had chose beforehand a number of suitable Celebrate learning objects for the pupils, and he arranged an external expert visit. His role as a technical support was important. He demonstrated the use of the CELEBRATE DemoPortal and the LOs so well and clearly that the students managed well even during the following lessons. He helped students in problems with computers, and he handled the technical problems during the working period.

The teacher was especially experienced in guiding the use of the virtual discussion. His guidance was mainly directed to individual pupils in the classroom, and he could also solve the technical problems so well that they didn't cause any harm for the pupils. It was interesting that the teacher didn't really teach the content; it was left to the other school-related expert and to the IQ-Form learning object.

The pupils were active participants during the sequence. However, the students had to do so many activities that processing the content perhaps remained less important. There was this kind of a feedback from the pupils; they would have liked to have more virtual, in-depth discussion of the topic under study.

Nature of knowledge processing

The working sequence was based on processing the content from various points of view. The pupils used different kinds of virtual sources from the net, and they had several tasks, which all aimed at processing the content. (The teacher described his approach often as 'emergence'.)

In the pupils' feedback, the possibility for virtual discussion was highly appreciated. Several pupils thought that by discussion and argumentation they learned more, and became more motivated in the topic. There were probably several reasons for that: the discourse helped to clarify one’s own ideas; before writing the students had to think what they wrote and thus, e.g., read about the topic; virtual discussion promoted students' activity; the longer processing time helped learning, and it was democratic: everyone could write to the common forum.

The process can be said to, especially, have supported meta-consciousness about one's own competences by the use of the test, making the mind maps, presenting ideas in a discussion forum, and even by the face-to-face presentations.

The responsibilities/roles of the teacher and the students

The teacher was responsible for the structuring and organisation of the activities, and for the technical support.

The pedagogical approach emphasized the pupils' responsibility and activity in thinking and processing the content of the theme. The pupils were responsible for conducting the reflection process, searching for and evaluating the learning objects, and participating in virtual discussions. However, the pupils had a clear structure and timetable within which they worked.

The lesson observations and the discussion forum notes revealed that all students participated and probably felt ownership in terms of the topic; for instance, in their written feedback after the course, several of them continued to talk about intelligence as a kind of continuum to the virtual discussion. This was certainly a result of the authentic approach: students were guided to think about intelligence based on their own "intelligence test" and the elaboration of the mind map.

5. The evaluation of the learning objects

The pupils used several learning objects. The IQ-Learn was used as **an exploration and reflection tool**. The Mind Manager was **a tool** for making mind maps, which also allowed pupils to reflect on the nature of intelligence. The CELEBRATE Demo Portal acted as a learning object library for the students, and the learning objects of the portal were **objects for evaluation**, based on how useful students found them for developing their various areas of intelligence. Because students evaluated all possible learning objects in the CELEBRATE DemoPortal, it is not possible to define exactly, which ones the students used. They wrote just a common evaluation, which can be regarded as an evaluation of the possibilities and functions of the whole DemoPortal.

Advantages of the learning objects

Students thought that *IQ-Learn* was rather interesting, and it stimulated the discussion and argumentation about intelligence. It also consisted of a large knowledge base about the topic, which was found useful and which students probably applied during the virtual discussion. In a way, this learning object was the basis for the whole course. The content was the basis for the following discussion, and the structure of the content formed the structure for the mind maps and for the virtual discussion.

Mind Manager was familiar to the students beforehand. In this process, it helped the students to form quickly a visual outlook of their own thinking.

The CELEBRATE DemoPortal and Celebrate learning objects were used as a kind of library. The experiences showed that students could easily use the portal independently, they tried several learning objects and found some of the evaluated learning objects to be helpful to develop some specific area of intelligence.

Problems of the learning objects

The problems of the learning objects of the CELEBRATE DemoPortal can be divided into three types:

1) The DemoPortal was still under construction when the case study was conducted. This caused some problems; e.g. during one of the few face-to-face lessons the Portal went down and the students could not use it. For school it is always a challenge to use applications, which are prototypes. Typically a teacher plans to use the application during a certain lesson and if the application is unavailable at this time, it can only seldom be used during the following lessons.
2) The students reported a number of rather undefined technical problems with several of the LOs, suggesting, for example, that the LOs were "technically unsure" or "went off several times". As the case study was carried out in February-March 2004 it is possible that some of the comments reflect the fact that students were possibly using prototype LOs that had not been fully tested on the Demo Portal.
3) At the time of this evaluation, the students did not find sufficient LOs for age 16 and above; they suggested that most of the CELEBRATE LOs in February - March 2004 were mainly designed for younger students or primary and lower secondary school levels.
4) Maybe this kind of activity is not the best way of evaluating LOs. Students didn't have time to concentrate well in each LO, and only the LO, which were user-friendly and quick to understand, were picked and evaluated. Students didn't spend time to overcome e.g. technical problems of a LO; they just left it.

National conclusions

The nature of pedagogical practices

The learning activities in all four cases under study represented “advanced pedagogical practices” in many ways. All cases supported authentic activities, at least, to some extent. The students did activities, for which they were responsible; the process concentrated on self-reflection (as in case 1), the activities were designed by the students (as in cases 2 and 3), or the starting point was highly student-centred (as in cases 1 and 4). Especially in case

1, the results of the process (the exact amount of calories, nutritive values etc.) were used also in mathematics lessons later; the students used the data, which they had produced by themselves, as a source for tasks in mathematics. Of similar importance, for supporting the students' ownership was the personal dictionary in case 2.

Especially in cases 1 and 4, the teachers broke away from the usage of schoolbooks; they relied totally on other information sources: learning objects and other materials from the Web, external experts, and the students own knowledge sharing. In cases 2 and 3, the schoolbook was still a basic element in structuring the content to be learnt. In all cases, the learning content was enriched by other experts: learning objects (in all cases) or other human experts (in cases 1 and 4). In this sense learning objects gave extra value for learning.

In all cases, the students and students collaborated in a meaningful and natural way, even though they carried out individual tasks. They helped each other and shared expertise, e.g., by showing drafts to each other or by discussing virtually. This is probably based on the freer working atmosphere when using computers. Similar results have been reported, for instance, by Schofield (1995).

The usefulness of the learning objects

In all the cases, the learning objects were used as an important part of the teaching and learning sequence. Especially the cases 1 and 4 which were based on the use of the learning objects, and the learning objects actually structured the content to be studied.

The cases 1 and 2 revealed that a well-designed LO can be used in various learning settings, with students of different ages and grades, and in various subject domains. The main reason was the pedagogical affordances of the LO: it supported a student-centred exploration, which offers possibilities for a variety of pedagogical activities. Originally, the LO used in these cases was produced for vocational education. Also the functional and user-friendly design made it re-usable, as the idea of learning objects should be, described, for instance, by Collis and Strijker (2001–2002).

One problem, especially in cases 3 and 4, was the narrowness (both in content and in pedagogy) of the LOs available in the CELEBRATE Demo Portal. In case 3, the learning objects did not help the ordinary teacher to apply more high-level tasks and activities; on the contrary, they promoted the usage of fact-oriented knowledge processing tasks. In case 4, the teacher and the students found it difficult to find proper learning objects for their subject domain and secondary level curriculum. Though, the CELEBRATE project did not even concentrate on producing LOs for psychology. Maybe the usage of the learning objects was unnecessary in these two cases; they did not seem to bring much added value to the students’ activity compared to other, more challenging and meaningful tasks in the sequence.

The importance of teacher's pedagogical ICT competence

In the studied cases, learning objects were mainly integrated as natural parts of the teaching and learning sequence. One of the most important reasons for this was probably that teachers in the cases 1, 2 and 4 had good ICT skills and they were used to use technology with their students. In line with what Lim and Barnes (2002) presented in their case study, the teachers of the cases 1, 2 and 4 had the necessary attitude, skills and knowledge to identify the cognitive opportunities and limitations of the programs, and plan and organise activities to take up its opportunities and address its limitations. In these cases, the activities related to each other in a flexible and meaningful way. The less advanced teacher in case 3 had problems in organizing the process; the activities didn't form a clear entity. In case 4, the CELEBRATE Learning objects were perhaps a somewhat detached part of the sequence because they were used in an unusual way (students evaluating their value in developing various types of intelligence); but the idea of students evaluating LOs was interesting and worth trying.

Working with ideas or working with tasks?

Ordinary teaching practices concentrate on students' tasks and activities. The design of more challenging activities is often difficult and the nature of the learning activities might contradict the high-level goals of learning. In cases 3 and 4 there were signs of this kind of contradiction: although students were active, they had to do so many activities that processing the content was perhaps less important. This has similarities with the findings of Law, Lee, and Chow (2002). They argued for working with *ideas* instead of doing *activities*, following the ideas of Scardamalia (2002); she made a distinction between *idea-centred* and *task-centred* education.

Teacher as an organiser and guide in the process

In cases 1, 3 and 4, the teachers had a facilitating and guiding role; they spoke explicitly about the substance only seldom. The learning objects, books and the external experts were responsible for the content. In case 2, the teaching and learning sequence included also parts, in which the teacher explicitly taught some parts of the substance (e.g., English grammar or pronunciation), but the main emphasis also in that case was the students' own knowledge seeking and collaborative knowledge creation: students created together dictionaries and produced presentations about healthy eating.

In all the cases, the teachers appeared to have a clear design about the ways, in which the students' activities and collaboration would be organized. In cases 1, 2 and 4, the overall structure, and the main goals of the sequence was also explicitly presented to the students through written guidelines in the beginning of the sequence. Especially in case 2, the teacher also gave students, on several occasions, metalevel explanations and reasons about good and wise ways of working. In case 3, the teacher did not model the overall goal and

structure of the whole sequence so explicitly, and it probably caused some extra confusion and disorientation in the students during the sequence.

French cases

Case study 5 Water cycle

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1. An overall description

This case study focuses on a primary school[1] in the centre of the city of Nancy. It is a privileged establishment, dynamic in its use of ICT, and always at the cutting edge and enthusiastic when it comes to innovative projects. There are about 250 pupils and some ten teachers. Several of the permanent staff are qualified to supervise trainee teachers and have them in their class throughout the year. This increases their work-load, but also permits more flexibility when classes are split in two.

The principal, who is highly involved and competent, manages the computing and network equipment. His scope for action is limited however, because Greater Nancy metropolitan council, a local government body, funds schools and is responsible for their maintenance. Exceptionally, the principal nevertheless has the network administration code, which enables him to install more or less what he wants, in accordance with the needs of the teaching staff.

This school made extensive use of CELEBRATE learning objects, and four teachers were involved in the project, three of them to a greater degree than the other.

The case study outlined here involves a teacher with significant professional experience, but little or no ICT experience. The case study was conducted on children in the CM2[2] class (for 10 to 11 year-olds) The teacher mainly teaches writing, and had never organised a learning sequence using a learning object, so it was her first time. She is very enthusiastic and always keen as far as innovative experiments are concerned. The school's teaching team is very close-knitted. This was why, in spite of her total unfamiliarity with the area, she accepted to participate in the project. She knew that she could count on colleagues with more experience in this area. She also knew that she would have the PUEL's technical support, as promised.

This year, Nancy City Council is completing installation of ICT equipment and broadband Internet connections in all of its primary schools (primary schools come

[1] Translator's note: the French name for this school is an *école primaire d'application*, which is a designated primary school where trainee teachers acquire their practical experience.

[2] Translator's note: CM2 is the *Classe moyenne, deuxième année,* (second year of the intermediate class). It is the last year of primary school.

under the responsibility of local authorities). The school therefore has a computer room with about ten high quality terminals. They are not all the same however, because new terminals have not replaced old ones but have been introduced alongside them. The operating systems are therefore different: the new ones have Window XP and the old ones have Windows 98.

In agreement with the principal, the PUEL organised to have somebody prepare the computer room so that it could be used for the project. This required about two hours of work, to download all the plug-ins onto each terminal. The fact that not all terminals were the same turned out to be a major handicap during the sessions. The computer room is often in much demand, and it is not easy to organise something on a sustained basis.

The case study took place over two sessions, one week after the other and involved two groups of nine pupils from the CM2 class. The learning/teaching objective of each session was the same, although the sheet to be filled in by pupils was modified for the second one, to make up for software problems which came to light in the first one. The two groups were fairly similar, and there was a very good atmosphere. There was a good level of understanding between the teacher and her pupils. The learning object selected was “The water cycle”, by the French publisher Hachette Multimédia.

http://www.hachette-multimedia.com/celebrate/data/HMLOESPG0000EN/global.swf

Drill and practice, exploration

Figure 6. The water cycle LO

The goals defined by the teacher were as follows:

In the explanatory sheet, the teacher presented the session as an activity for discovery, research and sharing. The aim of the object was to provide an understanding of the different stages in the water cycle, the three different states, and the energy required for making the cycle go round. The teacher felt that the presentation of the various reservoirs and necessary residence times was too complicated for CM2 pupils. She therefore planned to skim rapidly over these notions during her learning sequence. It should furthermore be noted that the publisher, Hachette, proposes that the sequence should be used for pupils aged 11 to 15 years. Primary school teachers had apparently estimated that they could use the object to construct sequences for their pupils. The teacher made the most of the activity by having pupils write up notes on some of the information they gathered. The tools proposed and the web links were interesting and exploitable during the session.

2. The structure and phases of the teaching and learning sequence

The session was quite strictly supervised. The stages were clearly set out in advance. They were based on the sequence imposed by the LO structure, with each screen corresponding to a different stage. This session lasted one lesson, around 45 min / 1 hour, and it was conducted with both halves of the class.

1. Getting the computers going was complicated
2. Distribution of the sheet to be filled in
3. First: note taking, information and definition research
4. Second screen: research and observations
5. Third screen: research and observations on more detailed elements
6. Fourth screen: too complicated, and to be gone through quickly, as the percentages are not comprehensible for pupils. This part was not exploited.
7. Fifth screen: a further observation phase
8. Sixth screen: go to the research and help tools, master the definitions and test the proposed web links, especially the game

This seemed to be highly ambitious. The sheet prepared by another teacher for the second session is provided in the appendix 1 (A sheet used in Water cycle). It outlines the approach desired by the class teacher, whilst attempting to sort out the technical problems which interrupted the learning process during the first session. This task was ultimately impossible to achieve.

3. An analysis of the pedagogical approach and an evaluation about the pedagogical role of the learning object

It is difficult to separate the analysis of the pedagogical approach and the critique of the software, because the former is so dependent on the latter.

It was intended that the first session should be highly structured. The teacher was not able to prepare the room before the session. The children were clearly not used to using computers. Oral instructions were therefore given:

- To set up the Internet connection
- To go to the site and provide the username and password
- To go to the basket
- To select the object
- To start it up

The technical assistance offered by the PUEL to the teacher turned out to be crucial. It is probable that if she had been alone, she would not have succeeded in starting up the object. Several long minutes went by before everybody was in front of the first screen. Because some computers were not as powerful as others, the downloads and animated graphics did work at the same speed, which made it considerably harder to manage the session.

The pupils were free to navigate through the LO. They only received one instruction, which was to follow the approach proposed in the sheet and to answer the questions.

The approach was primarily based on discovery and observation. It did not entail knowledge building, and facts were provided in a highly explicit manner. Pupils had to take in the information and note it down on the sheet.

The software's graphics were not very clear, and on the first page the stages of the cycle were mixed up with certain parallel phenomena. From the outset, pupils had a mass of information, most of which was completely new to them.

The teacher's instruction regarding the first page – "click on each stage to understand fully" – was not possible at this level, because the instruction in fact referred to another highly similar screen which came up later on. The only thing pupils could do on the first screen was to look at the graphic animation and try to understand. Then they got lost and were unable to answer the initial questions. A window occupying the whole screen indicated that when pupils come to the end of the stage, they should then go on to the next one. It was not possible to stay with the image or to go back, even slightly. The "previous" and "next" buttons did not generally lead back to the

previous screen, but rather to the beginning of the preceding sequence, and all of the information was lost. The screens were poorly identified.

The pupils navigated through the screens and went fishing for information. They gave a strong impression of doing more or less whatever. There were no instructions on how to use the tools, notably the memo function. Naturally nobody could find all the existing information.

This was a discovery activity that quickly turned into anarchy. The teacher nevertheless remained serene in face of the attitude of the children, who seemed to appreciate the session and remained active and highly disciplined throughout. However, on several occasions the technicians present were asked to help out, in order to put pupils who had got lost back on the right track. The teacher let them get on with it, because it was clear that she felt herself incapable of giving guidance on how to use the software. She seemed to make a distinction between the technical part, which was unfamiliar to her, and the learning aspects she was responsible for.

Information which could have enabled pupils to answer all of the questions included in the sheet was scattered around the screen, and was sometimes even in the tools and memo function, which would therefore have to be opened.

The work was carried out individually, with no contact between pupils. Each one had to search for the information alone and autonomously. The teacher's role uniquely consisted in helping pupils who had got stuck because they had misunderstood a question, although this was rare. The need to break the pupils' progress by providing opportunities for sharing information turned out to be crucial.

Without conflicting with the class teacher's learning/teaching objectives, the sheet for the second session, aimed:

- to resolve some of the technical problems arising during the first session;
- to ask new questions linked to the screen they had in front of them;
- and, lastly, to provide a framework for filling in the sheet, thus helping them carry out the task.

The session also ran into problems. The children only had time to see three screens; whereas the previous week's group had seen them all but in fact it seemed that more answers were given. Paradoxically, the class teacher considered the second session to be a failure, because the pupils had not managed to complete the activity.

Throughout the two sessions, the children were generally motivated until the end, and there were even signs of regret when the bell rang.

It is clear that in spite of having a vast amount of goodwill, the teacher was not sufficiently trained in how to use the tools, and she followed more than guided this type of session. It would furthermore seem that mastery and perfect knowledge of the software is a necessary pre-requisite for the pedagogical success of the sequence. Several signs indicate that this was not the case in this case study. The learning benefits for pupils during the hour will no doubt have been relatively few. The schoolteacher was the victim of a pedagogical illusion. Pupils' drive and motivation in interactive sessions of this nature, although important, should not be a substitute for pedagogical benefits and value in terms of knowledge. This study is unfortunately incomplete because there are no results on the tests handed in for this sequence.

To conclude, it was a good end of year activity, which was experienced more as a distraction than a real pedagogical activity.

4. The evaluation of the learning objects

The object "Watercycle" offers a complete pedagogical sequence, during which the pupil is obliged to follow a given path. Each table is linked to the next one, which renders flexible usage almost impossible. There is a fairly complex degree of interactivity, and the stages are not particularly well identified. Pupils were constantly being misrouted.

Advantages of the learning objects

The object's complexity and the range of knowledge it covers allow it to be used at several levels, but this makes it difficult to integrate it into the activities and ongoing units of the curriculum.

It is very attractively designed, which helps to secure pupils' immediate engagement in the activity. They gave it their full attention from the beginning, and remained totally motivated throughout the session. This LO is very simple to use. At a technical level, there is no real problem. The glossary, the memo function and the web links are all easily accessible. Page design, titles and instructions are clearly set out.

There is a lot of information, and it is very comprehensive, although sometimes complex. The graphics are highly aesthetic, but not always very pedagogical.

In sum, it is a fine object, but there are serious reservations about its usability in class.

The main defect, as noted above, is its lack of flexibility in terms of the pedagogical scenario, which does not give the teacher much of a margin, if any, for manoeuvre. This drawback seems to constitute a relatively major obstacle to using it effectively in class.

Examples:

- It is not possible to have the children work on the first animated graphic (see the following screenshot). Information is conveyed from the beginning until the end of the animated graphic, which unfolds more or less rapidly, depending on the speed of the processor. It is impossible to stay with a particular image in order to note down the stages and the vocabulary used, or to differentiate between key terms and secondary ones.
- The designer's idea, which is no doubt praiseworthy, was no doubt to provide an overall insight into the matter. There is too much information however, and pupils get lost in vocabulary they are unfamiliar with. It goes too quickly and does not seem to achieve the objective of highlighting the stages of the cycle to be gone into in more detail later on.

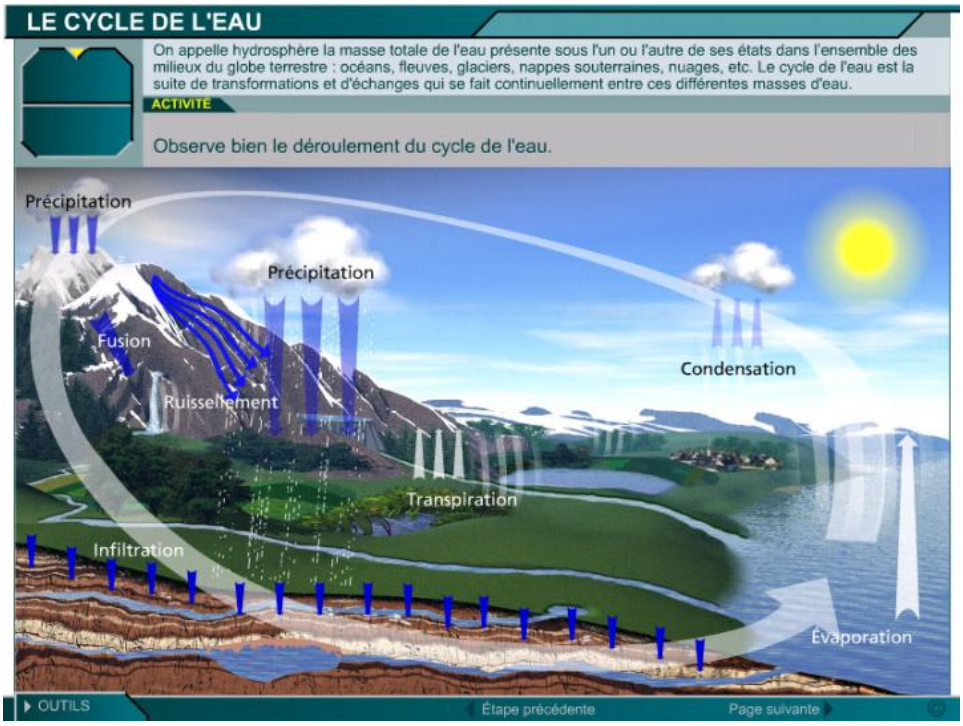


Figure 7. The LO screen just before the window opens

In this sequence, the teacher had already wanted to reduce the size of the task using the introduction, to enable pupils to grasp the problem as a whole. This is not possible because a window opens automatically right in the middle, inviting pupils to continue. No alternative is provided (see the figure 7). It is not clear how

to return to the introduction, as the “previous page” button does not always go back to this sequence.

In the second session, the sheet told pupils how to keep the screen by technically making the window disappear, but this disrupted the process considerably. The majority of pupils did not know how to do it and had to be helped.

- Another example is the fact that the navigational path is imposed, demonstrating that the designer again denies pupils’ an opportunity to consolidate their knowledge. The move from the screen showed in the following screenshot to the next deleted pupils’ work, without them having been able to note it down in any way. They were therefore unable to answer question 3 of the second sheet, where they had to put different elements of the landscape into order, in accordance with the three states of water.

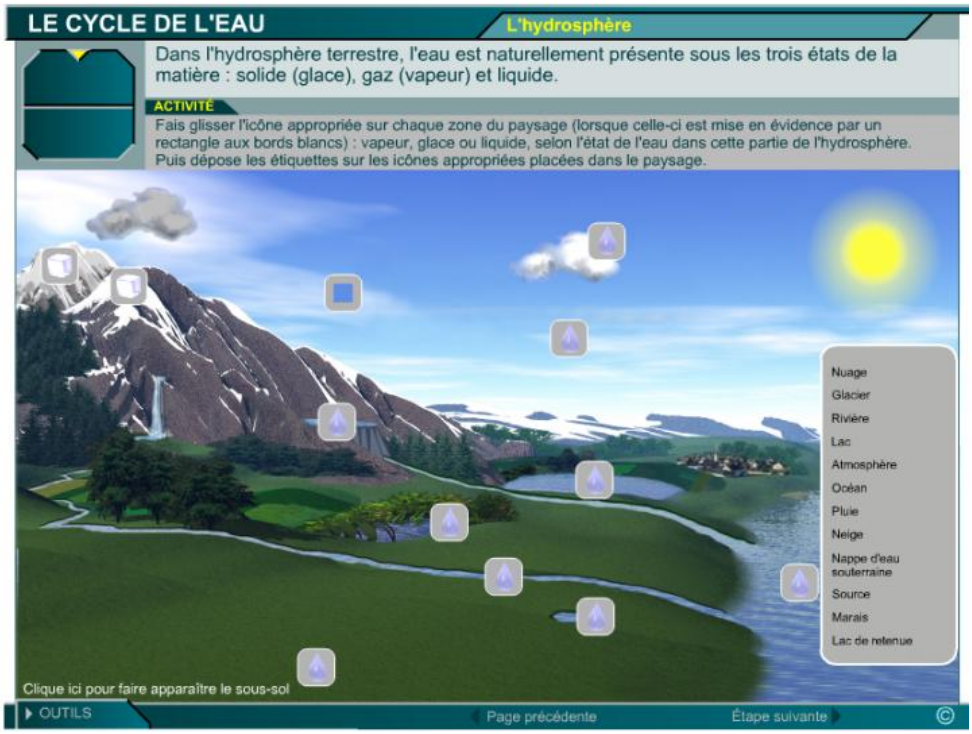


Figure 8. A drill and practice exercise included in the LO

- The elements of the landscape had to be dragged to their respective places. When this was completed, the third stage was launched. The pupil’s work was lost and it was impossible to go back. There was no technical way out. The teacher was unable to see whether the pupils carried out the work correctly, because the latter could skip to the next stage by clicking on the “next page” button. Even more seriously, it was impossible to exploit the work in writing.

Case study 6 Bread making

Cyrille Raymond, Pôle Universitaire Européen de Lorraine

1. An overall description

This case study is in a lower secondary school (or a junior high school, for 11 to 15 year-olds) with about 500 pupils and some fifty teachers. An ICT coordinator deals with the IT network and equipment. The two teachers concerned in the case study have been teaching for about five years, and using ICTs in their lessons for about two to three years. One of them (responsible for Class 1) was directly trained in how to use the templates by the relevant PUEL staff member. The teachers' ICT level is in line with the national average, although the first one seems to be a little more advanced that the second one.

The school has fairly typical technology equipment compared to other junior high schools in France. There is a computer room with about fifteen terminals with a high-speed Internet connection, and there are some freely accessible terminals in the school's documentation and information centre. The computer room is often in use, and it is often necessary to book it along time in advance. This does not make it easy for the teachers to use ICT, especially on a regular basis.

The case study focuses on the work of two biology/natural sciences classes in the sixth form (in the French system, the sixth form, or *6ième*, is the first year of junior high school, for 11 to 12 year-olds). Each class has exactly the same teaching and learning sequence with their respective teacher. The two teachers say that their classes are fairly different. In the first, the teacher has experienced no particular difficulties in organising lessons, and the atmosphere is very good. For the other teacher, the pupils are generally more distracted and less attentive. No social problems have been noted in either class.

Two learning objects have been used in this case study:

a) An object created using LOBE by Hachette Multimédia. According to the CELEBRATE metadata, it is an **exploration LO.**

The "Bread making" object is available at the following address:

http://learning-assets.eun.org/lo/fabrication%20du%20pain.zip

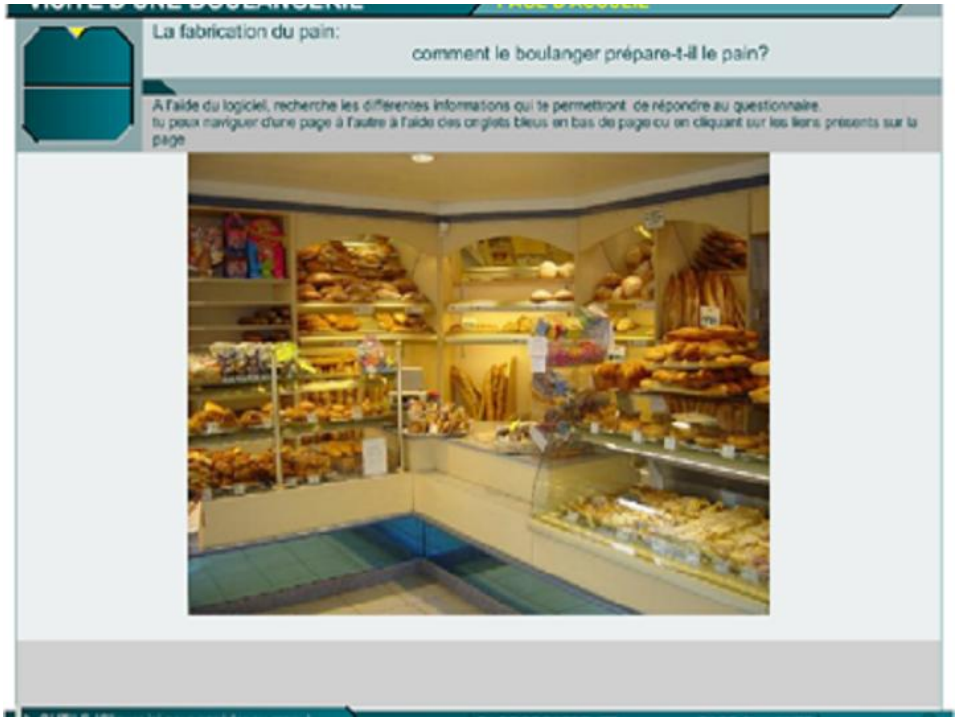


Figure 9. An exploration LO on bread making

b) A drill-and-practice (according to the CELEBRATE Metadata), created using the Digitalbrain template, with a view to compiling a crossword. It is available at the following address:

http://eundp.digitalbrain.com/emeline.eundp/web/fabrication%20du%20pain/crossword/?verb=view

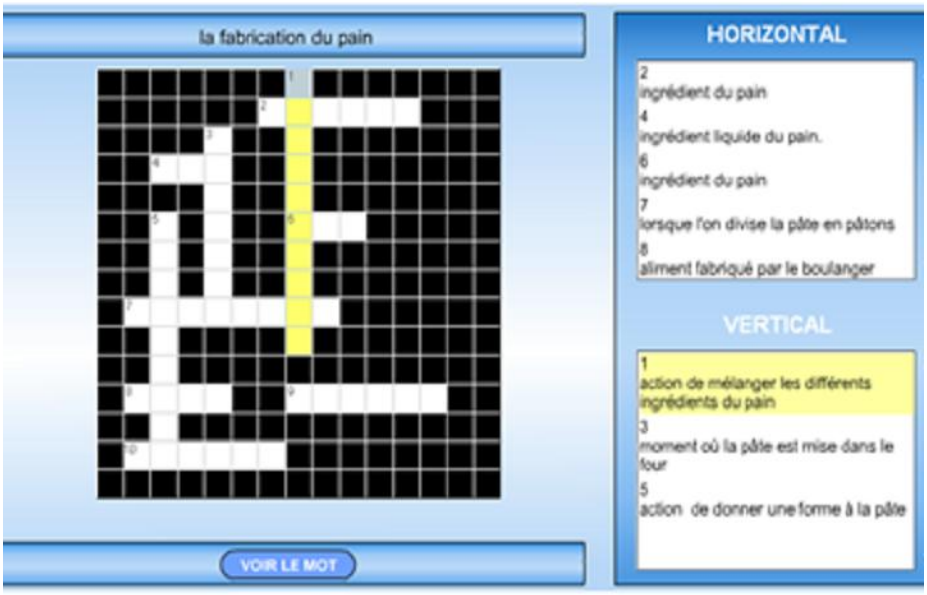


Figure 10. A crossword for testing what has been learnt about bread making

The teachers prepared an exercise sheet in A4 format (see Appendix 2) with questions and tables to fill in, using information solely obtained via the first LO.

The goals defined by the teacher were the following:

The pupils had to learn the basic bread-making principles: the recipe, the various steps, machines used and different types of bread.

2. The structure and phases of the teaching and learning sequence

The process was organised into two consecutive stages.

The first stage was organised in the computer room, for 15 pupils (one pupil per PC). Each terminal had been switched on and the LO set up beforehand, to minimise time lost in starting the sequence as far as possible. Once each pupil had settled into a place at a terminal, the teacher handed out the A4 exercise sheets containing various questions and tables that were to be filled in (see Annex 2). She also read the questions out loud. Each pupil then had 40-45 minutes to navigate freely through the LO in order to find the answers to the questions and fill in the tables. They notably had to find and transcribe:

- Bread-making ingredients
- The various steps / the recipe: the name, the purpose of the step, temperature, etc.
- Different bread types and their differences
- The definition of a word situated in the LO tool bar

During these 40-45 minutes, the teacher was generally available to reply to possible questions, which might be made to obtain clarification about a question arising, or concerning a problem linked to the use of the LO. Two games were available for pupils finishing early, to enable them to test what they had learnt. One was directly included in the LO, and the other (the crossword) was accessible via the links in the toolbar.

The second stage took place in the classroom. The teacher referred to the exercise sheets, which should by then, have been filled in, and then asked the pupils, question by question, what answers they had come up with. This was effectively a sort of collective correction process.

At the end, each pupil came out of this two-stage session with his or her work corrected. It should be noted that, with the exception of one pupil with major difficulties, most pupils found the right answers.

3. An analysis of the pedagogical approach of the case

The pupils knew exactly what they are doing throughout the session in the computer room, as everything was noted down on the exercise sheet given to them. The session was highly structured. Even though the pupils remained free to navigate through the LO how they liked, progress was in fact highly linear. Knowledge was presented in a very factual way and pupils mostly only had to transcribe information provided on the screen. The information was furthermore given in the same order as the questions asked; which facilitated the pupil's "pseudo-research" task even further.

Lastly, the work was carried out on an individual basis, and there was no contact between pupils. Each one had to look for the information alone and autonomously.

A comparison of the two classes revealed that even though Class 2 was indeed noisier than Class 1, it succeeded just as well in reaching the objectives.

The teacher's role uniquely consisted in helping pupils who had got stuck, for various reasons, including poor comprehension of a question, problems linked to using the LO, etc. Few pupils asked the teacher questions, and when they did, they were mostly rather redundant, such as: "we are being asked to note down the temperature of this step in the bread making, and it says 'room temperature', so what temperature should I put?" The teacher therefore only rarely had to intervene during the sequence in the computer room. Pupils discovered how to use the object very rapidly and intuitively. Help was only really necessary when it came to getting the crossword up and running.

4. The evaluation of the learning objects

The learning objects have two different purposes. Firstly, during the first and longest stage, the LO represented a source of information for pupils, allowing them to understand the bread-making process. Then, at the end of the sequence, the two available games provided them with an enjoyable way of checking and even evaluating their own achievements.

Advantages of the learning objects

The main advantages of the LOs stem from the fact that they have been entirely created by the teachers using them. They are therefore perfectly compatible with ongoing activities and course units in the curriculum. They are furthermore attractively designed, which is a notable advantage when it comes to keeping pupils' attention from the outset.

The LOs are very simple to use as far as the functions are concerned. No problems were mentioned in this respect. It should however be noted that beyond their graphic content, these resources were fairly elementary insofar as they did not permit a great deal of interaction between pupils.

Problems of the learning objects

While the autonomous information research aspect was interesting, this was only slightly the case. On the one hand there was practically no further information other than that which the pupils had in front of them, which regrettably did not enable them to acquire a more critical insight into the information provided. On the other hand, the information to be found was provided in the same order as the questions, and in most cases this only necessitated the simple task of recopying the text.

A majority of the drawbacks are however closely linked to the functional limitations of the current version of LOBE (published by Hachette Multimédia). It does not currently permit the creation of particularly interactive exercises, and it notably does not allow for the creation of a simple link from an image. This functionality would have been greatly appreciated by the teachers.

Case study 7 Exploring the comparative form

Cyrille Raymond, Pôle Universitaire Européen de Lorraine

1. An overall description

This case study is in a lower secondary school (or junior high school, for 11 to 15 year-olds). It is of average size, with just over 300 pupils, and is situated in a predominantly rural area. An ICT coordinator deals with the IT network and equipment. The teacher concerned in this case study has been teaching for about 25 years, and using ICT in his lessons for seven or eight years. Broadly speaking, his ICT level is fairly high compared to the national average.

The technology equipment is fairly typical, and comparable to what other schools in the country have. There is a computer room with about a dozen terminals, all of which have a high-speed Internet connection. The school also has six freely accessible terminals in its documentation and information centre, on which they can use BCDI 3 software to find a book, carry out research on the Internet or format a piece of work.

The case study focuses on the work of an English class in the sixth form (in the French system, the sixth form, or *6ième,* is the first year of junior high school, for 11

to 12 year-olds). The class includes some less able children, and we did not have their parent's authorisation to film them. No observations were made about them.

In all, seven learning objects were used in this case study, and, according to the CELEBRATE metadata, they were all drill and practice ones. The aim of the seven objects is to enable pupils to learn about the comparative form, and then to use them in exercises and games.

a) "Cars are fast, but planes are faster" (see Figure 11):

http://content.opit.wsoy.fi/celebrate/englanti6/17_7.htm

Figure 11. A drill and practice LO on the comparative form.

b) "Large-larger, hot-hotter, happy-happier" (see Figure 12):

http://content.opit.wsoy.fi/celebrate/englanti6/17_4.htm

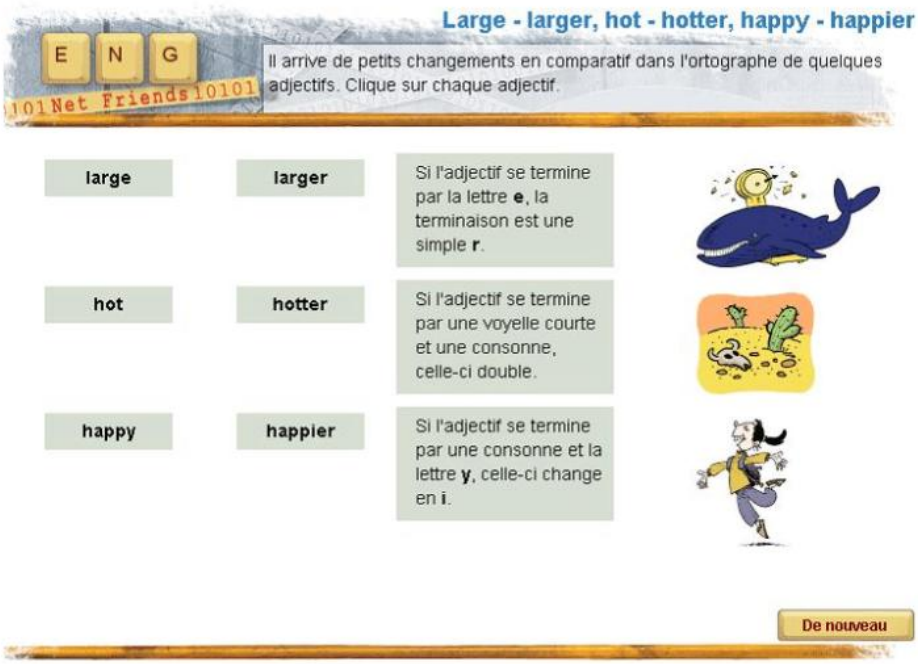


Figure 12. A drill and practice LO on the comparative form

c) "Comparison: bigger, older"
http://content.opit.wsoy.fi/celebrate/englanti6/17_8.htm

d) "Good-better, bad-worse":
http://content.opit.wsoy.fi/celebrate/englanti6/17_5.htm

e) "More dangerous, more interesting" (Figure 13):
http://content.opit.wsoy.fi/celebrate/englanti6/17_10.htm

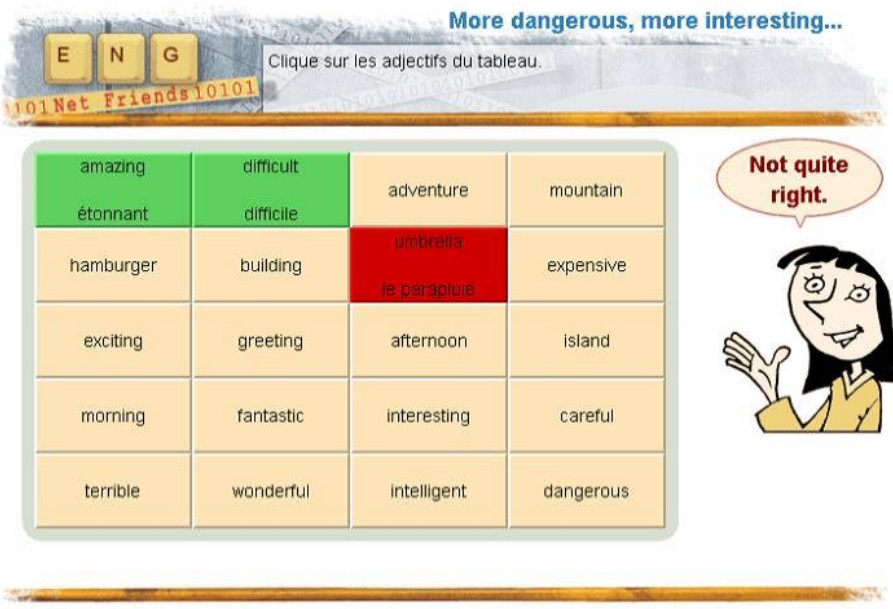


Figure 13. A drill and practice LO on the comparative form.

f) "Fast-faster, dangerous-more dangerous":
http://content.opit.wsoy.fi/celebrate/englanti6/17_11.htm

g) What is the comparative of… ? (Figure 14):
http://content.opit.wsoy.fi/celebrate/englanti6/17_12.htm

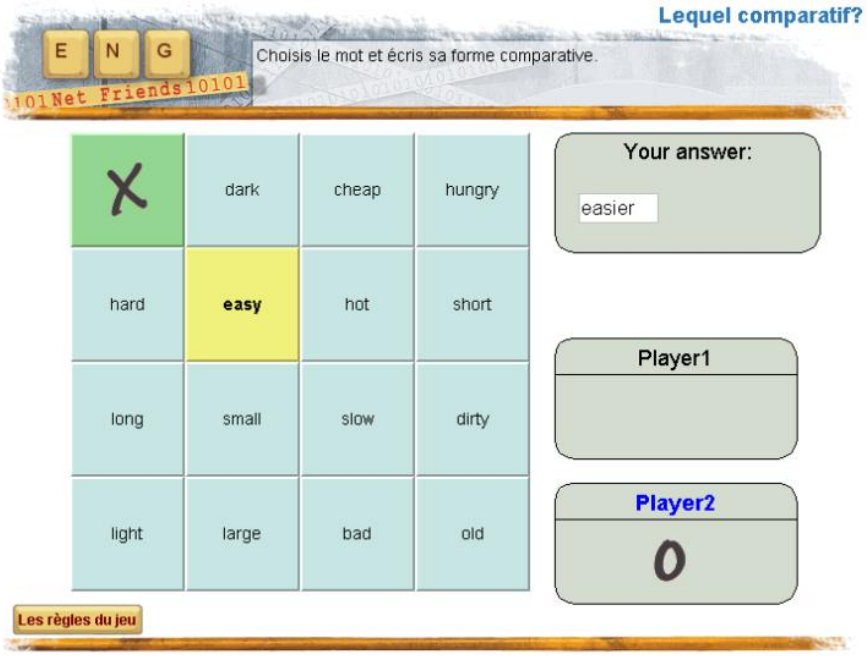


Figure 14. A drill and practice LO on the comparative form

2. The structure and phases of the teaching and learning sequence

The process was organised into two ICT sessions lasting 55 minutes each, over a period of two weeks.

Preparation by the teacher

In the interest of efficiency and to provide the session with an organised structure, the teacher had created an HTML index page listing the seven LOs in the order they were to be started up and used by pupils. The teacher had previously downloaded each LO on to the school's network to avoid possible network and/or portal problems. Lastly, she had prepared a web page providing help in French.

The first stage took place in the computer room with 20 pupils working in pairs on 10 PCs. At the start, the teacher explained how to use the HTML index page by providing them with the path to the right directory on the school's server. She also explained how it can be displayed on full screen to avoid problems in the use of scroll bars. Once the page was set up on each terminal, the teacher gave the following instructions:

- Only go on to the next stage once the current stage has been perfectly understood.
- Come back to the previous stage when you are stuck.

The teacher reminded the children that it was not a game, but a piece of work. The pupils then started to use the first LO, with no technical difficulty. The teacher provided some instructions at the beginning, but practically none thereafter. Pupils progressed at their own pace, and the teacher intervened to sort things out if difficulties arose or to check that each stage had been finished and fully assimilated before pupils went on to the next one.

Pupils in each group whispered together, but generally speaking it was remarkably silent and there was a good degree of motivation and interest in the exercises. After five minutes of the exercise, the teacher reminded pupils that the words should be learnt off by heart because this would be tested in the classroom (see the *intermediate stage* below*).* Some groups talked among themselves, requested help or compared their results. The teacher intervened when one group gave the answers to another, as this would not have helped them understand or find the logical solution on their own. When a group got completely stuck, the teacher tried to find a sentence drawn from another context (big, happy…), and asked the whole class to give the comparative of "big", thereby helping the group to get over the problem.

It emerged quite clearly that the vast majority of pupils did not read all of the LOs' instructions before starting them up. For example, for the "Good-better, bad-worse"

LO, some pupils got stuck on the translation of “worse”, even though the answer was in the object’s title and at the top of the page!

At the end of the first session, the teacher announced “end of the lesson”, and disappointed “oh no!’s” could be heard.

Intermediate stage

In class, the teacher organised a paper-based test to assess acquired knowledge. The test enabled her to check what had been assimilated stage by stage, and to identify what had to be redone.

The second stage also took place in the computer room. Before letting the pupils use the LOs and continue where they left off at the end of the first stage, the teacher went through the sheet filled in by each pupil during the intermediate stage and, if necessary, asked him or her to redo the stage or stages which had been not been fully understood. The pupils then worked autonomously, in the same way as during stage one. One pupil had already progressed to stage 7, which is a game for two. The problem is that she was the only one to have got that far. The teacher therefore offered to do a round of the game with her while waiting for another pupil to reach the same stage. Both the teacher and the pupil thoroughly enjoyed themselves. The atmosphere in this second session was calm but animated.

The teacher tested each group’s understanding and whether they had assimilated the rules, sending some pupils back to a stage which had been not fully absorbed. Some pupils rapidly progressed to the game (the seventh LO), sometimes to the detriment of previous stages. This was why the teacher had to systematically check that they had been assimilated. One group asked one of the observers what the answer was, and the latter tried to help them find it by using the example of another adjective, which met with success.

Throughout the two sessions, the teacher gave constant encouragement to the pupils, and all this happened in a most positive and lively atmosphere.

After the game there was a test (prepared by the teacher in Word format). It entailed a small amount of writing. The pupils were supposed to fill the sheet in for the following week. Several groups found it hard to stop playing the game and start writing. The game seems to have had much success!

Over the whole of the two sessions, the teacher only once had to intervene strictly, albeit kindly, to refocus the attention of a group which had gone on to the next stage without having perfectly assimilated what they had just finished.

3. An analysis of the pedagogical approach of the case

The pupils knew exactly what they were doing throughout the session in the computer room, due to the fact that each stage had been listed in order on the HTML index page. The session was very structured because each stage corresponded to a LO and had to be completed in a very precise order. However, each group of two pupils was allowed to progress at its own rate. Lastly, all work was carried out in groups of two, and the pupils were therefore able to find the solutions in a collaborative manner.

The teacher's role here was first, to provide initial instructions in order to kick-off the session; to help children who were stuck for various reasons: either because they could not find the right answer or due to a problem with the way the LO functioned (the colour red indicated that the answer is wrong …); and above all, to test the pupils' acquired knowledge, to ensure that each stage had been fully assimilated and, if necessary, to send a group back to a stage which had been not been fully understood.

In this case, the teacher integrated five of the six functions defined by Bruner (Crahay, 1999, see Appendix 3):

- *Recruitment*: the teacher announced the theme of the activity and provided initial instructions. He motivated pupils and ensured that they were on board.
- *Reduction in the degree of freedom:* when a pupil got stuck, the teacher provided an example from another context known to the pupil, in order to help him/her find the right answer.
- *Direction maintenance:* the teacher sent the pupil back to the previous stage if it had not been fully assimilated, reminding him/her what the general objective was (in this case, the comparative form)
- *Marking critical features:* the teacher checked that each stage had been understood, and if this was the case, validated it and authorised the group to continue.
- *Frustration control:* the teacher constantly motivated pupils in a highly positive manner, by providing encouragement, even in face of failure.

As for the last function – *demonstration of model solutions* – the session took place at the end of the year, and the teacher did not have time to clearly set out the "official" rule in class. He did however do so individually with each group before completing the sequence.

4. The evaluation of the learning objects

Advantages of the learning objects

The seven LOs used are short activities from ten to fifteen minutes at most, and they are fairly flexible in terms of sequencing. Each stage/LO is relatively short, and the information provided is fairly limited, so that pupils do not become submerged in a mass of knowledge that they haven't yet mastered. Knowledge can be tested at the end of each stage, after which pupils can go on to the next LO.

The LOs' design is relatively simple, but nonetheless attractive. They can be used with elementary skills and a good degree of intuition, and pupils do not get lost in over-elaborate or confusing graphics.

Problems of the learning objects

In the particular case of the "More dangerous, more interesting" LO (http://content.opit.wsoy.fi/celebrate/englanti6/17_10.htm), it is regrettable that the words listed do not come up in a different order each time. In several groups the pupils redid the exercise several times and ended up learning more about the position of the correct boxes than about the actual words themselves. They used their visual memory to the detriment of the pedagogical objective of the LO. Some pupils were observed to be clicking on all boxes, visualising the position of the right answers (in green), and then starting the exercise again and clicking on the boxes without even reading the words they contained!

This principle of having questions or features come up randomly in order to prevent the use of visual memory could be applied to several LOs.

Case study 8 Relations

Philippe Leclère, INPL - Institut National Polytechnique de Lorraine

The following case study concentrates in the use of the LO in a very detailed way: how pupils used the LO. For this reason the case description is structured somewhat differently than the other cases.

1. An overall description

The school is located in the centre of the city, and although many children from disadvantaged backgrounds attend, it does not have Priority Education Zone status.

several activities vis-à-vis the outside world, the school holds the development of ICT in everyday life to be a key aspect of its educational objectives. The overall aim is enable children to make the most of new technologies and, in accordance with course texts, to provide them with the knowledge and practice opportunities required for obtaining the B2i (*Brevet Informatique et Internet* – computing and internet diploma).

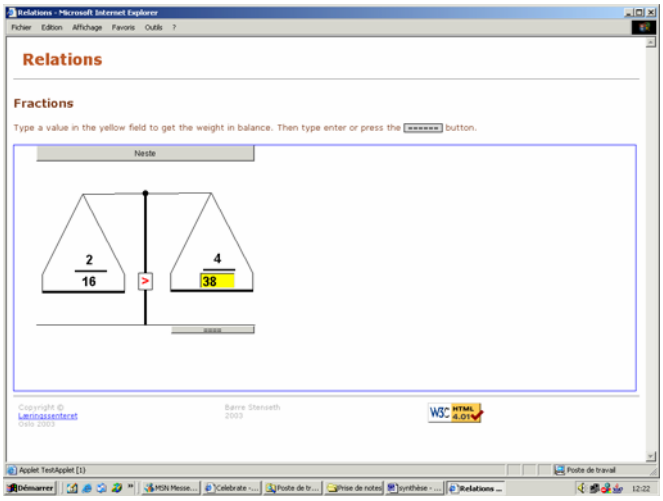
The study was conducted in a CM2 class of 11 students (10 to 11 year-olds), similarly as with the case of the Water cycle. The topic of the mathematics was relations. An exploration LO according to Celebrate Metadata.

The goals of the teacher were:

- Individual work: discovery, then practice and repetition of procedures.
- Formalisation of procedures used by the pupils
- Exploitation of strategies

2. The idea of the learning object

This object's icon is a set of scales, presented in a very rudimentary way by two pans and one of the following mathematical symbols (< or > or =), which are understood by everyone and enrich the image. This addition is useful because it strengthens the metaphor by releasing a different thought mechanism, although it is also necessary because it is not easy to see when the scales are balanced, especially when they are nearly so.



Every time one clicks on the Neste button, the object starts up again and a new balance is proposed. Some children sometimes clicked on this icon at the beginning to try to confirm their answer, and they quickly understood that it was necessary to press Enter on the keyboard or mouse click on the "=" button.

When it starts up, the software asks one to guess the numerator or the denominator of the fraction on the right hand side. One can change the number sought as many times as one likes.

It should however be noted that the sign in the middle "illustrates" the comparison between the number to be found and the one which is fixed. The mathematical inequality which can be read naturally from left to right is correct, hence the interest of including it between the two fractions. Some children nevertheless systematically made the wrong decision, by increasing the number when it had to be decreased, or by decreasing it when it had to be increased. One might speculate that they had misunderstood the mathematical symbol.

The "=" button, for confirming the answer, and the "**Neste**" button, which renews the numbers, should be noted. They are as simple as can be.

At a symbolical level, the scales are a physical object permitting a comparison between two weights. But their more subjective symbolisation of the notion of justice should also be noted. They represent judgement and truth, time and balance, day and night. They permit the balancing of opposites. They can be mishandled and mistreated and they will always recover their balance and stillness. Unconsciously, children know that the trial and error method will lead to a solution.

3. The structure and phases of the learning/teaching sequence

The activitites of the sequence were:

- Individual and/or collective discovery of the object.

- Once understood, explanation by one or several pupils to the rest of the group.

(Possible recourse to translation of the instruction)

- Identification of solutions by trial and error.

- Progressive completion of a table which will be used to provide the summary.

The pupils' activities were:

- Using the summary table, try to match equivalent fractions, in order to specify the process (evaluation of the various lessons learnt about fractions in class, in traditional style)

- The learning/teaching sheet. Firstly, pupils had to find, using the object, 10 equalities of fractions and to write them down to the sheet. Then, they had to, just by using their sheet, find the rule. Finally, they had to test their rule with the object. If their rule was not verified, they had to retry thinking with their sheet. Before each session, the teacher fills in a learning sheet specifying the context, and providing a description of the learning/teaching objective of the sequence, with information on his intentions and the way that the activity will be organised.

Account

This section provides a chronological account of the session.

- The various stages of the learning process are underlined
- Scaffolding in the learning process and class dynamics is commented on **bold**
- It is useful to establish some hypotheses regarding the use of multimedia and its influence on the learning process on the one hand, and on scaffolding in the learning process on the other. Such comments are made in *italics*.

Starting up

Scaffolding: this is an important scaffolding phase: recruitment. This word has a slightly military connotation, but it is suitable for describing the teacher's desire to ensure the pupils' engagement. He had to resolve technical hitches during the starting up, and ensure that the problem has been fully understood, even if this meant reformulating it.

There were 11 pupils, who were divided into groups of 2, and one group of 3. The object had been downloaded onto the hard disk of each computer in the room. It was firstly necessary to find the learning object and then start it up. The instructions were precise and the teacher used specialised computer language which the children understood perfectly and were clearly familiar with.

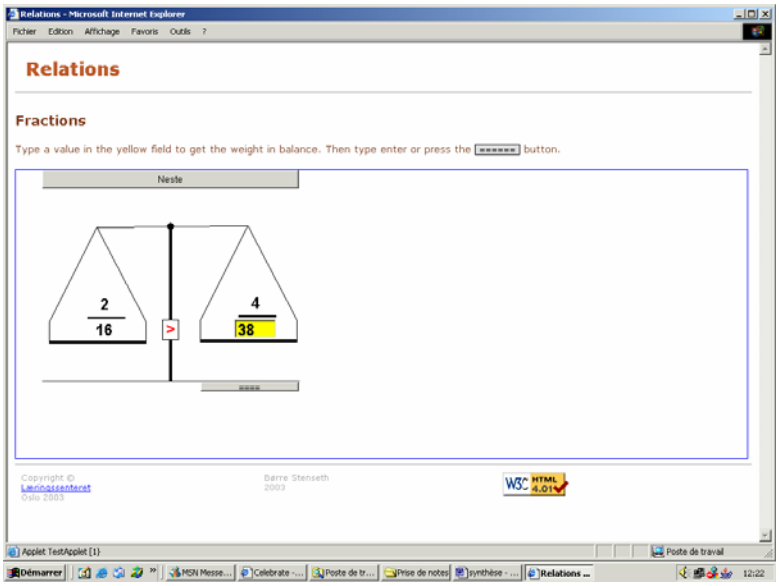
It was necessary to recognise the right file – the HTML executable – without its name having been given. Some pupils couldn't find it and asked the teacher to help, but he refused to give them the name of the file to be opened. The pupils were used to this, and then found it on their own using the Internet Explorer icon (the blue E).

Process**:** the teacher's instructional approach can already be observed. He was keen to make each pupil as autonomous as possible. The pupil's first calls for help were considered to be a form of intellectual laziness, which the teacher refused to give in to.

Once the object had been opened, initial reactions started flowing:

Alexandre: wow!

Abdallah: hey, is that the Internet?



The page that came up seemed to please. Interest and attention intensified, and motivation regarding the object was already palpable. The start of the session seemed to have been perfectly successful, and the pupils were now very keen for instructions and already beginning to wonder what they were going to have to do.

Scaffolding: the recruitment aspect consisting of engaging the pupils' interest was successful. Some pupils asked whether it was normal that the scales had come up on the screen. They were not sure that they had done the right thing.

The object was now running on all terminals, less than five minutes after the beginning of the session.

Hypothesis: it seems clear that the attraction of information technology played an important role in motivating pupils during this phase, seemingly making it easier for the teacher. In a more traditional context, he would no doubt have been obliged to get involved. This is what the tool is for.

Giving the instructions

Scaffolding: this is still part of the recruitment function. Everyone had to understand what he or she was doing and what the objectives were. Here again, the teacher tried to get the children to speak, in order to reformulate the problem themselves.

The object was explained by a short phrase in English, which the teacher translated on the blackboard without remarking on it. It seemed that that very few children in fact needed this help.

Hypothesis: it is certain that the way chosen to depict the scales to illustrate this idea facilitated rapid comprehension of the problem raised.

It was however necessary to ensure that the mathematical symbols (<,> and =) were fully understood in this context, that the objective of the exercise was clearly established and above all that the pupils had understood when they had succeeded and could then go on to the next example.

> Teacher**:** how can we be sure that it they are balanced? How do we know whether it is right or not?
>
> Paul: thanks to the scales.
>
> Teacher: and?
>
> Alexandre: thanks to the <, > or = symbols
>
> Teacher: <, > or =?
>
> Abdallah: =

The pupils had therefore found the aim of the exercise in less than a minute, and in a collegiate manner.

Scaffolding: the teacher's contribution at this level served uniquely to get the pupils to formulate or reformulate the instruction so that everyone could start the activity and know when the answer had been found. At no moment did he suggest the response. No explanation was given on what the children could do, notably concerning how to fill in the box, what effect that would have on the scales, etc.

First stage: the exploratory phase and random attempts

Process**:** development of the exploratory phase. The pupils proceeded on a trial and error basis, in all freedom.

> Teacher: you should use the object for a few minutes and call me when you have filled in the sheet.
>
> Fatima: I've got it.

Fatima has indeed balanced the scales, but it seems that this was by chance because the cry of victory was not to be heard for the next fraction.

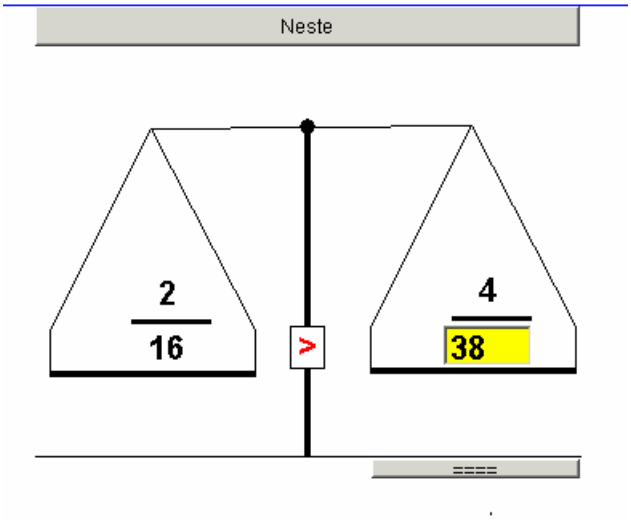
The atmosphere was very friendly and the children were captivated by what they were doing. The pairs started to organise themselves, and one sensed that there were already conflicts in the strategy to be adopted.

Zoom in on a group comprising Alexandre and Abdallah.

Alexandre was trying to organise his method and making comments out loud about the approach to adopt. Alexandre's remarks were mainly aimed towards the other person in his pair; however they may also have been aimed towards the observer who he sensed was giving his pair ongoing attention. However, Abdallah barely said anything at all.

> Alexandre: you have to put a number in the yellow box, and it shifts the scales
>
> Abdallah: try this number

Alexandre did so, and it worked. The scales went up.



Abdallah seemed to be more intuitive and never explained his approach, even when his classmate asked him. However, he often got the right answer, and ended up having an influence on Alexandre, who had noticed his higher success rate.

The initial attempts were purely based on chance, and the children tried out numbers, hoping that they would hit the right one. One did not sense that any particular observations were being made about the movement of the scales during each attempt. The pupil with the keyboard filled in the number and rarely asked his partner's advice. It seemed probable however that the constant and fruitless attempts unconsciously helped lead to the development of a certain number of rules.

> Alexandre: Sir, we've found it, the scales are balanced
>
> Abdallah: no, look, it doesn't display the "=" sign

In spite of having the visual impression that the scales were balanced, the mathematical symbol was unequivocal, and the children accepted that it was not the right result. They therefore took account of the approximate nature of the image and accepted the judgement via the more abstract symbol and consequent modelling of the

result. Also perhaps, and more unconsciously, the metaphor of the scales as a symbol of justice was influencing their reactions.

> Alexandre: look, when you have to find the numerator, you just have to find the denominator of the other one
>
> Abdallah: no, wait. I am going to put a bigger number, and see, the scales are tipping upwards.

Process: this was clearly part of the exploratory phase of the learning process, and an initial crystallisation of the results was already taking place. The pupils were working on a trial and error basis and speculating on the rules in relation to their experiential sphere, which was limited to poor or even non-existent knowledge about the subject and some results that they had pinpointed during early attempts.

Scaffolding: the teacher's contribution can be described as frustration control regarding one or two pupils who found it difficult to balance the scales because they were making wild guesses. This remained very marginal however. He did not need to put other pupils, who had perfectly understood the instructions and fully mastered what they were doing, back on the right track.

Completion of the first stage of scenario 1. The groups were now fed up with random attempts and began to draw up some rules.

Second stage: emergence of some rules.

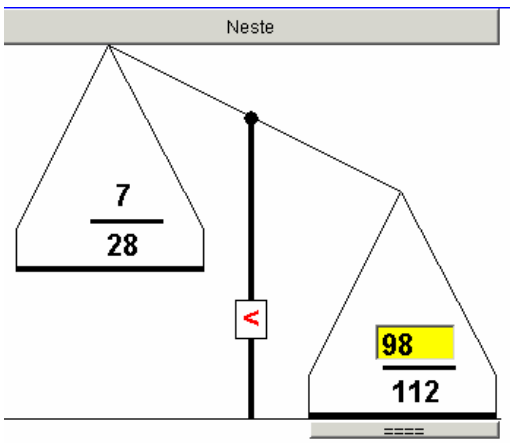
Process**:** the pupils began to find some rules, drawing on their various efforts and sphere of experience. Sometimes the rules were wrong because they were linked to the context of the software.

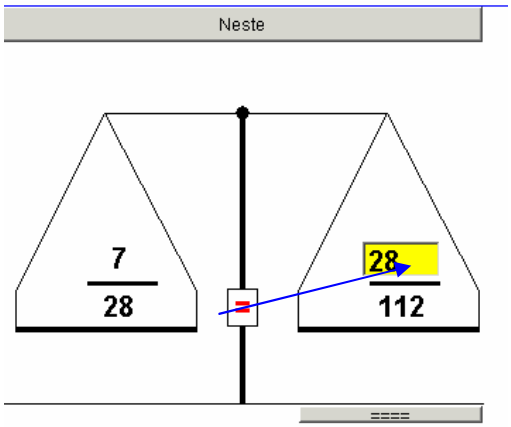
Scaffolding: The teacher distributed a sheet to each group, on which pupils had to note down the ten first equivalent fractions they were to find.

Date:		My name:	

1	— = —	**6**	— = —
2	— = —	**7**	— = —
3	— = —	**8**	— = —
4	— = —	**9**	— = —
5	— = —	**10**	— = —

Example of a misleading rule**:** the software has a defect, so that when it is the numerator that has to be found, the answer systematically has to be the denominator of the other one.





Here, 28 has to be put in.

Some groups therefore established this specific example as a rule. (The defect has been pointed out to the designer).

It is difficult to analyse the damage this error in the software can have, although it is certainly not negligible and, in spite of all the teacher's efforts to prove that the rule is false, the learner still partly remains with a wrong impression.

One can however exploit this example in order to warn against the danger of establishing general rules on the basis of a particular example, and therefore to raise

awareness about the need to go on to the formalisation phase by distancing oneself from one's immediate real-life experience.

It is furthermore somewhat noteworthy that this false rule passed over the heads of several pupils, even though it was astounding.

The right rules

Progressively, after about ten or fifteen minutes, the various exercises made it possible to establish some rules:

- By increasing the number in the numerator box, the weight is increased
- By decreasing the number in the numerator box, the weight is decreased
- By increasing the number in the denominator box, the weight is decreased
- By decreasing the number in the denominator box, the weight is increased

This stage of the reflection was not relevant for all the groups. The teacher chose not to impose it on the whole class during this session, in order to let pupils progress at their own rate.

Scaffolding: The teacher:

- confirms that groups which had identified the rules were right, and encouraged them to continue (direction maintenance);
- asked the groups which had established the false rule to test it with a fraction for which the denominator had to be found. He was positive about the mistake, saying that it was understandable bearing in mind the software (frustration control).

When guiding the pupil, it is important to distinguish clearly between the different types of mistakes made:

- those which are due to insufficient reflection, bearing in mind that the pupil possessed all of the different elements required;
- those which seem to be well-founded, but which nevertheless needed to be checked in another context.

It was noticeable that some groups had found techniques for speeding up the research.

Little by little, each pupil in his/her own way understood that the scales had to be balanced: by chance, by dichotomy or by watching the reaction of the scales.

The dichotomy method was established intuitively by two groups. The teacher never said anything. The pupils made small increases to their numbers, starting with a small one – generally 2 – and little by little the technique was refined and the increases became bigger and bigger in order to accelerate the convergence.

Example: 49 is the number to be found, and the first number is 12. The sequence is therefore: 14, 16, 36, 56, 40, 50, 45, 47, 49….

From time to time, there is a slip up, and the pupils got it the wrong way round. The idea of "systematically putting the number in between" is approached, although it is never really formalised.

Process**:** The pupils had mentally crystallised this method, because in the following examples they applied it by immediately making big steps.

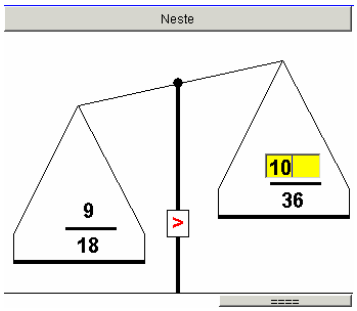
Scaffolding: Having observed the two groups, the teacher encouraged them. He let them continue what they were doing, and never asked them to formalise or improve on the method they were using. He did not find it appropriate to let this method be shared with the rest of the group, as this would no doubt disturb some of the other pupils and would leave them further from the objective, which was in any case to find the number in one go. It was probable that he did not want to make the problem any more complex and wanted to maintain direction.

Teacher: What do you do to balance the scales?

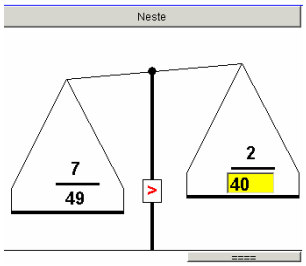
The group changes on its own accord and finds the solution!

Instead of clicking on "=", one group clicked on "new exercise" and thought they had made a big mistake. "What should I do?". In the end, the group continued with the new example, without having spoken to the teacher about it.

Remark: During this exploratory phase, a group appeared to be having difficulty with analysing the scales' reaction and the mathematical symbol appearing in the middle of the two fractions. The children seemed to be systematically making the wrong decision and increased the number when it had to be decreased and decreased it when it had to be increased. It would have been useful to go into the reasons for these mistakes more deeply by asking the pupils questions about their chosen method, but the number of groups to be managed did not permit a more detailed analysis of the reasons for the error. However, it is probable that it was a problem linked to the representation and interpretation of the mathematical symbol. One can speculate, although this would need to be confirmed, that the ">" symbol is not understood as meaning "more than", but rather as a piece of advice suggesting "put a higher number".



For this example, there is not really a problem because the command “put a higher number” corresponds to the mathematical symbol “>”. It is in fact necessary to increase the numerator in order to balance the scales.



However, in the next example, there is a real problem. If the pupil obeys the command “put a higher number”, s/he will tip the scales even more by increasing the denominator. The reasoning established is of an altogether different nature and this would require the pupil to use a greater level of abstraction. This hypothesis would need to be supported and, by monitoring the pupil’s progress, it would be necessary to observe whether significantly more mistakes are made in this scenario.

Minor problems linked to filling in the number disrupted a group of pupils. Spaces added by mistake in front of the number block the software and the message “only a whole number >0” came up. The teacher came to their aid and immediately found the reason for this problem.

Third step: Establishment of one or more general rules

Most groups of pupils had filled in the sheet given to them by the teacher at the beginning of the session, containing ten equivalent fractions to be found. The teacher then went around and, as soon as he was asked, gave the following advice individually:

> Teacher: you must fill in the box at the first attempt
>
> Teacher: by examining the ten results you have on your sheet attentively, you must find a rule for coming up with the right number at the first attempt

The pupils then turned their eyes away from the computer and looked at their sheet attentively. They reflected intensively for some minutes. Little by little, the right answers started to flow in certain groups. The teacher was then called on.

> Abdallah: Sir, we’ve found it
>
> Teacher: so, what?
>
> Alexandre: look, one multiplies the numerator by 4 in order to obtain the denominator, and you have to do the same on the other side
>
> Teacher: are you sure? Is that a general rule?
>
> Marie: it should be checked with the other results
>
> Teacher: perhaps that would be a good idea, no?
>
> Alexandre: yes

Teacher: well, check it and call me as soon as you are sure

Scaffolding**:** the pupils had formalised their rule without taking the time to check it. The teacher put them back on the scientific track. The pupil's critical skills were made use of, and it was they who pointed out the need for a phase to verify their hypotheses and invalidity of their approach.

Only one group was still to complete its sheet, and the teacher came over to find out where they were up to, looking attentively at the method they were using. It was apparently based on dichotomy. This delay was no doubt due to them being less confident in what they were doing.

Process**:** the crystallisation process had now taken place all around. The rule seemed to have been found by all of the pupils. One or two groups had no doubt benefited from the advice of their neighbouring group.

Scaffolding: the teacher did not want the results to be shared together during this session. All groups functioned independently. There was nevertheless some communication, making the session even more dynamic. Motivation did not falter and the pupils' attention was even greater.

The hypotheses then had to be verified on an experimental basis.

Abdallah: we have found it, Sir
The teacher came over to the group that had called him. The next group joins in the discussion.
Teacher: good, so you have found it then?
Marie: yes, you multiply the number on top by the same amount to obtain the number below
Teacher: on top?
Marie: the numerator!
Teacher: I prefer
Marie: and the one below: the denominator
Teacher: good, which number are you talking about?
Alexandre: well, the one that is used on the other side
Teacher: can you show me on the sheet? Does it work for all the results?
Marie: Yes, we tried
Teacher: for all ten of the results?
Alexandre: No, not all ten, Sir
Teacher: well! Now you should test it on the computer. You should find the right answer at the first attempt every time
Teacher: you are allowed to do your calculations on a rough piece of paper beforehand

The session was soon to be over. As soon as the teacher had checked that the children had understood the rule, he came and validated their result and asked them to cross-check the rule found on the computer.

Process**:** the teacher had not yet initiated the concept-based formalisation phase among pupils, which we stress must be achieved by the pupils themselves. This stage of the learning process is important because it generally entails writing down the rule which will then be tested outside their own experience and in another context.

The session ended with another go with the software, to validate the hypotheses established as a result of the ten examples. We are still in the realm of experience, and therefore in the crystallisation phase.

Scaffolding: the teacher still did not intervene in the children's discovery efforts. He was happy just to maintain the right direction and ensure that each pupil still had in mind the final objective of the problem to be solved. He marked critical features by validating tasks as and when they had been successfully accomplished. He controlled frustration fairly easily, because pupils' interest and motivation remained so constant.

Last stage of the session: consolidation of the hypotheses established

The formalisation phase could not take place until the following day, when a collective summing up session was planned, far from the computers.
In the interim, all of the groups went back to the computer and tested the rules they had established or that they had perhaps acquired … thanks to their neighbours.

Fairly surprisingly, two groups were not capable of using, on screen, the rule they nevertheless had clearly seemed to have established. They again made practically the same mistakes as those at the beginning of the session, accompanied by rather disordered research.

It is necessary to look in to the reasons for such regression in the process.

- Was the game-like nature of the software the most important factor? It is not particularly amusing to apply a rule which works each time.
- Was the rule fully absorbed? The learning of a complex notion often happens in an irregular way.
- Was it linked to the ergonomics and use of the multimedia programme? Were there problems moving from written work to work on screen? Etc.

These remarks were not applicable to all groups, most of which were systematically applying the rule and finding the result at the first attempt.

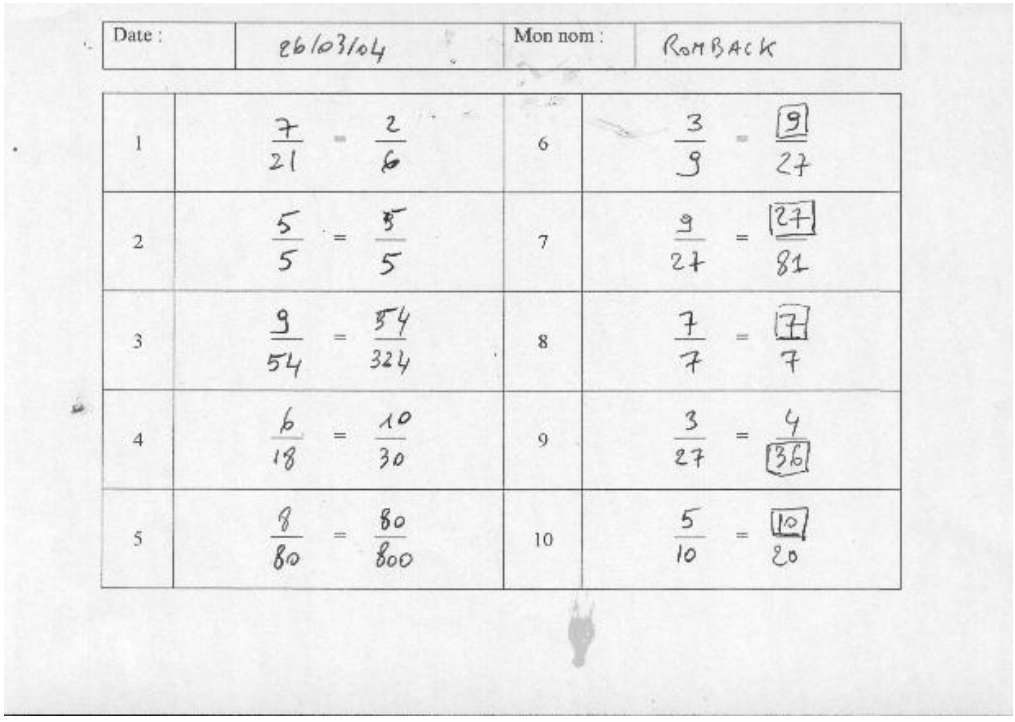
Conclusion

The end of the session was announced by the bell. All of the pupils seemed to be disappointed that it was already over. The sheets with the ten results were collected. The teacher's highly detailed preparation of the session, both at pedagogical and technical level, had permitted more than fifty minutes of highly intense and non-stop activity. Other examples enable us to stress how fundamental such preparation is for the success of a multimedia-based session.

4. The evaluation of the learning objects

A certain number of defects, mainly linked to the way the learning object was programmed, came to light during the study and were confirmed when it was used in other classes. Some of these defects constitute an obstacle to the use of the object in school because they cause major disruption, and it is difficult to observe the extent to which this has a negative influence on the assimilation of the "equivalence of fractions" concept.

Remark*:* It would seem necessary during the development phase of future learning objects to establish a method for permitting improvements at all levels (design, ergonomics, interactivity, exploitation for learning purposes, etc.) in objects to be used in the classroom. This would require a sufficiently long development phase for testing the objects in various contexts, with real interaction between users and designers.



Date :	26/03/04	Mon nom :	ROMBACK

1	$\frac{7}{21} = \frac{2}{6}$	6	$\frac{3}{9} = \frac{9}{27}$
2	$\frac{5}{5} = \frac{5}{5}$	7	$\frac{9}{27} = \frac{27}{81}$
3	$\frac{9}{54} = \frac{54}{324}$	8	$\frac{7}{7} = \frac{7}{7}$
4	$\frac{6}{18} = \frac{10}{30}$	9	$\frac{3}{27} = \frac{4}{36}$
5	$\frac{8}{80} = \frac{80}{800}$	10	$\frac{5}{10} = \frac{10}{20}$

Figure 16. A pupil's sheet.

Accordingly, it is important to note:

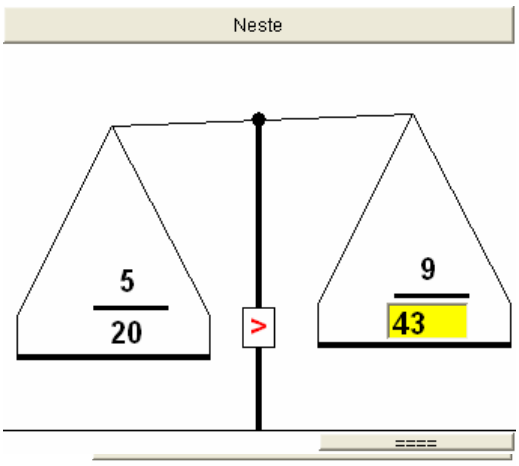
- The main defect has already been highlighted above, and it should absolutely be corrected, such is the extent it can disturb the learner. It concerns the sample range of random numbers proposed by the software, which is far too limited and in certain particular cases gives rise to incorrect general rules. When a numerator has to be found, the answer is always the denominator of the other fraction. This systematic aspect distracts pupils, some of whom establish it as a rule and never disprove it.
$\frac{3}{18}$ *et* $\frac{?}{108}$ where the answer is 18.

- There are too many trivial examples, such as: $\frac{1}{1}$ *et* $\frac{8}{?}$, which do not provide any added value at pedagogical level, aside perhaps from providing pupils with satisfaction and fuelling their motivation because they can find the answers rapidly.

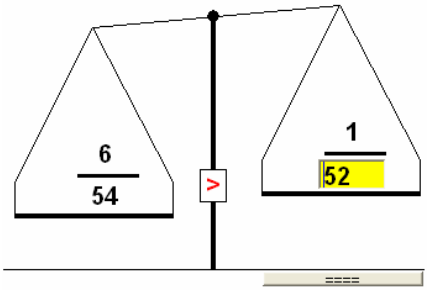
- All of the fractions represent rational numbers smaller than one. It would be useful to have numerators larger than denominators. The rule to be found is the same.

- In the examples proposed, although this may be the designer's intention, and we do not know what his/her motivation maybe, only one rule is highlighted and it is not necessarily the right one for the teacher.

$\frac{5}{20}$ *et* $\frac{9}{x}$, here it is necessary to highlight: "one multiplies 5 by 4 to get 20, so therefore 9 should be multiplied by the same amount (4) to get *x*. The result is therefore 36.
On the other hand, it is practically impossible to express the rule. When one multiplies the two numbers in a fraction by the same figure, one obtains an equivalent fraction. In this example $\frac{5}{20}$ *et* $\frac{9}{x}$, it is not possible.



It is possible in the following example: to get from 6 to 1, one divides by 6, so therefore all one has to do is to divide 54 by 6, and one gets 9. Here the two rules apply. But clearly very few examples prove this rule.



- There is no example for which there is not a whole solution, which would make it possible to work with brackets and perhaps to discover the cross-product rule, which remains the general rule applied to equivalence of two fractions.

- Lastly, it might be useful to be able to select the complexity of the numbers by providing the maximum number of figures wanted: 2, 3…figures

Possible improvements:

A menu providing all of the following options might be useful.

1- To select the size of the numbers
2- To work on the "multiplicative relation between the numerator and the denominator" rule
3- To work on the "multiplicative relation between numerators" rule
4- To work on the use of brackets
5- To work on the cross-product
6- Altogether, mixing up all the rules.

National conclusions

The importance of high-level quality

One might advance the hypothesis, to be verified, that the more an object is sophisticated and has an impressive and complex pedagogical scenario, the more essential it is for the object to be of high quality if the session based on it is to be a success.

The question of pedagogical approach

One often hears that "what is important is not the object itself, but the use one makes of it". This is true if the object is sufficiently "refined" and "atom-like" for it to be used flexibly. If to the contrary the stages are imposed, if one cannot stay with an image when one wants, or if there is too much information which is dispersed in a disorderly fashion, then it will probably be difficult to use it and the teacher will become subservient to the object. For most teachers, this is evidently not desirable.

The object's designer, who was contacted on the matter, is aware of this problem and intends to make each part independent. The "wider public" and "teachers" are conflicting target groups, and it is difficult and indeed impossible to satisfy both, because their usage is so different.

The teacher who participated in the design of this object no doubt had in mind his/her own idea of the best course it should take, and it would not be appropriate to judge

this because all teachers must be the master of their own educational approach. One realises that the scenario's inflexibility does not permit it to be used and adapted with different objectives set by other teachers. They have to adapt to the object and consequently lose their pedagogical freedom.

The key features that learning objects should have if they are to be used without difficulty by several teachers in different contexts:

- A strong degree of independence between the different parts, divided into basic and relatively autonomous sequences and focusing on a limited number of concepts. It should be possible to organise several sessions with the same object. This is not quite the case here. It can be noted, however, that other objects by the same designer fulfil this condition better.
- Simplicity of the interface, with efficient help tools which do not clutter the workspace. This is the case here insofar as the tools (the memo function, glossary and web links) are very well done. On the other hand, it is not always particularly easy to identify the stages.
- The graphic design can be more rudimentary. A fine object, which this one is, is of course always more attractive. But it would however be better to put more effort into the design of the scenarios, in collaboration with teachers. There should be more extensive work on the pedagogical context and the multiple possibilities for using an object.

Case study 9 Energy

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1. An overall description

The case study was conducted in a suburban elementary school, with 400 students and 32 teachers. Students range from 6 to 14 years, there are 8 levels. This is the most traditional length of the elementary education in Hungary. There are other versions as well: students can go to a secondary school at the age of 10, 12 or 14.

The school tries to meet the requirements of today's world and wants to fulfil parents' expectations. They have narrow internal financial resources and continually need external help. The school started using ICT 10 years ago, after the success of a huge ICT tender and regularly participates in projects and in competitions, to be able to develop their ICT equipment and to get familiar with more innovative methods.

The school has two computer labs but these are mostly used for teaching computer studies. It is an attractive characteristic of the school that they offer computer lessons from the first grade and they teach pupils aged 6 how to use the Internet.

Both the head teacher and the deputy have been taking part in the Celebrate project. The head teacher participated in training for teachers at the Nancy summer school.

This case study was carried out in a project day, which means that participant teachers (three altogether) gave lessons in succession of each other on the same day on a topic related to energy. All the lessons were held in a computer lab, where as well as computers, there was also a projector. Teachers combined the aspects of physics, chemistry, history and geography. In this school – just like in the majority of the Hungarian schools – it is rare to teach science or any other lessons drawn together around one topic or have a project day such as this.

The project day was organised for students in the eight grade (13-14 years). There were 18 students, girls and boys mixed in a balanced proportion, in the class. The class originally consisted of more than 20 students but the school did not have the

suitable size computer room for the amount of students and wanted to create an ideal situation for this observation. In a normal case teachers would have paired some students to some computers. Pupils do not have much nor considerable experience in using computers for learning purposes within lessons.

The chemistry (and maths) teacher is a middle aged woman, the deputy head of the school. She is very good at organizing events. She is responsible for the school participation in local and national and some international events (OECD study, Celebrate). She has 30 years' teaching experience and she has been using computers occasionally in lessons for 10 years. The teacher of physics (and informatics) is experienced in innovative and ICT-like activities. She has been teaching for 12 years and using computers for teaching purposes for10 years. The third teacher is a historian and librarian, she teaches human studies. She is very adventurous and in the last couple of years, she has been trying to use and create materials and ready software (like excel) for teaching purposes. She has teaching experience of 6 years. The observed teachers did not participate in the Celebrate LO development (WP4) but became very much involved in LO creation during the pilot period. All of them used the templates and created LOs. They also translated and modified LOs as tasks in the pilot phase.

The teacher have had some experience using LOs and the CELEBRATE templates, the portal and the pedagogical methods brought novelty into their professional development.

Two weeks before the observation of this case, we, the researchers, proposed a way of working with the teachers and asked them to prepare lesson plans that fit their working plan. There were some preconditions to be considered:

- we asked the teachers to prepare a day (lessons) that are unusual and outstanding even in their own practice ICT-usage
- we asked them to document each stage of planning and delivering of the lessons
- we asked them to help with the writing of this report by checking if everything is summarised correctly
- we told them that we were going to interview them before and after the session.

In the preparatory phase there were frequent email exchanges between the coordinator and the school. Two of the teachers were contacted and were also personally helped over the phone.

On the day of the observed project day teachers did not keep the traditional lesson duration of 45 minutes. They followed the natural rhythm of work and had breaks when they were natural or needed because of fatigue. The next teacher was present while another teacher was delivering her lesson and in this way other teachers could take over the lesson at any time without breaking the natural flow of the project day.

By being present for another teacher's lesson, the next teacher could refer to points that had already been touched upon.

We, the researchers, observed that students were disciplined throughout the project day. There was no reluctance or disciplinary problems amongst students thanks to two facts: firstly the use of computers kept students focusing on their tasks and secondly, of course, students were aware of the presence of the observers and appreciated the peculiarity of the session.

The LOs used during the day were:

1. Energy (Hungarian CELEBRATE LO)

http://celebrate.digitalbrain.com/celebrate/community/celebrate/resources/Hungary/fizika/Az%20energia/home/ (In English:

http://celebrate.digitalbrain.com/celebrate/community/celebrate/resources/Hungary/physics/Energy/home/)

It is a problem based and exploration type of LO.

2. Conservation of energy (Hungarian CELEBRATE LO)

http://celebrate.digitalbrain.com/celebrate/community/celebrate/resources/Hungary/fizika/Az%20energiamegmaradas/home/ (In English: http://celebrate.digitalbrain.com/celebrate/community/celebrate/resources/Hungary/physics/Conservation%20of%20energy/home/)

It is a problem based and exploration type of LO.

3. Carbon *(Mineral coal as an energy resource)* (Hungarian CELEBRATE LO)

http://celebrate.digitalbrain.com/celebrate/accounts/zajaczne/web/szen2/home/

(In English:

http://celebrate.digitalbrain.com/celebrate/accounts/zajaczne/web/carbon1/home/)

It's an information resource.

4. Crude oil and natural gas (non-Celebrate material)
http://www.sulinet.hu/tlabor/kemia/szoveg/index.htm

This is an information resource. .

5. Nuclear energy (non-Celebrate material) http://www.npp.hu/

This is an authentic internet resource, a whole portal about nuclear energy and power stations, maintained by the biggest power station of Hungary.

6. NAME MISSING
http://celebrate.digitalbrain.com/celebrate/accounts/halacsy/web/maghasadas/home/
It's an information resource.

7. Green house effect (Celebrate LO)

http://celebrate.ls.no/English/Animations/Science/drivhus_eng.swf
It is an exploration type of simulation..

8. Wind energy (Celebrate LO)

http://celebrate.ls.no/Norsk/Animasjoner/NMfag/VindkraftXL.swf

It is an exploration type of simulation.

9. Hydro energy (Celebrate LO)

http://celebrate.ls.no/Norsk/Animasjoner/NMfag/vannkraftXL.swf
It is an exploration type of simulation..

10. Sun energy (Celebrate LO)

http://celebrate.ls.no/norsk/animasjoner/NMfag/solkraftXL.swf
It is an exploration type of simulation..

11. Hydro energy (non-Celebrate material)
http://www.nyf.hu/karok/ttfk/kornyezet/megujulo/vizenergia/Vizenergia.html
University material (information source). Not available at the time of the analysis.

12. Bio energy (non-Celebrate material)

http://www.nyf.hu/karok/ttfk/kornyezet/megujulo/Biomassza/Biomassza.html
University material (information source). Not available at the time of the analysis.

13. Geothermal energy (non-Celebrate material)

http://www.nyf.hu/karok/ttfk/kornyezet/megujulo/geotermikus/geotermikus.html
University material (information source). Not available at the time of the analysis.

14. Oil (non-Celebrate material) http://www.sulinet.hu/tart/ncikk/ja/0/12864/olaj.htm

A closed information resource in the Sulinet portal.

15. Energy page (non-Celebrate material)http://www.energia.lap.hu

Authentic online information resources. Every group used this URL since it has links to all kinds of energy pages.

16. Household energy

http://celebrate.digitalbrain.com/celebrate/accounts/somogyi/web/hazenerg/home/

(In English:

http://celebrate.digitalbrain.com/celebrate/accounts/somogyi/web/house/home/)

17. Spread sheet LOs

2. The structure and phases of the teaching and learning sequence

During the observed Project Day the students did not learn anything new but it was the way of recalling and revising everything they had learnt about energy at primary school. The teachers wanted them to see the facts that had been learnt from different viewpoints as well as from a wider perspective. They focused on sustainable development and environmental protection.

Physics

- A prepared student reads a short story aloud (Ferenc Móra: The energy conservation, - motivation with literature)
- Revising the concept of energy and of the energy conservation law with the help of two Celebrate LOs
- Filling in a paper test and a whole class frontal check – re-check individually with the tests within the LOs
- Deepening of concepts by frontal class work

Chemistry

- Review of knowledge about energy acquired during the previous lesson
- Forming student workgroups according to their interest; discussion of tasks and distribution of them
- Group work assisted by Celebrate LOs related to the kinds of energy and also through studying given websites and presentations (One previous prepared *PowerPoint* presentation and the those done by the groups)
- Whole group discussion about the importance of environmental protection

Chemistry 2

- Review of knowledge related to the curriculum with the whole class through frontal teaching class work
- Small group discussions about renewing energy resources
- Group work with help of the computer, preparation of reports on a renewing energy resource
- Reporting the group work to the whole class
- Common discussion, strengthening the main points
- Individual test and sending it to the teacher via e-mail

Geography/history

- Group work on different tasks using excel sheets (data processing and analysis)
- Presentation of diagrams produced or analysed in groups

The teachers' evaluation of the project day:

Everybody got quite tired; the day was longer than expected but they had reached the aim of revising and applying existing knowledge, and the students seemed to be concerned about sustainable development and environmental protection. It was nice to see how much students were interested in the LOs and various kinds of computer aided activities.

Originally the teachers wanted to divide the day into four equal parts of 45 minute sessions but very quickly changed their minds and decided to be flexible with time instead of hurrying the students and not giving enough time to complete task. The teachers (especially the history teacher) planned too many tasks and there was no possibility to fully analyse the lessons the students received.

3. An analysis of the pedagogical approaches

During the day the teachers explained very little explained to the students. They acted as puppeteers of activities but kept all the strings in strong hands. They did not allow student's to plan activities or choose with whom they wanted to work with. In some cases, groups were formed by the interests of individual students, for example everybody could decide which energy resources they want to have a closer look at. Individual work, group work, student's presentation and frontal discussions happened during the day, and students had much more active time than usual. They were not passive listeners to the teacher.

Most of the day was spent on activating previous knowledge with new tools and methods, with applications, simulations that conveyed the information in other ways

than text format. Students were supposed to recall their knowledge with the help of animations, simulations, pictures, diagrams etc. They had to translate visual information into verbal (mostly oral) forms.

The 'project' day meant no constant groups working on the actual preparation of a project product. The common topic, the massive use of computers and the unusual timing of the lessons made it a project. It was a really unique day and experience both for students and teachers. The students spent more time on computer tasks than other activities. Among the digital materials there were a lot of authentic resources like the public website of the largest Hungarian nuclear power station. (http://www.npp.hu/). The teachers did not instruct the students what to look for and pay attention to when visiting a website, they had to decide what is important in connection with the different energy resources. It was clear that the students had the responsibility to introduce the information to the others, since each group had different tasks.

The most expert-like activity was the creation and analysis of diagrams. The knowledge was presented and created by a wide range and types of authentic information resources from different view points. The PowerPoint presentation on Nuclear energy was prepared in advance by a student Problem based learning method was used, for example when the diagrams and charts of different energy resources were analysed, students had to find out what the possible problem and what the solution would be.

The teachers were always at hand when technical problems occurred. When task or topic clarification was needed they did not give closed answers but guided the students to find the correct answers themselves. Assessment was used many times during the day. The teachers wanted to know if students had understood the different phases of the topic and built in extra checks beside the topic with the LOs.

In Hungary the majority of innovative teachers have recently been learning the project method and the concept of project was unclear to them at the time of the observation. There was no common product as an outcome of the day and the groups did not work together during the whole day. Maybe these teachers wanted too much from the Project Day and at times there was not enough time for exploring certain parts of the lessons.

The students and teachers were equally excited about having this extraordinary day. They were aware that they had been trying something interesting. All knew that the day was to test a possible way of learning. Although it was exhausting, all agreed that it had been worth trying.

The layout of the room with fixed rows of desks does not allow for real group work, students were not able to discuss their findings. This is why sometimes group work

turned to be individual work and someone with the same task but having worked individually took the responsibility of reporting the findings.

4. The evaluation of the learning objects

About 20 digital resources were used during the day. It does not mean that all the students had to process all of them, but students in different groups were likely to have different tasks with different LOs. 11 of them were Hungarian Celebrate LOs, 4 Norwegian simulations with and without English text. They also used two resources of the Hungarian Schoolnet and five authentic web resources that were not specifically for teaching or learning.

Some of the Hungarian LOs used are for problem-based learning. (*Energy*, and *Conservation of energy*). These LOs do not contain too much text and use clear and simple pictures and animations to present the problem and the phenomenon. They are clear in concept and allow for self assessment.

None of the LOs caused technical problems for the students though they were uneasy with putting the simulations into words. (For example the *Green house effect*). It was clear that different kinds of information (visual, verbal) are not easy to translate into another language. Some students would have been happier with some help embedded in the LO.

Researcher's comments about individual LOs:

Energy

It is easy to use and the concept is clear. It has elements of demonstration, simulation and assessment with closed questions in the end. The interactivity allows for trying things and experiencing the result of the action made. The tasks simulate authentic tasks. It's a medium level cognitive challenge. The LO has no features of collaboration.

Conservation of energy

The author and the features of LO is the same as above with the exception of being a bit less interactive and explorative. The cognitive challenge is lower as well. The LO is also less attractive, the graphics are too simple and technically inactive. (This was made by a production company experienced in making educational CD-ROMs)

Carbon

It's a rich information resource LO. Knowledge is presented in a ready-made manner and understanding is guided through questions. It allows for little interactivity,

students have not much to do but read and answer the questions. (This was an LO produced by a CELEBRATE teacher with little experience with Flash animations.) The LO is open, it offers external information resources and this way it allows for individual exploration. The LO has no features of collaboration.

Crude oil and natural gas

This is an LO of an old CD-ROM published on the Sulinet portal, made by the same professional team as the first two LOs). The content is closed and small, the whole LO consists of two pages. This is an information resource of some text and animation. The LO has no features of collaboration.

Nuclear energy (non-Celebrate material)

It provides expert knowledge and exploration. It is an interactive LO but this interaction is little more than students clicking. The knowledge is presented from multiple viewpoints but closed. It does not support collaborative work directly and the content is rich enough to plan group activities or even a project.

Nuclear fission and chain reaction

Similar to the Carbon LO but it is not open and there is even less interactivity in it. The LO has no features of collaboration.

Green house effect

Students can make experiments and draw conclusions by themselves. It's a high level cognitive challenge, because no help has been given. The LO is very good for illustration or recalling previous knowledge. Students had difficulties with explaining the process represented by the simulations. The LO has no features of collaboration, but during the project work this and the following ones were used in group work.

Wind energy

It is very similar to the Green house effect simulation. It is easier to understand, represents a lower level of cognitive challenge.

Hydro energy

It is very similar to the Green house effect simulation. It is easier to understand, represents a lower level of cognitive challenge.

Sun energy

It is very much alike the Green house effect simulation. It is easier to understand, represents a lower level of cognitive challenge, but during the activities we asked one of girls if she knew what she had been experimenting with and she said 'no'.

Oil
An article with not too much text and 2 pictures. It does not allow for anything else but reading and trying to understand.

Energy page

Wide range of authentic online information resources. Students were asked to find the energy resource of the group. (Multiple information resources were used)

Household energy

It is the most exciting LO of all. However in design it is not outstanding, it offers life-like knowledge and activities and activates previous knowledge. Students can place household gadgets into a home and can explore how much energy they consume within the period that they can set. The test is like a quiz show, there are different help opportunities. It is interesting and keeps students busy. However it is not a collaborative LO by design or in-built tools but easy to use in pairs.

Spread sheet LOs

They were really motivating and useful. The students were given digital charts and they had to convert them into diagrams. Then they had to explain what the charts and diagrams told them about energy consumption. The knowledge was open and not worded.

Case study 10 The waves

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1. An overall description

The school was chosen on the following reasons

- Its location being the closest school to the Hungarian Schoolnet
- The school had a lot of involvement in almost all ICT projects on national and international levels
- Two of the teachers were subject consultants for the LO development process (WP4).

In the case of this school the teachers, but not the head teacher, were contacted by the national coordinator. The school is considered to be of exceptionally high standard. It is a school that is difficult for students to get accepted to, because the number of students applying is always doubled or trebled the places available. They accept 'problematic' students and look for a good mixture of personalities rather than bright children from the middle or upper classes. The school is situated in an area of a low standard of living, unemployment, crime and minority problems occur.

The school is known to be exceptionally well equipped regarding ICT. It has three such computer rooms, where not only computer studies but general subjects are taught. They also have classrooms, which are equipped with a projector and one or some computers.

The teacher in this case is female and is an experienced user of computers in lessons. She planned the observed lessons herself and with out the help of the researchers or coordinator. She has 17 years of teaching experience and she has been using LOs for three years. She has acquired the use of the digital LOs with help from her colleagues. She is continually trying to get more information accumulated for her computer supported teaching. She often searches for new LOs on the Internet to make her lessons more interesting. Like the previous observed teacher, she is member of the school's science workgroup. Members of this group use LOs very often. They have been developing a common LO database.

Although the school is very well equipped it is still not easy to organise lessons other than informatics in computer labs because of the high demands for labs. Sometimes teachers split a lesson: part of the lesson is delivered in a traditional room; then they move and the rest of the lesson takes place in a computer lab.

The observed class consisted of 24 students attending the 9th grade.

The lessons were held in different rooms and in all labs some students had to share computers in pairs, since there are 18 computers in a lab. They even had to arrange for chairs before the lessons. None of the rooms was ideal for collaborative working.

The LOs that were used:

First observed lesson - Origin of voice

1. Static waves
http://celebrate.digitalbrain.com/celebrate/accounts/kispalne/kozos/allohullam/visszaver/ (*In English:*
http://celebrate.digitalbrain.com/celebrate/accounts/kispalne/kozos/stand/home/)
Both an information source and exploration type of LO.

2. Surface waves

http://celebrate.digitalbrain.com/celebrate/community/celebrate/resources/Hungary/fizika/Feluleti%20hullamok/Interferencia2/?backto&verb (In English: http://celebrate.digitalbrain.com/celebrate/community/celebrate/resources/Hungary/physics/Surface%20waves/home/)
An exploration type of LO.

3. Sounds of Bars
http://celebrate.digitalbrain.com/celebrate/accounts/kispalne/kozos/palcak/home/?backto&verb (In English: http://celebrate.digitalbrain.com/celebrate/accounts/kispalne/kozos/bars/home/)
An exploration and an information source type of LO.

4. Sounds of strings
http://celebrate.digitalbrain.com/celebrate/community/celebrate/resources/Hungary/physics/Surface%20waves/home/ (in English:

http://celebrate.digitalbrain.com/celebrate/accounts/kispalne/kozos/strings/home/)

An exploration and an information type of LO.

Second observed lesson - Human sense of hearing, perception of sounds

1. Sound, noise and hearing – Air traffic noise
http://www.edu.fi/oppimateriaalit/aihiot/eng/physics/sound/ear_3/home.htm

An exploration type of LO.

2. How do we perceive sounds?

http://celebrate.ls.no/english/animations/science/orets_sanseceller.swf

A single flash file, just words the problem.

3. Ears – missing data

http://celebrate.ls.no/english/animations/science/orets_sanseceller.swf

http://celebrate.ls.no/english/animations/science/orespill.swf

Twin interactive flash files with inbuilt help to identify the parts of the ear.

Third observed lesson - Human's sight, perception of the visible light

1. How do we perceive sounds?

http://celebrate.ls.no/English/Animations/Science/oyets_sanseceller.swf

A single flash file, just words the problem.

2. The eye http://celebrate.ls.no/english/animations/science/spill_eye.swf

An exploration type of LO.

Fourth observed lesson - Electromagnet waves and their practical use

We were unable to identify all the LOs and digital resources used in this lesson because the students independently searched on the Demo Portal and the Internet for resources that were useful for their tasks. It was an additional source of information to that of the paper-based materials that the teacher had given to them.

2. The structure and the phases of the learning/teaching sequence

We observed four of thirteen lessons in a six week teaching period. We had preliminary discussions on the curriculum and the possible points to observe. We went to see ordinary lessons with no computer use and had several meetings, phone calls and e-mail exchanges to prepare the process. The thirteen lessons were not on just one topic but several topics of a knowledge area. The ordinary lessons were only interesting from the point of analysis to compare methods and motivation.

The observed lessons fit into the following syllabus:

Module 1: Centre of gravity vibratory motion – 3 lessons

Content: harmonious vibratory motion; calmed vibrations; forced vibration

Module 2: Material waves – 10 lessons

Content: introduction to waves; development of waves; characterisation and grouping of waves; meeting of waves, interference; deviation of waves, diffraction; development of standing waves; instruments: stringed, percussion, wind instruments

The teachers' evaluation of the lessons and the whole teaching sequence:

Each lesson had its own aim. The overall aims were to develop students' cooperative skills, sense of responsibility, problem recognising and solving thinking, reading comprehension, speaking skills and their ability to use computer tools. Majority of the previously set pedagogical aims were fulfilled, like the development of cooperation and ICT skills. Group work and knowledge transfer between the groups went well. Process of problem solving was not really successful. The teacher considered the pictures, animations and simulations were very important, the tests proved that the students remember the topic better than the text based information.

3. Analysis of the pedagogical approach

Nature of activities

Although cooperative methods were used more widely than in usual Hungarian lessons, there were significantly more of them during the computer supported lessons.

Individual, pair and group work were applied in quite a sophisticated way. Blended learning took place in all observed CSL (computer supported learning) lessons. Previous knowledge usually was stimulated by non-computer group activities. For example all groups (4-4 students) got an envelope with the same four sentences, cut up into single words and they had to recall them in a competition amongst groups.

The students in a group often had individual tasks (for example searching for pieces of information) and the group gathered knowledge in discussions, using these small, individual parts.

During computers supported lessons oral tasks were rare and the teacher did not take any time for explanations. When summarising through frontal teaching she stressed one or two things but it was clear that the students were the active participants in the lesson. In the teacher's ordinary lessons, she spoke quite a lot however she applied numerous cooperative activities as well.

Among the expert-like authentic activities the most valuable was when the students in pairs made crossword puzzles for each other to revise their knowledge. They used the Digitalbrain templates and the LOs and websites that they had visited during the previous lessons.

Nature of knowledge processing

Searching for and processing information occurred a lot of times. They were supposed to take notes while doing this and the teacher often reminded them that in the end of the lesson a test would show how well they worked. 'Test' seemed to be a tool of discipline.

Exploration was often used individually or in pairs or in group discussions. The LOs used by students had a lot of simulations and they had to understand the theories behind them. The teachers sometimes asked them not to read the explanation but to find out what the simulation represented and what the idea was behind it. Traditional lessons allowed for less exploration

Knowledge building took place in an authentic way several times, for example when presenting some scientific concept with the results of the collaborative work from students; or when they created crosswords to revise their own studies and check the knowledge of other pairs.

The responsibilities of the teacher and the students

The overall structure of the activities was planned by the teacher and during computer supported lessons she took on a role similar to a coach or a helper but this was not the case when working in the ordinary classroom. It was significant that in traditional lessons, the student's learning was the teacher's responsibility and she controlled all the activities more closely than what she did in the computer lab. In the computer lab she had a less distinct role and she did not spend much time using the computers. During CSL she did not apply frontal approaches of teaching except at the very beginning and end of the lessons.

Sometimes, during computer aided lessons she should have been clearer as there was ambiguity about what to do exactly.

In pair and group activities students were responsible not only for their own personal development but for other members of the group as well. This responsibility was much higher in the CSL lessons. Since the 13 lessons were loosely chained and the activities did not build on each other, this responsibility was lower then possible.

In some cases the lack of responsibility from the teacher destroyed the aim of the lesson. For example, the fourth observed lesson was built on home preparation and planning where the students were asked to study paper-based materials at home and decide how they would present them with a given concept to others preferable using ICT tools. Though the tasks and the methods would have been interesting but the failure of the students to use the presentation software (PowerPoint) and the lack of careful preparation for the lesson resulted in a less than interesting lesson.

In the teacher's opinion, students did not have to be rebuked as many times in the CSL lessons compared to that of a traditional lesson. The observers visiting traditional and computer supported lessons did not see much difference regarding the level of class discipline. In the computer labs, their attention might have been more engaged than what it was in ordinary classroom, although they always found something more important than the curriculum to deal with.

4. The evaluation of the learning objects

Problems of LOs:

First observed lesson

The teacher wanted the students to use just one simulation at a time and draw conclusions, but this instruction was not clear enough and they were wandering all over the LO. It caused some problems since the next URL given in the next task was the same LO but another animation.

Second observed lesson

There were many technical problems. In the first part of the lesson the Demo Portal did not work. The teacher solved the problem by using oral activities but the students did not really adhere to the change. Some computers did not work either. Students who were supposed to re-register in the Demo Portal had forgotten to and those who had done so could not remember their passwords. Some software was missing. The Celebrate LOs downloaded slowly, the connection was inactive. There were too many technical mishaps so the lesson was a failure. The teacher postponed the activities for the next lesson. The time was especially short because they changed rooms during the lesson which was not unusual in this school.

Third observed lesson

Some students could not remember their Demo Portal passwords. The Internet access was slow. The tutorial for the crossword template proved to be not efficient enough, so the teacher used the intranet system of the lab and showed students how to edit crosswords with the template. All problems were solved and the students worked with interest and success.

Researcher's comments about individual LOs:

Static waves
Information is given, there are very clever interactive simulations and students can discover what happens when conditions change. More senses of the body are used (seeing, hearing, doing) so this LO allows for different learning styles. It has average cognitive level and, although it was not designed for direct collaboration; it was used in a collaborative way.

Surface waves

This LO starts with a life situation and introduces the topic interactively with student-led experiments (simulations) which we consider to be exploration. There are no external resources given, but still, it is not a closed type LO, since the experiment

allows for constructing and testing ideas and concepts. It is of average cognitive level and, although it was not designed for direct collaboration; it was used in a collaborative way.

Sounds of Bars
It is a well designed, attractive LO. It consists of several activities, including exploration and it calls for problem solving. It is an information source as well as an open LO as there are links to external resources. More senses of the body are used (seeing, hearing, doing) so this LO offers different learning styles and has quite a high cognitive challenge.

Sound, noise and hearing – Air traffic noise

This LO teaches sounds by a sounding LO which is very good. The sounds are in English. It can be considered a 'closed exploration', since there are no differences in viewpoints or external resources offered but the animations allow for cognitive challenge. There is no in-built collaboration.

How do we perceive sounds?

A single flash file, just words the problem. Quite irritating noise included.

The eye

This LO is an interactive animation about the parts of the human eye. It has an in-built help and indirect information. Students can learn by doing. It is a simple kind of exploration. The teacher gave students the Hungarian equivalents of the English terms, so there were no language difficulties.

5. Conclusions

The ICT tools took a role in each observed lesson. When the lesson took place in an ordinary classroom, they used one computer and the projector. Cooperative methods and group dynamics have been used quite well in both settings. The lessons at the laboratory were more playful and student centred.

Although the school is among the best equipped secondary schools in Hungary and they have two system administrators, we experienced technical problems in each lesson. The teacher is experienced in ICT and can resolve messy situations, but sometimes it was not easy or even was impossible to complete the lesson plan.

According to the interviewed students, computer supported lessons are motivating when they are rare or there are a few lessons where learning can take place with computers but this cannot be done in the majority of the subjects. They think that

there is no difference in learning when using a computer supported lesson to that of traditional lessons.

The assessment results revealed that visual information was acquired more effectively when using computers but the theory way behind.

Case study 11 Interactions of people and environment

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1. An overall description

The case study was conducted in the same school as case 10.

The teacher is one of the top ICT experts in education in Hungary. He has designed quite a number of LOs, he localised the Fle3 cooperative platform for Hungarian use, organised and led a lot of national and international ICT related projects. He has been teaching how to integrate ICT into subject teaching in teacher trainings. The teacher has a teaching experience of eight years; he has been using LOs since 1997 on a daily basis. He has also been working for the Hungarian Schoolnet consulting digital material and portal development.

The observed class was the tenth grade and15-16 years old, boys and girls. The class consisted of 22 students.

We observed the last 2 lessons of the lesson sequence. The lessons were held in different rooms; the first one in an ordinary classroom with one computer and a projector; and the second lesson was delivered in a computer lab where pairs of students sat at five computers; the other 12 children worked on their own.

The lesson delivered in the ordinary room had a frontal character and was computer supported. The teacher extracted pictures and animations with the help of a computer, demonstrating the actual knowledge area: ‘Regulation of the venereal functioning’ - Women’s cycle.

The second observed lesson was in the computer lab and it was based on individual work. The teacher offered six interactive tasks that he had made with the help of the Digitalbrain templates; students had to revise their knowledge with game-like

activities during the lesson. Students followed the lessons with great attention; there were no disciplinary problems.

The LOs that were used:

First observed lesson – Regulation of the venereal functioning

1. How do hormones work http://trial.learnexact.com/celebrate/celebrate/108/5b405b8a-c6b3-497b-8252-6cfc58f90e45/hachettelo/19/index.html

An information source.

2. The women's cycle

http://celebrate.digitalbrain.com/celebrate/community/celebrate/resources/Hungary/biologia/A%20noi%20ciklus/home/ (In English

http://celebrate.digitalbrain.com/celebrate/community/celebrate/resources/Hungary/biology/The%20women%27s%20cycle/home/=

An exploration.

3. How do hormones control the menstrual cycle?
http://celebrate.ls.no/English/Animations/Science/Menssyklus_hormoner.swf

A simulation.

Second observed lesson – Revising and testing acquired knowledge

1. The homeostasis http://www.poli.hu/term/bio/homeo/

6 Digitalbrain template tasks made by the teacher, organised in one page for the lesson.

2. The structure and the phases of the learning/teaching sequence

The observed lessons fit into the following syllabus:

Interaction of the living being and the environment

Internal equilibrium of the organism – homeostasis The liver	• Own Power Point Presentation http://trial.learnexact.com/celebrate/celebrate/108/5b405b8a-c6b3-497b-8252-6cfc58f90e45/hachettelo/19/index.html • Frontal lesson
Guidance and regulation. The energy household of the organism.	• Cooperative lesson
Regulation of the level of the blood sugar. Diabetes	• Own PPT • Frontal lesson
The water household. The kidney	• Own PPT • Frontal lesson
Autonomic nervous system. Hypothalamus – pituitary gland system	• Cooperative lesson • http://celebrate.ls.no/English/Animations/Science/hjernespill_enkel.swf
Regulation of the venereal functioning	• Own PPT • http://celebrate.digitalbrain.com/celebrate/community/celebrate/resources/Hungary/biology/The%20women%27s%20cycle/home/ • http://celebrate.digitalbrain.com/celebrate/community/celebrate/resources/Hungary/biology/A%20noi%20ciklus/home/ • http://celebrate.ls.no/English/Animations/Science/Menssyklus_hormoner.swf • Frontal lesson
Summary	• Practice and summary using the computer (work in a computer lab) • http://www.poli.hu/term/bio/homeo/
Essay	• Closing the topic: interview with a diabetic person (home task)

The teacher's had the following to say on his evaluation of the lessons and the whole teaching sequence which was that:

- It depends on the aim of the lesson if he uses computers and if he does use computers; how he uses them.
- According to his experience computer supported education is more effective, but it has to be combined with traditional methods (blended learning).
- Theoretically the book is the basic source of information in Hungary, but his practice shows, that students use their notes and the LOs. Books are used only as something extra, although he made students also use the book on every single occasion.
- The teacher also mentions that the lessons went on with no major changes to the plan. The student-made LOs were tried during the following lesson.

3. Analysis of the pedagogical approach

Nature of activities

During the first observed *lesson* the students did not use the ICT tools, which served as presentation tools for the teacher. The teacher used his own PowerPoint presentation and two of the Celebrate LOs. This was a multiple resource teaching and learning method, presented by the teacher. After having looked at 3 animations students had to choose which ones they liked the most. The teacher explained the concept using two animations chosen by the students. The second one was more complicated and repeated it step by step. Students quietly listened and took notes when they were not called to ask questions or have discussions.

In the second *lesson* the nature of activities were much more student centred. The teacher made six different tasks, kind of games using the Digitalbrain templates and put the tasks on a web page subsequent to his own site. (http://www.poli.hu/term/bio/homeo/). These exercises were aimed at activating students' knowledge acquired during the last couple of lessons.

The most authentic task of all was to create their own quizzes for each other using the same tools. Students were encouraged to process the tasks at their own speed.

The responsibilities of the teacher and the students

During the first observed lesson the teacher took central role; he was more active that than the students who were mostly listening, taking notes, asking questions and discussing the topic. He was the designer of the work in the second case as well, but there the students first checked their own understanding of the previous lessons. The

computer allowed them a certain time limit to complete one task and they proudly reported when they had been able to finish much earlier.

The process and the structure of the *lesson* were definitely planned and controlled by the teacher. Activities had a definite sequence, which was continually kept. Even during the *lesson* delivered in the computer lab the sequence of the six Digitalbrain template-exercises was defined. Students had to do the game-like interactive assessment LOs according to that sequence. Traditional and attentive teacher-student relationship was typical for both *lessons*.

They were happy to create interactive tasks for their peers.

4. The evaluation of the learning objects

During the lesson delivered in the computer lab some computers became frozen and had to be restarted, but it didn't cause any tie-up, students solved this problem independently by restarting the machines.

Researcher's comments about individual LOs:

How do hormones work?

This is a static LO with a graphic illustration and text. There is no challenge, it is a form of course book type information source. The student did not like it, so the teacher did not use it in detail.

The women's cycle

This problem-based LO helps to understand when and why women are likely to get pregnant. It is a simple material with not much text. It allows for interactivity, students can set the circumstances and see what happens. There are no external information resources but the simulation can offer for high level cognition. This time the LO was not used by the students but in a question-answer frontal interactive way.

How do hormones control the menstrual cycle?

This is a one-page simulation. It has some explanation but there is no technical help. The LO is good for an experienced teacher for presentation but someone with little experience in ICT may be unable to understand how to operate the LO.

The homeostasis

(6 Digitalbrain template tasks made by the teacher, organised in one page for the lesson).

No problem but with finding how to operate the tasks. The templates do not allow for translating the instructions or for using Hungarian characters with accents. This is a disturbing problem, since teachers usually insist on using correct materials. In some of these tasks the teacher inserted Celebrate assets like pictures in his own template-supported LO.

5. Conclusions

Students enjoyed the computer *lesson* much more. Although the exercises were motivating and they considered them as challenges, they cheated a little by copying. There was also a degree of competition as students tried to solve the exercises as soon as they could, then announcing their completion time to other students. It was not a problem if someone was not able to finish their LOs, the teacher asked them to complete the task by the next lesson when they would try them.

National conclusions

The importance of teacher's ICT competence

Learning objects were mainly used in blended teaching and learning sequences. All the teachers in the cases had good or extra ICT skills and they have already had years of experience in using computers and different materials for teaching purposes. All of them have already created more or less LOs within and outside the framework of Celebrate, and all have international project experiences.

The teachers in case 9 and 11 did not have obstacles that would have ruined their lesson plans. In case 10 there was a lesson which became messy because of technical mishaps. The teacher said that this happens sometimes and she was not the least disappointed .

Analysis of the pedagogical nature of the activities

The cases had several features that represent *advanced* pedagogical approach, like computer supported collaborative learning, knowledge building with the help of authentic, open materials and explorations.

Students' responsibility was variable, but we found out that more responsibility was given to students when they were in labs than in an ordinary classroom setting. The learning sequence was designed by the teachers in all cases but with considerable flexibility in all of them. In case 9 the teachers decided to free the time frames of the original plan, in case 10 and 11 the students could choose among the templates to create the tasks, and in case 11 students told the teachers which animation they liked and those ones were used.

Students' responsibility was higher when (often) working in pairs or groups and there was interdependency on each other. We consider those tasks the most authentic when they had to produce a 'product' applying the knowledge that had been acquired by authentic multiple resources (case 10 and 11, the template tasks) and when they had to translate visual information into verbal (in case 9, spreadsheet tasks).

In case 9 the learning content was chained to some expert knowledge (ex. the website of the power station), and in case 11 the students had to make an interview with a person who has diabetes.

Primarily in cases 10 and 11, collaboration among students was natural and valuable while in case 9 group dynamics did not work. (Students did not sit together in 'groups'; group work only meant having the same exercise without group interactions or discussions). It was obvious that more collaborative tasks occur in the computer labs than in ordinary settings.

No school books were used in any of the cases during the observed lessons, but two of the teachers mentioned their importance. In case 9 a teacher tried to make the students remember a fact by saying where it was in the school book, and in case 11 the teacher with extraordinary ICT skills said that he always calls the students' attention to use their books. In case 10 students reported that they do not see the difference between using digital and non-digital learning resources regarding efficiency.

In all cases they used external resources not just a couple of given LOs and the students had open tasks. In case 9 there were a lot of Internet resources offered for collecting and processing information, in cases 10 and 11 there were more open tasks like creating exercises for each other.

Ordinary teaching practices in Hungary concentrate on knowledge that is acquired and not the activities or the ideas. The learning resources are the teachers and the schoolbooks, and the students have to learn what they say. When students' tasks and activities take the majority of school time it is considered an "advanced" pedagogical method.

All observers looked for meaningful activities, individual and group learning, collaboration. The advanced teachers know that this is the 'trend' and they try to follow it by designing a lot of various activities especially when being observed. In all cases we came across examples of not having enough time for completing all the exercises planned, and in all cases there were tasks left over for the next lesson. In case 9 the most meaningful and authentic exercise (spread sheet) was not fully explored, in case 10 they did not have time to clarify what the cut up sentences really were. In case 11 the students completed their self-made interactive LOs at home. It means that in all cases fewer activities would have brought deeper understanding of the content.

Teacher as an organiser and guide in the process

In cases 9 and 11 the teachers had more central roles than in case 10, however in all cases they were the designers and controllers of the activities. During lessons held in the computer labs, using LOs teachers usually refrained from explaining and they took the role of the coach or guide. When in their most familiar surroundings, they were more traditional and took more control and explained the ideas instead of using multiple resources. In case 11 the teacher had a blended lesson in the ordinary classroom and gave a presentation, so he and the content were the focus, not the students' own knowledge seeking and collaborative knowledge creation.

The lesson plans, schemes and aim of the activities were well designed in all cases, and in case 9 and 10 they presented this information to the pupils through written guidelines in the beginning of the sequence. In case 11 the teacher prepared an online tutorial for enabling the students to process the task at their own speed.

Some activities were rigidly structured, some of them were open but most of them were scaffolded in some ways. In cases 9 and 10 the questions helped the students to concentrate on ideas, theories and in some cases these written questions put the students' imaginations and motivation into motion. (Case 10 connected to charts presented in a spread sheet and the teacher asked: 'What do you think the most important energy resource will be in a 100 years time? Why? Try to prove your opinion by using the digital resources!' They had been over this task when they converted the charts into diagrams and they had already had the information to report what the diagram said.)

The usefulness of the learning objects

In all the Hungarian cases, a lot of learning objects were used, and they were the structuring elements of the lessons. Especially in cases 9 and 10 where too many LOs were used, so these resources were not fully exploited and sometimes the lack of time made the activities less effective or useful, especially in case 9.

Some remarks:

- It turned out that some teachers did not like the animations, simulations that are not put into context but others can live with them very well, they build them in their own learning process design. Especially some Norwegian assets were used in case 10.
- Similarly, most teachers do not want to have a look at those LOs that are in other languages while others have no problem with some simulations regardless if they have any text in any languages. These are mostly the ICT-accustomed teachers (all cases).
- Students and teachers find the LOs with multiple senses more interesting. When there are sound effects, pictures, movies the LOs are not only more attractive but students have reported that they are easier to understand and remember.
- The Digitalbrain templates are extremely popular among the Hungarian teachers and students. However most of them are for assessing knowledge, they have the general feature of games. Teachers usually are against 'playing' in lessons but these games are accepted. The problem is that the tutorial/in-built guide in the templates cannot be translated. Another negative feature is that the Hungarian characters with accents cannot be used, so these tasks are a bit incomplete or idle.
- Definitive majority of domestic schools are not nearly as well equipped as the average school in the European Union regarding ICT infrastructure. From the studied schools the secondary school is considered extremely well equipped, and also the elementary school counted as better than the average. In those schools, where there are suitable computer and information science labs it causes problems and conflicts that schools can ensure places besides information science lessons only for foreign language lessons. Therefore it is very difficult to bring general subjects in the computer labs of the Hungarian educational institutions.
- Taking part in ICT-related projects like Celebrate is the most effective way of improving the level of expertise in both technical and pedagogical terms. In the interviews all the teachers and students were highly positive about the whole project and they are pre-occupied with further collaboration. They want to know if anything can be further used after the lifetime of Celebrate.

Ireland

Case study 12 The Spreading of the HIV Virus

Carmel Clifford, Robert McCormick, The Open University, UK

1. An overall description

This secondary school is located in a suburb in the city of Dublin, Ireland. There are about 1200 students in the school aged between 11 years and 18 years. The school participated in CELEBRATE project because of it's involvement with research by a Ph.D. student from Dublin City University (DCU), Ireland. This DCU researcher chose to be part of CELEBRATE because it offered access to digital material for schools involved in his PhD study.

This Irish school has a poor technological infrastructure compared to schools who have participated in the project in the UK. It has two ICT suites and according to the teacher, the suite where the observed lesson took place was the better of the two. The layout of this ICT suite was in a 'U' shape with some PCs in the centre of the room. Students in the class used approximately half the desktop PCs that faced two walls. The teacher and the DCU researcher stayed in the half of the room where students were located. The other PCs were used by a different class for the first fifteen minutes of the observed lesson. All the PCs were connected to the internet. The teacher said that he had difficulties in getting access to the ICT suite and ICT resources. The teacher of the observed class thought the involvement with the researcher's PhD enabled him to get access to ICT resources and fulfil his obligation to integrate ICT to his lessons.

The case study was conducted on a class of ten fifth-year biology students (aged 16-17 years) of mixed gender. The class took place in the last term of the school year and these students were shortly to do their end-of-year exams; this was to be a revision lesson. The LO initially to be used was called *Interdependence* and this was linked to a previous lesson on ecology. The metadata has described this LO as a Guide. (Go to the CELEBRATE Demonstration Portal to access LO: http://demoportal.eun.org/celebrate_dp/). This LO aimed to assist students to learn how different organisms within a community depend on each other for their survival.

The 'Interdependence' LO failed to download to the students computers on the day of the observation. A second LO was used called 'The spreading of the HIV virus' available at: http://celebrate.digitalbrain.com/celebrate/community/celebrate/resources/Hungary/biology/The%20spreading%20of%20the%20HIV%20virus/home .

The learning object type was described in the metadata as 'Drill and Practice'. A sample screen print of this LO is presented in Figure 17.

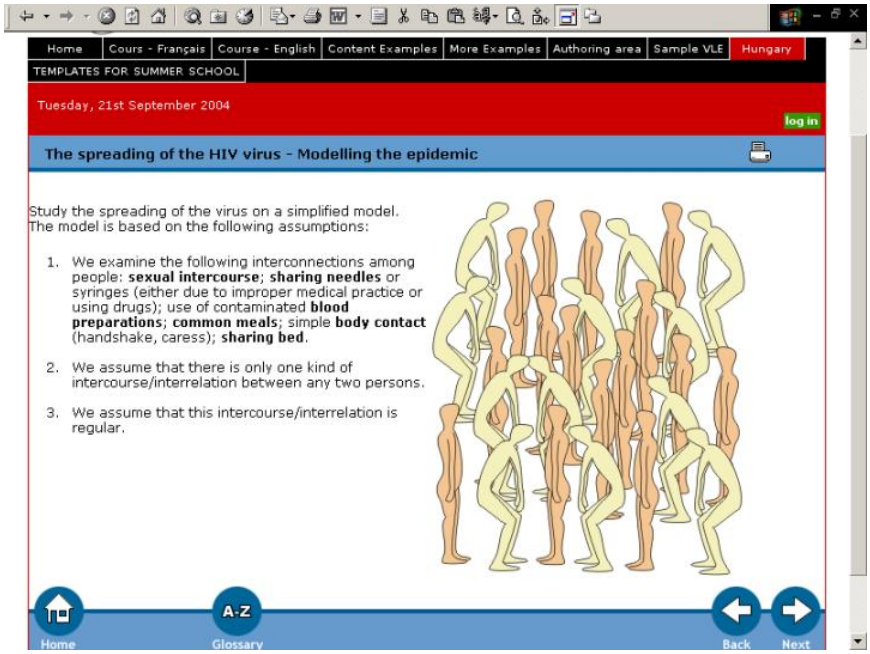

Figure 17. Sample screen from The spreading of the HIV virus LO

This is an interactive LO to investigate the spreading of the HIV virus. It demonstrates the working mechanism of the HIV virus, the development of the AIDS disease, the mode of defence and methods to fight the virus. This LO was the focus of the observation and will be discussed in more detail later.

The teacher's goal for the lesson was to revise previous material covered in an earlier lesson. He hoped that the use of the LO would:

> Reinforce what we have learned in the text book and the task will evaluate that. (Post-lesson interview with teacher).

2. The structure and phases of the learning and teaching sequence

Table 12.1 shows a detailed sequence of the observed lesson. The lesson was initially to be a revision of ecology but because the *Interdependence* LO did not download, the topic changed to revision of immunization and used the LO *The Spreading of the HIV virus*. In spite of the change in topic, the goal of the lesson remained the same as the teacher explained:

> We are linking this in with the immunity; remember we did that with the blood, circulatory. We couldn't get the link with the, interdependence but its still, it's still revision work because we've done the circulatory system and we linked that with the immunity system, okay? So it's still valuable revision work we're doing." (Observation transcript)

Table 12.1 Type and length of each activity

Activity	Length of time (approx)
Introduction	3 mins
Log onto the portal	2.5 mins
Accessing LO from Basket	2 mins
Downloading Interdependence	2 mins
Downloading HIV Virus	1 mins
Instructions for HIV LO	0.5 mins
Student using LO as information resource	16 mins
Test part of LO	5 mins
Discussion	4 mins
Researcher's questionnaire	4 mins

Time was an obvious issue for this lesson, with only forty minutes available to use the LO. As can be seen from Table 12.1, the process of logging on to the Demonstration Portal to downloading the second LO took 20% of lesson time. The introduction and explanations of the LO took 25% of the lesson (excluding interactions between teacher/researcher and students). Thus the LO activity made up 50% of the lesson.

The teacher did not take the lead in the class and allowed the DCU researcher, almost immediately at the start of the lesson, to take the leading role, a decision which may have been due to the teacher's unfamiliarity with the LO. The DCU researcher accepted the role offered by the teacher, but consulted the teacher occasionally. The DCU researcher was to some extent familiar with the class and had met them in a previous lesson as this class was involved in the data collection of his PhD research.

Before the students started the LO activity, the DCU researcher told them to read the material of the LO first and then do the activities. He said that he would let the students know when they could do the test. Near the end of the LO activity, students seemed to take more control of the lesson by doing the test without being told by the teacher or researcher.

The teacher and the DCU researcher had little interaction with the students during the lesson. When interactions did occur this was mainly with individual students to discuss either technical issues or LO content. The LO acted as an information resource and the students worked actively with it. They read the material of the LO and used the simulations that were built into the LO. The students were assessed by a test that was also part of this LO.

The students gave feedback about the lesson and the use of the LO in a whole class discussion at the end of the lesson. The DCU researcher gave the students a short questionnaire that was to be used for his own research which was separate from CELEBRATE.

3. An analysis of the pedagogical approach of the case

Nature of activities

The DCU researcher controlled the structure and the LO activity of the lesson using the teacher as a consultant as he was the expert on what the students had covered in previous lessons. The teacher was unfamiliar with the LO and questioned the researcher several times during the lesson. The lesson was organised around the LO. After brief instructions on how to use the LO, students appeared to work on the LO mainly individually on their own on desktop PCs; only one group of three girls appeared to consult each other. The DCU researcher and teacher responded to individual student's questions and dealt with technical problems as they arose.

Nature of knowledge processing

The lesson was centred around the LO which was mainly an information resource for the students. Students learnt about the HIV virus by reading the information in the text and looking at the diagrams provided in the LO. Simulations were also provided by the LO so students also explored how the HIV virus spread.

The LO assessed students knowledge of the HIV virus through a test consisting of a series of multiple choice questions. For every correct answer the student would receive a score and for an incorrect answer a minus score would be given. If students got all the answers correct; they would get a 100%. The feedback of the test was immediate. There was a mistake in the test that was initially discovered by students and confirmed by their teacher; this mistake introduced problem solving to the process of learning.

Responsibility of the teacher/researcher and student

Both the DCU researcher and teacher structured the lesson in what in effect was a team-teaching approach. The researcher took most of the responsibility in preparing the lesson. He chose appropriate LOs, in consultation with the teacher; he put LOs in his basket; he set up the desktop computers for each of the students; he gave his username and password to each of the students in order to log-in to the Demonstration Portal. The teacher was the main source of knowledge on the topic for students, however the teacher also acknowledged the LO's role.

> So this is going to teach you about the issue so it could get me out of a job you know (laughter). (Observation transcript)

The teacher had low-level interaction with students during the lesson. He was the student's source of knowledge and this was established through his confirmation to the students of the mistake in the test part of the LO.

The students were responsible for following the instructions of the teacher/DCU researcher and the LO. They took more responsibility for their learning when they started the test part of the LO without waiting to be told. Although the LO had options to go to different sections, all students appeared to follow the same linear sequence as on the contents page for the LO.

4. The evaluation of the learning objects

The role of the learning Object

The structure of the LO, *The spreading of the HIV Virus*, was divided into sections which were listed on the contents page: 'The problem', 'Modelling the epidemic', 'Characteristics and operation of the virus' and 'Test'. The problem section described the problem of the HIV virus. The section of 'Modelling the epidemic' explains how the virus is spread through text and simulations. The simulations show the spreading of virus by allowing the students to choose options to spread the virus or not to spread it; e.g. using a syringe of an infected person or using a syringe of a person not infected; e.g. shaking hands of an ill person to a healthy person or shaking hands of a healthy person to a healthy person. These simulations showed the result of the action a student chose. The 'Characteristics and operation of the virus' had more information in the form of text and diagrams. The student's knowledge was assessed through a 'Test'. There is no required sequential order to these sections as they all can be accessed through the contents page. There was also a 'Glossary' of terms that students could refer to for explanations of terms in the content of the LO that they did not understand.

Advantages of the Learning Object

Students learned independently of the teacher when they used this LO as most the interaction was between the student and the LO. In an open discussion in the class, the students gave individual feedback on what they thought of using this form of learning. The following are student's main comments:

- they thought it was a fun way to learn;
- the material was better than a book as it allowed them to learn the material in their own time;
- they thought the LO acted as a support for other material.

The simulations within the LO enabled students to explore how the virus spread by choosing a variety of methods and also allowed students to dispel myths of how the virus is spread by giving options where it did not spread. It would be impossible by conventional teaching methods to illustrate such a process, and might go some way in affecting student attitudes and beliefs.

Students individually used the LO and this could free-up the teacher's time to work with students who may need assistance. However, the teacher only worked with

students that approached him and did not appear to check student's progress otherwise. The teacher's limited interactions with students may have been due to his own insecurity of using ICT in a lesson; his lack of familiarity with the LO or the time pressures of only having the ICT suite for forty minutes and completing the task of the LO activity.

Problems of the Learning Object

Lack of time was an issue during this lesson as the class only had the ICT suite for 40 minutes and the class had to complete the LO in this time. It took 20% of class time to actually download an LO onto the desktop because of technical difficulties. This greatly reduced the time for the learning activity and also emphasised the difficulty of integrating an LO into a lesson.
The use of the LOs in this lesson was unpredictable. The class expected to use the LO of Interdependence but when it failed to download the topic of the lesson changed.
It was established in the case study lesson that the test part of the HIV virus indicated incorrect answers as correct in two of the questions. In spite of these errors some students received a 100%. The result of these students may have been because;

1) these students did not realise that the LOs had errors and gave incorrect answers;
2) these students wished to receive a 100% rather than have correct answers.

There is some evidence from the transcript of the observation to support the second explanation. The teacher and the DCU researcher had initially congratulated some students who had received a hundred percent in the test. However when the error in the test was found by other students the teacher asked a student who had achieved a hundred percent if he/she had 'reinterpreted the answers?' and discovered that the student had actually realised that there were errors in the test but had wished to get a hundred percent. Students therefore had not taken the test seriously, one students saying "This not a test, it's a game". (Field notes).

The teacher later said, in the post interview, that he saw the errors of the LO as positive. He was happy that some of his students had recognised where the mistakes lay in the test and had not accepted the answers to be correct when they knew they were not. The teacher did alert the other students of the error, but did not check the answers.

Students in the feedback session of the lesson said that they thought that this LO could be improved upon with the use of more graphics. They also thought that there was not enough material in the LO and that there was more material in books.

5. The teacher's reflections on the lesson

The teacher had a very positive attitude though the lesson had some problems; they were unable to use the original LO intended for the lesson and the LO used had some errors. The teacher was very philosophical about the difficulties recognising that being flexible in a lesson is part of the job. He felt that sometimes, when using technology in a class, unpredictable technical problems arise, which cause some students to 'lose track'. He was happy that the goal of revision for the lesson was achieved:

> "I didn't find that too much of a problem. We were able to do a different topic which we had done earlier when we were doing circulation." (Post-lesson interview).

He believed his class had handled the errors of the lesson very well in that some of them were able to see where the errors lay in the LO and saw this as a problem solving pedagogy.

> "It was useful to show them that – how you can get information and how they can work through the information and then there were certain questions that they could answer at the end. Now and again there were some glitches in the question but you know students should not just swallow information whole and feel there's a definite answer. They picked that up quickly that there was a problem and you know I think that's good because they're problem solving and they're not just … accepting things. Also I think it's important that students when they leave school that they have this ability to see material" (Post-lesson interview)

Overall the teacher was very positive about the LO. He thought that the students stayed on task and he thought that despite the glitches, LOs have potential for student's learning as it introduces a different way of learning that they enjoy.

6. Conclusions

There were very clear issues related to the technical problems that were related to the school's network. Also access to ICT resources and computer suites was difficult and, in the first fifteen minutes of this particular lesson, the room was shared with another class. Clearly this case study indicates the importance of preparation when using LOs as both the teacher and researcher had not known about the error in the test part of the LO. However, the teacher saw the positive side of the errors in that as a result of the error; his students were problem solving.

The role of the teacher was very low level throughout the lesson and this may have been linked to his lack of familiarity with the LO and the Demonstration Portal. The error of the LO was discovered by the students but even then the teacher still did not discuss the details of the error with the class, but simply confirmed that there was an error. One effect of relinquishing control to the LO, may be that the teacher does not use his normal repertoire of teaching, for example, stopping the whole class to discuss the issue.

There is a need for flexibility and continuous pragmatic planning from teachers when using technology and especially software that is new to them. This case shows the

necessity of a second backup LO and the willingness to find a learning opportunity in the errors of the recorded LO.

United Kingdom

Case study 13 Reproduction

Nai Li, Carmel Clifford & Robert McCormick, The Open University, UK

1. An overall description

The observation took place in a Combined School which teaches pupils from ages 5-12 years. There are approximately 380 pupils on the roll. This number of pupils is above the national average for schools of this type in the UK. The last Ofsted[3] inspection in 2000 has described this school as being an 'effective' school. The Ofsted report describes the area around the school as 'socially mixed' and the proportion of children eligible for free meals (a measure of social deprivation) is 12.3 percent, which is close to the national average. The majority of pupils come from white United Kingdom families; approximately one in ten pupils come from other ethnic backgrounds. The number of pupils from traveller families is very low (Ofsted, 2000). The Ofsted report paints a positive picture of pupil's progress in this school and suggests that standards in ICT (as a subject) were satisfactory throughout the school.

The teacher in this case study was the school's ICT coordinator. He was a confident user of ICT, had taken more than ten ICT training courses, and had been using digital learning materials in his teaching before he joined the project. He attended a CELEBRATE workshop at the start of May of 2004 and received training on the use of the Demonstration Portal and authoring tools (the latter by a *Digitalbrain* consultant).

The teacher described the school ICT infrastructure as medium level compared to other schools in the same local education authority area, but would like to see it improved upon. The ICT resources distributed around the school at the time of the research were: 16 desktop computers available to pupils; 16 stand-alone computers available to teachers (to be replaced by laptops shortly); and 21 laptops available for pupil use. The school has a wireless internet connection and wireless cards for laptops, which means that pupils do not have to leave their classroom to use computers. He also rated the ICT competence of teachers in the school to be on average medium to high.

[3] Office for Standards in Education (Ofsted), the principal role of Ofsted is the management of the system of school inspection defined originally by the Education (Schools) Act 1992. This provides for the regular inspection of all 24,000 schools in England, which are wholly or mainly state-funded.

This classroom observation study focused on a science teacher using CELEBRATE learning objects (LOs) with a group of year 7 (11-12 year-old) pupils in a lesson on reproduction. There were 19 pupils in the class, 9 girls and 10 boys. At the start of the lesson pupils were mostly divided into pairs though one pupil sat alone, one pupil sat with a classroom assistant and there was one group of three. Most groups were same sex, but there was one mixed pair. A classroom assistant sat next to a pupil with special educational needs. The tables were laid out in a conventional classroom so that there were four pupils sitting around a table and the pupils sat in their groups across from each other mainly in pairs. Each group shared a laptop with wireless network connection. The teacher also used a TV and video-player and a data projector with a laptop, which were located at the front of the classroom.

The subject for the lesson was the reproduction system of females and males, part of the scheme of work linked to Personal Social Health Education. The learning objectives of the lesson were:

a. to be familiar with male and female reproductive organs;

b. to be able to suggest why human male and female reproductive organs are structured as they are.

The learning objects used for this lesson were:

a) the '*Abdomen – man*' (Figure 18)

http://celebrate.ls.no/English/Animations/Science/underliv_mann_spill.swf

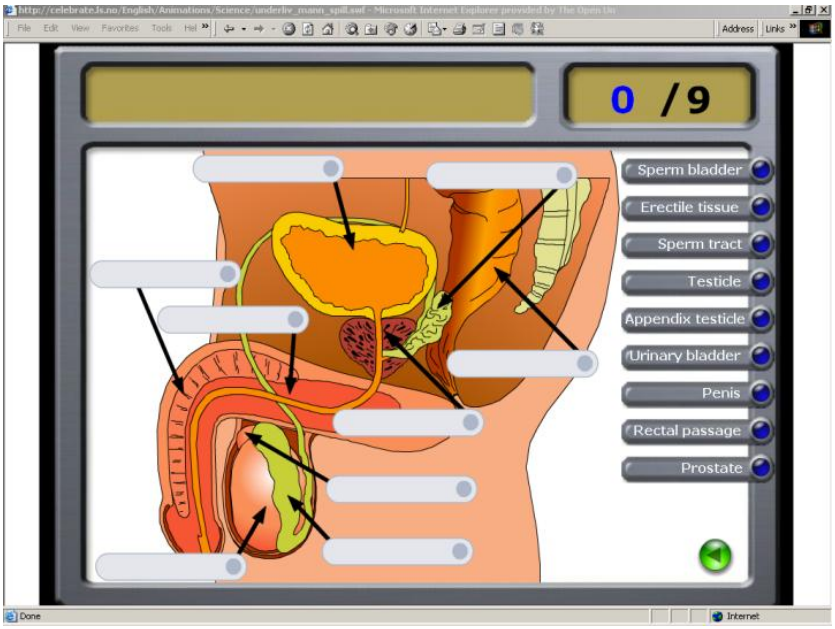

Figure 18. Screenshot of the LO: Abdomen – man.

b) the '*Abdomen – woman'* (see Figure 19)[4]

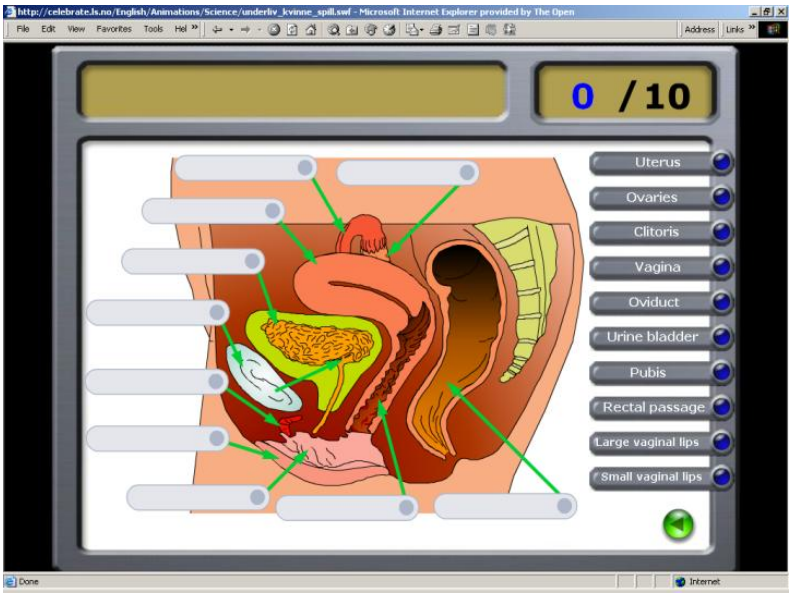

Figure 19. Screenshot of LO: Abdomen - woman.

Basically the task was to move the captions on the right to the correct positions on the diagram (one of the 'blank' spaces). This could be done in any order and, for scoring purposes, the pupils were allowed only one attempt, i.e. the final scores showed how many labels were correctly placed at the first attempt.

The two LOs were described as 'drill and practice' and 'exploration' by the content provider[5] and the target age group is 12-18. (In Section 4 of this case study we comment on the pedagogic categorisation of these LOs.)

The teacher also created his own learning object (see Figure 20)[6] using a crossword template based on the DigitalBrain authoring area on the CELEBRATE Demonstration Portal. The template supports a maximum of 24 words, and the grid size can be between 10 and 15 cells square. Clues should be kept relatively short. In play mode, the learner selects a word to be completed by clicking the appropriate clue. The learner can then type in their answer one letter at a time in the highlighted spaces in the grid, and click the 'Reveal Word' button to check their answer. The teacher, however, used this LO for assessment of the material taught in the lesson as

[4] http://celebrate.ls.no/English/Animations/Science/underliv_kvinne_spill.swf

[5] Norwegian Board of Education

[6] http://eundp.digitalbrain.com/eundp/accounts/MikeLewis.eundp/web/Crossword%20-%20Reproduction/Reproduction%20crossword/

part of whole-class teaching. This LO was located on the teacher's authoring area of the Demonstration Portal.

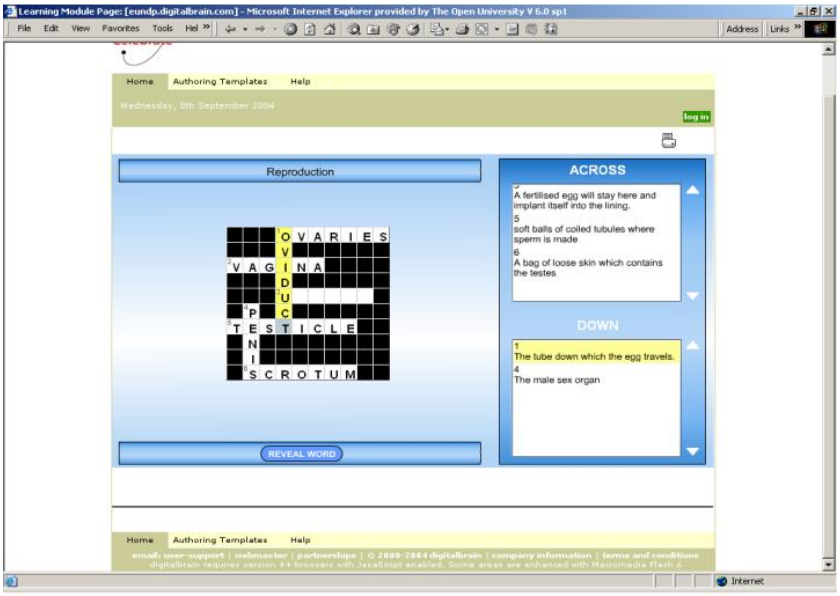

Figure 20. Crossword created by the teacher.

Other material used in the lesson included a video about reproduction of trout and humans (produced by a UK television company, Channel 4) and a *PowerPoint* presentation to show the pupils diagrams of the male and female reproductive systems.

2. The structure and phases of the learning/teaching sequences

The case study involved one observed lesson which lasted one hour and a half. Table 13.1 shows the structure in type and duration for each activity of the lesson.

Table 13.1 Type and duration of each activity

Activity	Duration (approx)
1) Introduction : whole-class	5 mins
2) Video: whole-class	25 mins
3) PowerPoint Presentation of the Abdomen of a man / woman: whole-class	10 mins
4) LO Activity - Abdomen of a man / woman: pupils working in pairs	25 mins
5) LO – Crossword: whole-class	10 mins
6) Discussion: whole-class	20 mins

1) *Introduction*: the teacher referred to previous lessons and revised the pupil's prior knowledge on the topic of reproduction through a series of questions.

2) *Video*: the teacher showed the class a video called *Life Cycles* that goes through the life cycle of a trout and a human-being, focusing on the reproduction process.

3) PowerPoint *presentation*: the teacher showed pupils two slides of a front view of the abdomen of a man and of a woman, during which he labelled each organ of the abdomen and described their functions (see Figure 21). However, the diagrams the teacher used in the presentation slides were slightly different from those in the LOs; front views rather than side views (*cf* Figures 18 & 21).

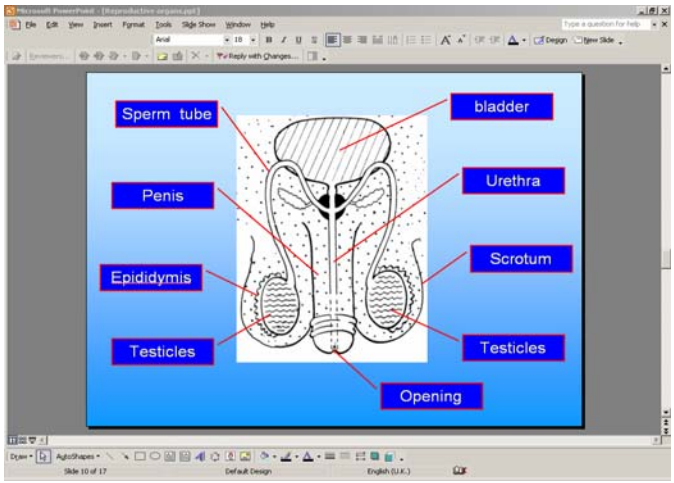

Figure 21. Screenshot of one of the teacher's PowerPoint slides

4) *LO activity*: this was conducted on the laptops, and pupils used the two LOs previously downloaded from the CELEBRATE Demonstration Portal onto the school network. The boys were instructed by the teacher to start with the *Male – abdomen* LO and the girls with the *Female – abdomen* LO. They changed LOs when they have completed the tasks of their first LO. The task involved dragging and dropping labels of organs onto the appropriate place of the abdomen. The teacher also asked the pupils to read the description of each organ (that appears when the organ is clicked upon).

5) *LO – Crossword*: this was used by the teacher to assess what the class had learned from the lesson. Some of the descriptions from the abdomen LOs were used as clues for the pupils to give the correct word (see Figure 20).

6) *Discussion*: the class discussion of the lesson allowed for any questions the pupils might have, but which they were reluctant to raise in front of the researchers and the video camera used to record the class. The researchers were therefore asked to leave for this discussion, and no data is available for this except from the teacher post-lesson interview.

3. An analysis of the pedagogical approach of the case

Nature of activities

The teacher structured and controlled the activities of the lesson, initially building on the pupils' prior knowledge of what they had learned in previous lessons on reproduction. This was a question-and-answer session, consisting mainly of factual questions and higher-level closed questions. Some new information was also given.

The video presentation of the reproduction of the trout and the reproduction of humans was used as a visual and audio resource, with a short question-and-answer session immediately following it. This latter activity focused on recalling the content in the video. The *PowerPoint* presentation by the teacher involved him didactically giving information on the structure of the male and female reproductive organs.

The learning object encouraged the initial stage of constructivist learning amongst the pupils (i.e. giving information and asking for pupils' response and feedback). Pupils were learning by themselves through reading the description of each organ on the diagram and by repeating the activity several times (they were to some extent revising ideas given in the teacher presentations). They had to place the correct label onto the organ and, through this, become familiar with what the organ looked like and the correct label. If they placed an organ label in the incorrect place they received a reduced score and were asked to 'try again' at the end of the activity.

Most pupils appeared to stay on task during the LO activity. Pupils were told explicitly by the teacher how to work (i.e. to each try the activity), but some worked collaboratively in pairs on the activity, others appeared to take turns doing the activity. Pupils who worked collaboratively shared the laptop by placing it in the centre of the table; one set of pupils appeared to discuss their action before carrying it out and read the description together. When speaking to the teacher about their score pupils working together often said 'we' indicating team work. There was only one set of pupils noted by the researcher who appeared to take turns; each moved the laptop to their side of the table and appeared to work individually on the task. The teacher would check on these pupils to make sure that each pupil had a turn on the tasks.

The teacher gave the pupils instructions on how to access the LO and how to do the activity. He moved around the room to monitor all the pairs of pupils and to see if they needed help or were doing the activity properly. This help was both technical and, on occasions, related to the content. The teacher assistant appeared to do the same on one side of the room.

The crossword was a question-and-answer session between the teacher and the whole class. This was an assessment of what the pupils should have learned from the lesson. Because of this the bulk of the questions were low-level and higher-level closed

questions. There were no pupil-initiated questions, perhaps because the pupils would have an opportunity in the final discussion session. This crossword was displayed on a overhead projector and controlled by the teacher through his laptop. However, he felt that this projection was rather small as a visual resource (it was, however, clear at the rear of the classroom). The crossword displayed clues and answers related to the subject material completed in the lesson. The teacher went through each clue of the crossword and asked the pupils for the answers, sometimes asking the pupils to spell the words.

Throughout the lesson the pupils were attentive and, during the LO activity, evidently motivated and on task.

Nature of the knowledge processing

The working sequence was based on processing knowledge from a mixture of sources. The lesson used different means to achieve the objectives of the lesson. There were some expert-like features in knowledge processing during the lesson

- The teacher gave several perspectives to the content: acting as an 'expert' by presenting information to the whole-class, showing a professional video containing outside experts, and the LOs were an additional source of knowledge.
- Authentic knowledge was presented to pupils by showing the video.
- The pupils had an opportunity to use a small amount of analytical reasoning, as the diagrams of the abdomen of the man and woman were presented differently on the *PowerPoint* presentation and LO activity

Understanding the reproductive system does require conceptual understanding, however, through the use of both types of LOs there was a large emphasis on factual recall. This is indicated by the predominance of recall questions by the teacher.

The responsibilities of the teacher and the pupils

The teacher's roles were as follows:

- He structured and planned the activity, and through this tightly controlled pupil activity.
- He presented information and knowledge as an 'expert' and brought in other experts (using the *PowerPoint* presentation and the video).
- He built on prior knowledge (in the Introduction and after the video).
- He scaffolded the understanding of some pupils (during the LO activity) and helped them clarify ideas (in the Introduction).

- He assessed pupil knowledge during the introduction, after the video and during the use of the crossword LO.
- He checked progress and kept pupils on task (during the LO activity).

The pupils' roles during the lesson were as follows:

- They were mostly passive receivers of knowledge, but with some low-level agency through the LO activity. Their only responsibility for their own learning was in how they reacted to the feedback in the scores within the LO activity and the 'Try again' message at the end.
- Through teacher questioning they were required to think, albeit largely at a low level.
- For some pupils there was an opportunity to collaboratively build their knowledge of the structure of the organs.
- The discussion at the end of the lesson gave them an opportunity to initiate topics personal to them, and to evaluate their own learning (there were no data on this).

The many interactions between teacher and pupils at the beginning of the LOs activities were technical-related. The teacher spent a considerable amount of time on solving general technical problems such as intranet connections, log onto laptops etc, although he had spent more than half a day preparing the learning objects in terms of resolving technical problems to upload them onto the pupils' computers prior to the lesson.

During the activity the teacher realised that many pupils had focused on the score, rather than on learning the construction of the human reproductive systems. Some were trying to get full score, others realised that it was possible to get a higher score than this (by 'right clicking' on the label in its correct position). To try to focus pupils on learning the teacher used different strategies:

Strategy 1: telling pupils to repeat the activity

Pupil 1: We got full score

Teacher: Have you?

Pupil 2: Yeah

Teacher: Right, full score congratulations. Okay.

Pupil 2: We are going to get one thousand.

Teacher: Okay see if you can repeat it. … see if you can repeat it on the male man, see if you have remembered it.

Strategy 2: telling pupils to read the descriptions

Pupil: …the last time we got the highest score…..

Teacher: Right, okay. Yeah so this is the …okay.

Teacher: (To class) Remember to read the description, because you will need it later. Do read that, stop and take your time.

Strategy 3: telling pupils they will be assessed later through a crossword

Pupil: Yeah we have done it over and over again and we keep getting full score.

Teacher: Okay you need to make sure that you are reading those descriptions. Practice those descriptions because the last activity I have got for you is a crossword and you will need to know those descriptions so that you can ….

The teacher also assisted some pupils to complete the LO activity by scaffolding through simplifying problems, eliminating, and providing a conceptual map for them.

However, these kinds of interactions only occurred on a few occasions.

4. The evaluation of the learning objects

The roles of the LOs

The major part of the information and conceptual ideas about reproduction were provided by the video and the teacher's *PowerPoint* presentation. The LO activity pupils carried out consolidated this and helped them to see where their lack of knowledge or understanding occurred. This was a form of 'Drill and practice', and through the provision of a correct/incorrect mark (score), pupils obtained feedback on their learning. The provision of information with the label allowed for additional learning or reinforcement. Hence, though it was not a straightforward 'Drill and practice' LO, it certainly was not 'Exploration', one of its metadata categorisations. When pupils repeated the activity (as requested by the teacher when they wanted to get a higher score), they were using the LO in a classic 'Drill and practice' way. The lesson also includes some element of 'Assessment', but the teacher did not use this information, only pupils (a form of self-assessment).

The crossword LO was also acting as an assessment of pupil knowledge of what they had learned from the lesson. The clues were mainly taken from those used in the description of organs in the LO (Abdomen of a male/female) and the pupils were expected to have read descriptions carefully when doing LOs activities. The teacher's role was to choose pupils to respond (8 in all, about half of the class), and initially to prompt them to spell the words, which he then entered. On occasions he was also encouraging responses from pupils by telling them to continue to try. This LO, along with the teacher, reinforced what pupils had learned from the lesson.

Advantages of the LOs

Most pupils felt that the computer activity was more engaging; one child thought that computer activity made them think more about what they were doing. The scoring mechanism of the LO motivated some pupils to get a score of ten out of ten and therefore to repeat the activity until they had achieved that aim. The LO offered a description of the organ which pupils could read and learn, at their own pace. The LO activity done by pupils would help the teacher, as he was not familiar with teaching this topic.

According to the teacher's opinion, the pupils were able to cope with the change in the presentation of the abdomen in the LO from the one on the teacher's *PowerPoint* slide (a frontal view of the male and female abdomen in the *PowerPoint* compared to the side views of the LO diagram); better than they had been able to in a similar activity in a previous class using a paper and pencil.

The crossword was a useful resource to reinforce the objective of the class. It helped the pupils to review what they had learned in the lesson, though as only particular children responded, the teacher would from this have a partial view of the class' understanding. The LO's assessment function was not fully utilized.

Problems of the LOs

Pedagogical issues

The LOs used by the pupils did not have any instructions or indication of how they should be used. The teacher asked the pupils to read the description of organs, not a requirement within the LO. Thus some pupils could use guess work in order to place the organs in the correct position.

The design of the LO scoring system allowed many pupils to quickly find a way to achieve high scores. This acted as a distraction for some pupils and also led pupils to engage in 'game playing'. The teacher had to continually ask pupils to focus on their learning to try to reduce pupils guessing and simply trying to get high scores (see the three strategies in Section 3 of this case study). The teacher felt the score system of the LOs should be redesigned to prevent this.

The teacher also felt the LOs were designed to be used for individual activities, but pupils had to share their laptops and work in pairs. But, he felt if the school had an interactive whiteboard, he might use the LOs in a slightly different way.

Technical issues

The teacher reported that he spent a lot of time preparing the learning object in terms of resolving technical problems to upload the LO onto the pupil's computers prior to the lesson. The teacher felt that his fellow teachers, who were not technically minded, may become irritated by these problems and abandon using LOs in classrooms.

Because of the technical issues related to the school intranet, there was a delay in downloading the LO onto pupils' individual laptops, and some pupils had difficulties in accessing the LOs on the school sever. During the first quarter of the LO activity, the teacher had to resolve various general technical problems, which was a significant drawback with the lesson.

The crossword LO was too small as a visual resource to use as a whole-class activity. The teacher suggested its design should fit into the requirements of whole-class teaching.

5. The teacher's reflections on the lesson

The teacher did not claim to be an 'expert' in the field of biology and in fact had to 'brush up on the subject the night before'. He was pleased with the outcome of the lesson:

> They [pupils] all agreed that the main objective on the board … had been achieved and then the secondary learning intention of being able to explain why a land-based animal was reproduced differently to a water-based animal, when I asked that question there was a clattering of hands, they were a little bit lost on that but the ones that I asked were able to say why.
> (Teacher post-lesson interview)

The teacher believed that the pupils responded 'fairly well' to having technology in the room but he thought that there was 'a bit of the wow factor' for some of the pupils (i.e. novelty adding to motivation).

The teacher thought the LO itself was overall 'quite good'. However, he believed that the scoring in the LO was a mixed blessing:

> ... There was a couple of the 'less focused pupils' who quickly found that whenever they clicked on the label in it's right place that it added to their score so the scoring in particular for some pupils was a distraction where for other pupils it was a motivation because they'd go through and they get 4 out of 10 and think that I want to go through it again and get more. But for some of them it was a distraction because when they click, click and click – they'd get a score of 250.
> (Teacher post-lesson Interview)

Because the pupils were able to 'cheat' the scoring in the LOs, the teacher felt this indicated many of the pupils were familiar with downloading cheats from the internet for their computer games and said that pupils wished to achieve the highest score by 'any means possible'.

Though the teacher liked the LOs used for the activity part of the lesson, he was concerned about the different presentations of the abdomen in the LO diagram and that in his presentation. He thought that in the event the class had coped really well.

He believed that technical problems in preparing the LOs for the lesson might make other teachers with low ICT skills, and limited time to prepare a class, reluctant to use the material.

The teacher also used the authoring tool from Digitalbrain to create his own crossword LO. He was impressed with this tool and thought the crossword was an easy resource to construct for a lesson, and a good way to reinforce the lesson.

The teacher made a mistake in the spelling of a word on the crossword, and he associated this problem with his own lack of familiarity with the LO.

The pupils also gave feedback to the teacher on what they thought of the crossword:

> Some of them thought that it was a good way to sum up the lesson rather than have a chat; some of them thought that 'yeah do that and have a bit of a chat as well'. A couple of them thought that they would have preferred to have done that on their own desktop.
> (Teacher post-lesson interview)

6. Conclusions

Overall, the teacher and pupils were both very positive about the LOs used in the lesson. Most of the pupils reported they enjoyed the LOs activities and were satisfied with their learning progress. The teacher also reported that he would use the material again from CELEBRATE and most likely use it in a similar style as he had for the observed lesson. However, there were a number of problems in terms of using LOs in classrooms, and the teacher hoped they would be improved in the future:

- Within LOs, there should be some instructions of how LOs should be used in different types of classroom activities;
- The scoring system of the LOs should be redesigned to prevent pupils 'game playing'.
- The crossword template was too small as a visual resource to use as a whole class activity. Its design should fit into the requirements of whole-class teaching.

III Cross-country conclusions

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The cross-country conclusions are based both on the descriptions and conclusions of individual cases, and on the national conclusions. We have tried to summarise the common issues and phenomena, in order to answer the original questions of the study:

- what kinds of LOs best support the development of learning culture;
- what is the relationship between the pedagogical practices and the characteristics of LOs;
- what kinds of possibilities and challenges teachers experience in using LOs in advanced pedagogical practices;
- how do learning activities and the use of LOs support expert-like features in knowledge processing;
- what kinds of ideas and recommendations the case studies bring for developing LOs.

As explained in the introduction, the cases represented various pedagogical approaches, and many of them do not represent "advanced" pedagogical settings: the teaching was teacher or LO centred, and students were mainly receivers of knowledge instead of being active constructors of learning. For this reason, the conclusions based on the cases, and reported here, are somewhat different than our originally intentions.

One important question is how much a LO can affect in the teaching and learning sequence. In our opinion, based on the case studies, LOs are just one element in the sequence. LOs can give ideas and support advanced ideas of learning, at their best. There is a mutual interaction between the LO and teacher's thinking, and, the use of LOs is dependent on the overall classroom culture, including the concepts of learning and teaching, the level of ICT skills and the level of ICT infrastructure.

The features of LOs that support the development of learning culture

One of the original goals of the CELEBRATE project was to support the ideas and practices of new pedagogical thinking. The concept “advanced pedagogical approaches”, used in the present study, means learning activities that are based on, among other things, learners’ active participation and collaborative knowledge creation (see Introduction). The role of learning materials in such approaches is not to deliver knowledge or over-direct the learning process, but to provide support for the learners’ knowledge work in a versatile way.

One way to discuss the supportive features of LOs in various pedagogies, is to use the concept of affordances. Affordances refer to properties of things that suggest or instigate some sort of activities and uses (Gibson 1979; Norman 1988; McGrenere & Ho 2000). Affordances of LOs mean the interaction of LOs and their method of use. According to this, LOs have certain kinds of properties, which have a tendency to support some specific activities. These tendencies are seen in practice, and in this sense the skills, the practices, and the background knowledge of users influence crucially how these properties materialise. It can then be maintained that LOs have different kinds of pedagogical, cognitive, social, or even epistemological affordances. In this respect, the pedagogical classification of LOs developed for the CELEBRATE project roughly describes the pedagogical affordances of LOs, although each LO is also special. For instance, an information source LO that presents text, pictures and animation provides information to be learned, but it does not by itself provide possibilities for students to make their own experiments and learn from their own actions and choices, as an exploration-type LO might do. Similarly a drill-and-practice LO can be good for memorizing the pieces of information it contains, but it is not necessarily useful for collaborative knowledge creation practices, as a collaborative discussion tool.

The majority of the LOs used in these 13 cases were drill-and-practice LOs, as are defined by the CELEBRATE Application Profile 1.1. The possibilities of drill-and-practice LOs to support "advanced" pedagogical practices are limited; the affordances of such LOs support knowledge acquisition, as, e.g., in cases 7 and 13 presented. As the authors of case study 13 notes, the metadata definitions of the LOs may sometimes be misleading. The basic activities of LOs should define the possibilities for learning, not some incidental functions, which might support gaming or browsing of knowledge.

The affordances of drill-and-practice LOs can be restrictive for a teacher who would like to develop her own pedagogical practices, and has an intuitive idea of more advanced pedagogies; she cannot easily get support for the pedagogical development from the LOs. We may conclude that this was the condition in case 3, in which the teacher combined in the same sequence rather arbitrarily the usage of fact-oriented drill-and-practice LOs with challenging, open-ended problem-driven research task. The affordances of a LO can sometimes be created through how they structure the whole learning sequence. It is difficult for a teacher to change this structure, especially if she or he has limited technical or pedagogical skills; in Case 6 is an example of a LO that was problematic in this way. An over -strict structure of the LO was also in case 5. The LO can lead the students to concentrate on less essential aims, as in case 13: The drill-and-practice LO tempted the pupils' to aim at the highest scores, instead of supporting learning, as the teacher (and the researcher) in the case noticed.

In several cases the exploration-type LOs appears to have affordances that supported features of advanced pedagogical practices. Examples of such are Cases 1 and 2 (the LO provided for exploration to examine the nutrition value of combinations of dishes,

and lifelike cases to be solved with the exploration tool). Also in case 4 . These cases also demonstrated some encouraging possibilities of LOs; the LOs used in the cases helped the teachers to design learning activities that supported authenticity, ownership and knowledge sharing. An important indirect remark about the kinds of affordances was made by the teacher in case 4: he emphasized the need for more advanced LOs.

Because the case studies concentrated on classroom practices, students were observed when they were using LOs. It was interesting that in the majority of the cases, the students liked to use LOs; they worked properly and seemed motivated (in some case descriptions, the researchers noted also boredom and less motivated activity).

In our opinion, whether students like or dislike a LO is valuable feedback for a teacher but it is not sufficient source to evaluate LOs. If students don't like an LO, they are probably right that there is something wrong with it, either in its technical or pedagogical usability. Even if students say that they liked to work with an LO, it is difficult to say what it actually means. In some of the cases, the students liked to work with technology probably because it was a new way to work in school and brought variation to ordinary work, it offered more freedom than traditional classroom work, or the LOs as such were attractive. Such novelty effect is likely to be temporary, as was witnessed by the teacher's evaluation in case 3. In some other cases the students perhaps liked to work with technology because the tasks were more challenging and supported their ownership, or were close to their own daily life. Such descriptions tell about various motivations of using technology in general, not necessarily about the impact on student achievement of the LOs as such.

The relationship between the pedagogical practices and the characteristics of LOs

Previous studies indicate that the use of technology changes teachers' and students' roles so that the atmosphere in the classroom becomes more open and liberal (Schofield, 1995). This phenomenon was also reported in many cases of the present study, and in some cases this relates to some advance features of the pedagogical practices. The following advanced features were present in the teaching and learning sequences of those cases: authenticity of the tasks, students' mutual collaboration, students' ownership of the tasks, and students' responsibility of the tasks.

In some cases the nature of the LO(s) and the pedagogical practices fitted well together, particularly when the teacher saw the possibilities of the LO, and those were appropriate for her/his pedagogical goals (e.g., Cases 1, 2, 4, and 6). It was typical for such cases that the teacher also had the appropriate ICT skills. The characteristic of such cases were that they could be conducted as planned, or the teacher was able to solve the emerging technical problems so that they did not disturb the learning sequence.

The templates for creating own LOs made it possible for teachers to design the very LOs they wanted to use, as in cases 6 and 13. Although there surely are teachers who do not want to produce LOs themselves, the templates have turned out to be "a small success story". Templates don't diminish the need for ready-made high-quality digital material; with templates teachers can create LOs that support and complement other elements of the pedagogical sequence in a special way. It was also interesting how the students in case 10 made crossword puzzles for each other to revise their knowledge, or a teacher in case 13 used a drill-and-practice LO, designed by himself, as a test; this addresses the need for flexible templates, which can be used to produce LOs for various purposes.

The data of the case studies is too limited to evaluate, in more detail, the crucial characteristics of templates, but probably there is a request also for tools to create other, more interactive type of LOs besides drill-and practice or information sources: explorations and simulations, open activities, etc. For example, the teacher of case 4 was both interested in creating LOs and very critical of the drill-and-practice LOs, and the teachers in Case 6 wanted to add more interactive features in their LO about Bread making.

The possibilities and challenges that the teachers experienced in using LOs

The case studies revealed that teacher’s role is crucial in organizing, structuring and guiding the whole working process, especially in such pedagogical activities that combine several LOs and multiple activities. All cases indicated that the teachers were really interested in learning more about using LOs and technology in teaching. We can say, with good reasons, that the participating teachers were ready to take the challenges of changing their practices and developing the learning environment. The challenges varied; for one teacher the step to start using LOs was challenging enough; for another teacher the challenge was in creating inquiry learning practices. The following are issues that emerged from the analysis of the cases.

Technical problems

In all the reported cases, there were technical problems that disturbed the activities in the classroom. This is a common issue when using ICT in schools, even if the participating schools and teachers are advanced in this respect. In some of the present cases, the teachers solved the technical problems by replacing the planned activities with some other activities, or organised the tasks somewhat differently, but in other cases the use of technology disturbed the planned teaching and learning sequence in a crucial way. The reasons for the problems in the reported cases can be divided into two categories:

1) *Test versions of the products*

Some problems arose from the incompleteness of the LOs or the Demonstration Portal (e.g., in case 4 in the early stage of the CELEBRATE project). These kinds of technical problems are understandable and somewhat tolerable in development projects like CELEBRATE, but we still have to keep in mind that school is not a good place for testing incomplete products. Probably it was somewhat optimistic to expect that it is possible to both develop new models and products, and test them in the field within a two-year project.

2) *Technical infrastructure of the schools*

Many technical problems reported in the cases related to the shortcomings in the technical resources or network connections of the schools. This probably is a problem that will always exists because there will never be enough resources to equip all schools with the newest, fastest and most powerful technologies. LOs should be easy to "reuse" in a more modest technical infrastructure, without a requirement to always have the newest and fastest versions of software and hardware. The implementation of an advanced pedagogical idea in a learning object does not necessarily require the usage of newest or most complex technical features.

The new role of the teacher

It is often suggested (e.g., Lim & Barnes, 2002) that teachers' roles change when using technology, but some very teacher-centred cases in the present study indicated that traditional knowledge-delivery can still occur when using LOs and technology. There were changes in teacher's role, e.g., in cases 1, 4, 9 and 10 indicate. These cases showed that the teacher was a facilitator and organizer rather than that of a content deliverer. In some cases (e.g. Case studies 12 and 13) the teacher did not engage with the content of the lesson, except when something appeared to be wrong with the LO (Case study 12).

New skills and competences required from the teacher

1) The relevance of good ICT skills

One reason for the adverse impact of technical problems in the cases related to the teacher's competence in using technology, not to the shortcomings in technology itself. Although more and more teachers are experienced in using technology in teaching, there remains a requirement to provide teachers with technical support. In the present study, we may conclude that those cases that represented more advanced pedagogical solutions (e.g., Cases 1, 2, and 4), were carried out by teachers who had high ICT competence. They had good technical skills, and they had a good understanding of the role of technology in pedagogical practices.

2) *The challenge to master new kind of pedagogical design*

The pedagogical design for the activities including the use of LOs has to be clear; whether they support the traditional knowledge acquisition approach or new (more demanding) pedagogical approaches. Some of the case study teachers solved this demand by structuring the sequence strictly (e.g. in Cases 5, 6 and 13), so that the students were more or less passive objects of the teacher's activities. Some teachers designed the activities so that they had the overall control but, within a defined framework, students were free to work as they thought fit (as in cases 1 and 4). In some cases (e.g., in Case 3), the teacher's inexperience in adequately designing and organizing the overall sequence, consisting of multiple elements and activities, appears to have resulted in students not always knowing what they were doing. Case 9 indicated how teachers can together become familiar with LOs and the challenges of pedagogical design; teachers' joint projects are likely to be a good way to support professional development in the use of technology in classroom practice.

3) *Teacher's conceptions of learning*

Windschitl and Sahl (2002) concluded in their study that the influence of the availability of computers on middle school teachers' instructional decisions was mediated by teachers' belief systems about learners in that particular school, and about what constituted "good teaching" in the context of the institutional culture. Niederhauser and Stoddart (2001) compared teachers' conceptions of learning (didactic or constructivist) with the type of educational software (skill-based software or open-ended software) that they reported using. Their results indicated a fairly consistent relationship between the teachers' own perspectives, and the types of software they used with students: The usage of open-ended software related to learner-centred orientation and vice versa. It is possible therefore that in some of the reported cases, which involved rather low-level learning approaches, the problem was not the affordances of the LOs, or even the teacher's inexperience in using technology in teaching and learning practices, but more fundamental limitations in the teacher's conceptions of learning. In the present study, typical low-level learning approaches were teacher-centred or LO-centred activities, in which the students, e.g., fulfilled ready-made questions for which they found the answers in LOs used, or they had to click right answers in a LO. Some characteristics of such approaches were found, e.g., in cases 3, 6, 7, 9 and 13.

Learning activities and the use of LOs in supporting expert-like features in knowledge processing

The activities of some cases supported expert-like knowledge processing, e.g., multiple views to the studied phenomena (Cases 1, 2, 3, 4, 7, and 9), several means for presenting knowledge (Cases 1, 2, 3, 4, 9, 10, and 11), using authentic knowledge sources and experts (Cases 1, 3, 4, 9, 10, and 13), connection of theory and practice

(Cases 1 and 3), a sustained process to create and develop knowledge and ideas (Cases 1, 2, and 4), and possibilities for knowledge sharing (cases 2, 3, 4, 9, and 10).

However, the majority of the cases still represented knowledge acquisition approach, in which the main goal was to learn pre-defined factual content, and only a few cases were really pedagogically "advanced". For some cases it is difficult to say whether this was because of the LOs used in the case or because of the teacher's conceptions of learning.

Ideas and recommendations for developing LOs and their usage in European schools

Design flexible LOs

The idea of flexible, re-usable LOs, which support the possibilities of adapting and localising them, should be an aim of LO producers. As many of the cases revealed, the designer's idea of the use of a LO is sometimes far from how it is used; one of the best examples was the LO Healthy meal. The French researchers gave some important recommendations for the designers in their national conclusions:

- A strong degree of independence between the different parts, divided into basic and relatively autonomous sequences, focusing on a limited number of concepts. It should be possible to organise several sessions with the same object.
- Simplicity of the interface, with efficient help tools which do not clutter the workspace.
- The graphic design can be rudimentary. A well designed object is of course always more attractive. But it would, however, be better to put more effort into the design of the learning scenarios, in collaboration with teachers. There should be more extensive work on the pedagogical context and the multiple possibilities for using an object.

Create support for the use of a LO

Open LOs are difficult to use in an ordinary classroom situation. An advanced teacher, with good ICT skills, might know how to guide students, and how to structure the sequence well in advance, but for a less competent teacher an open LO is challenging. If an open LO is badly designed (e.g. inadequate situational help to pupils) this will affect pupil learning. It is important to recognise that learning sequences that are vague, and allow the students to do whatever they want, give both the teacher and the students an impression of ineffectiveness of technology to support 'serious' learning. We are afraid that in many schools, and among many teachers this is the situation. A good LO allows possibilities to engage in cognitively challenging activities, but also provides helpful structuring and scaffolding for the learners to succeed.

Mind the usability

It is self-evident LOs, as for other digital applications, should be designed according to usability standards. In the present study, the usability issues were not the focus of research, but they could not be ignored. In some of the reported cases, there were indications of problems that were caused by poor and non-standard interface design of the LOs. Designing software that follows the established usability standards should be the basic expertise of LO producers. The designers of the products and materials for schools should also take the limitations of the technical infrastructure in the schools into account; for instance, the baseline level of infrastructure needs to be specified.

Produce LOs that can become catalysts for pedagogical change

Teachers are experts in their field, and their opinions should be taken into account when developing LOs for schools. But it appears that sometimes material producers and officials are too careful in following teacher's hopes and ideas about desirable material. There is a danger that new digital materials are just another way for actualising prevailing pedagogies, and nothing develops. In our opinion, advanced learning materials can be a catalyst for pedagogical change in schools, and resources should be allocated to developing and producing pedagogically demanding and innovative materials, which was an original goal of the CELEBRATE project. There were some good examples of such LOs in the investigated cases (e.g., the *Healthy Meal* LO). We want to challenge the producers of LOs to concentrate on producing LOs of various pedagogical types: explorations, simulations, open activities, tools, and LOs that support advanced and challenging working practices.

It is important to develop multiple ways to evaluate the value and features of LOs for developing teaching and learning practices, and also collect experiences of long-term usage of LOs in advanced pedagogical practices. Producing LOs, testing them in authentic classroom settings, and developing them based on the test results is a slow and laborious process. In future, this should be taken into account when defining goals and allocating resources for similar development projects.

The pedagogical metadata categorisation appears to be a difficult issue. The metadata group produced useful categories during the CELEBRATE project to describe the pedagogical nature of LOs (categories Assessment, Drill-and-Practice, Information resource, Glossary, Exploration, Open activity, and Tool), but the categorisation of many LOs appears to have been inappropriately applied. For instance, some LOs that are hypertext-type information resources have been categorised as 'Exploration'. The pedagogical categorisation is important for choosing and evaluating LOs, but the definitions of categories should be defined more clearly, and the producers of LOs need to develop ways of using them properly.

Provide adequate technical and pedagogical support and training for teachers

Many teachers still need technical support and training, in order to use LOs and technology in general with their students. This is especially so in the case of implementing new, emerging technologies in schools, or trying to persuade inexperienced teachers to start using LOs or technology in their teaching.

As many of the cases indicated, teachers face a new situation in the classroom as they implement technology in teaching and learning. In addition to technical support, the teachers also need pedagogical support. Training is one possibility but also the facilitation of peer networks and teacher's mutual sharing of best practices and good ideas.

Furthermore, it is relatively easy to provide teachers' with technical support, and even pedagogical support in the form of new ideas and examples. More substantial change in the teachers' conceptions of learning is a slow process, which relates to general institutional or national school culture. In our opinion, the main aim in promoting the use of LOs in European schools is not to increase the use of technology, but more profound evolvement of teaching and learning practices. This requires long-lasting efforts and development work in teachers' professional training and support systems.

Appendixes

Appendix 1 A sheet used in Water cycle

Sheet used during the second session

The water cycle

The answers are provided directly on the screen or in TOOLS, then GLOSSARY

Page 1

1. Watch the animated graphic carefully and wait for the INFO window to open. **Do not click on CLOSE.** Keeping your finger on the mouse, slide the window outside the screen.

2. Using the GLOSSARY, which you will find in TOOLS, write down, in the right order, the definitions of the words describing the water cycle which appear on the screen: Runoff, Evaporation, Precipitation, Condensation, Melting, Infiltration Transpiration.

3. What is the hydrosphere?

Page 2

Read carefully the content of each window that opens after an answer. At the end of the exercise, complete the following:

WATER: cloud, …..

ICE: …..

STEAM: …..

Page 3

1. Identify the energy that makes the cycle go round

2. Click on the magnifying glasses which appear at the end of the graphic animation, and then explain the following terms in one sentence each: transpiration, runoff, infiltration

Page 4

Click on the globe several times to fill up the reservoir completely. Then list in decreasing order (from the biggest to the smallest) the different reserves that make up the hydrosphere.

Page 5: Observe again, there is nothing to do

Page 6

This page is rather complicated. Observe the graphic animation and then list in decreasing order the residence times, and try to explain them in a few words. Try thinking hard in order to obtain the right answers without making too many mistakes.

Web link: at the end of the exercise, you can go to TOOLS, then WEB LINK and find the JUNIOR game on the water cycle.

Appendix 2 Exercise sheet to be filled in by pupils during the session

Bread making

Objectives: to use a computer software programme to learn about bread making.

Using the software on bread making, fill in the following questionnaire.

A: the recipe

What ingredients are needed to make bread? (Specify the amounts used).

B: **The different steps of bread making:**

Fill in the following table by putting the name for each bread making step (note them down in the right order), and specify the temperature at which it should take place, the length and the purpose.

Name of the step	Temperature	Length	Purpose

C: **Some details**

Answer the following questions:

- What is a *pâton* (crude dough bread)?

- What is a *coup de lame* (the slash given to a loaf)?

- What is the *pétrin* (dough mixer)?

D: **Different types of bread:**

Explain the particular characteristics of each type of bread. What is the difference between these different types of bread?

-*pain complet* (wholemeal bread):

-*pain de campagne* (French country-style bread):

-*pain aux céréales* (wholegrain bread):

-*pain au levain* (sourdough bread):

E: **Test your knowledge**

If you have time, play the game at the end of the software programme and do the crossword, which you will find in the Internet links.

Appendix 3 The six scaffolding functions identified by Bruner

Bruner defines six scaffolding functions which can usefully be highlighted in the case studies. These functions have not been specifically defined for interactive multimedia learning aids, but they are applicable to pedagogical guidance in general.

- Recruitment *consists of securing the learner's engagement with regard to the requirements of the task, leading him/her to take account of the nature and difficulties of the problem to be resolved. It may notably be a matter of reformulating the problem, because the main difficulty often lies in the reading and comprehension of the statement.*
- Reduction in the degree of freedom *consists of facilitating the task by reducing the complexity of the problem-solving process. This simplification means that the learner has fewer parameters to deal with, and can therefore be more confident in associating given feedback to a particular task. This entails modular deconstruction of the problem into less complex tasks, which the learner can tackle more easily.*
- Direction maintenance *consists of ensuring that the learner does not go astray during this deconstruction process, and that s/he always keeps in mind the ultimate objective of the problem to be resolved. This is the major problem arising with interactivity in the context of autonomous learning aids.*
- Marking critical features *corresponds to the validation of tasks as and when they are successfully accomplished. The learner must at all times be aware of what still needs to be done before the solution can be correctly found. Part of this evaluation can be carried out autonomously by the learner, which makes it easier to propose a more efficient solution if there is a delay or a distraction in the learning process.*
- Frustration control *consists of constantly arousing the interest and motivation of the learner. One must always be positive about mistakes, especially when they are due to a methodology based on trial and error. It is nevertheless important to avoid the risk of creating a psychological link which is too dependent on the concept of reward, as this would reduce the learner's action to one of pleasing the teacher, and his/her identity would consequently be submerged.*

Demonstration of model solutions consists of stylising what the learner has achieved and validating it by setting out an "official" explanation of the concepts. It is a matter of "formalising" knowledge, which is the purpose of formalised conceptualisation (the last phase of the learning process presented at the beginning of this text). It should be the only external command, as we have defined it, received by the learner.

Appendix 4 The data and the analysis of the case studies

The data of the case studies

The data of the case studies is qualitative, and it consisted of the following data types:

1) Background information of the school and the setting. This data was gathered with a questionnaire for the schools as part of Celebrate evaluation.

2) The participating teachers‘ “agendas” based on short interviews of the teacher before and after the observed lessons;

3) Observation notes and video recoding of the classroom activities;

4) Possible unofficial discussions with the students during the classroom activities;

5) Notes of the discussions with the teacher;

6) Written / discussed evaluation of the teaching and learning sequence by the teacher;

7) Other informal data, e.g. emails with the teacher, notes of the informal, preparatory meetings.

Table 4 presents a summary of the data used in the cases.

Table 4. The data of each case

Case	Recoded & transcribed teacher interviews	Written observation notes	Video recordings of the lessons	Teacher's material to students	Students' emails, notes in discussion forum	Students’ final works with comments	Other, what?
1	x	x	x	x			*
2	x	x	x	x			
3	x	x	x	x		x	
4	x	x	x	x	x		
5		x		x			
6	x	x	x	x		x	
7	x	x	x				
8	x	x	x	x			
9	x	x		x		x	**
10	x	x		x		x	**
11	x	x		x		x	**
12	x	x	x				
13	x	x	x				

* A letter to parents, **Recoded and transcribed student interviews

The analysis

Finland

The analysis of a case was conducted jointly with two researchers. The final structure of the analysis was derived from the several preliminary analyses of the data. First, two researchers made a preliminary analysis of two cases, and then the findings were discussed and completed together. Some basic decisions of the analysis:

1) The teacher description is based on the discussions with the teacher (years of teaching, experience in using computers in teaching). Based on the level of expertise, the teacher was classified as a national level expert, municipal level expert, advanced school level teacher, or ordinary school level teacher.

2) The analysis of the case (the nature of the activities, the nature of knowledge processing) was done based on the observation notes. The researcher of the case was responsible in introducing the preliminary explorative analysis of the case, based on a joint analysis schema, and the analysis was then discussed, compared to other cases and modified. The research assistant participated in the analysis discussions.

3) The types of the learning objects in cases are described according to the Celebrate Application profile.

France

The French team for the case studies was composed of:

- the two French coordinators
- a trainee for video recording
- a trainee for observation & written notes

All the persons above were not present to all the case studies. Three of the case studies have been video-recorded by the trainee. At least two other persons (2 coordinators, or 1 coordinator + 1 trainee) were present to write notes. After the observation, each person has sent their notes to the coordinators who have written the final case studies together using the video support and the Finnish pattern for the structure.

Hungary

The analysis of a case was done jointly with two researchers. The final structure of the analysis was done according to the Finnish pattern. First, two researchers made a preliminary collection of all the Hungarian data, and the findings were then discussed completed and analysed together with the project coordinator.

UK and Ireland

Two researchers collected data in the UK and Ireland. The classroom observation videos were transcribed and coded based on the OU team's preliminary discussions. Data analysis was conducted and wrote up into two small reports by two researchers under the supervision of the project coordinator.

References

Anfara, V., Brown, K., & Mangione, T. (2002). Qualitative Analysis on Stage: Making the Research Process More Public. *Educational Researcher, 7*, 28-38.

Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *Journal of the Learning Sciences, 2*, 141-178.

Bruner, J.S. (1983). *Le développement de l'enfant : savoir faire, savoir dire.* PUF, 277-279.

CELEBRATE Application Profile 1.1. Report to the European Commission, IST-2001-35188. Retrieved 7.9.2004 from http://celebrate.eun.org/docs/CELEB_AP_v1.1_2003-11-17.pdf

Collis, B. & Strijker, A. (2001–2002). New Pedagogies and Re-Usable Learning Objects: Toward a New Economy in Education. *Journal of Educational Technology Systems,* 30(2), 137–157.

Crahay, M. (1999). *Psychologie de l'éducation*. Paris: Presses universitaires de France.

Ilomäki, L., Jaakkola, T., Lakkala, M., Nirhamo, L., Nurmi, S., Paavola, S., Rahikainen, M. & Lehtinen, E. (2003). *Principles, models and examples for designing learning objects (LOs). Pedagogical guidelines in CELEBRATE.* A working paper for the European Commission, CELEBRATE Project, IST-2001-35188, delivered May 2003. Available at: http://www.helsinki.fi/science/networkedlearning/texts/principlesforlos.pdf.

Ilomäki, L., Lakkala, M. & Lehtinen, E. (2004). A Case Study of ICT Adoption within a Teacher Community at a Finnish Lower-Secondary School. *Education, Communication & Information,* 4, 53-69.

Interim report on Pedagogical Models. Deliverable 2.1. Work Package 2, March, 2003.

Kozma, R.B. (2003). Technology and Classroom Practices: An International Study. *Journal of Research on Technology in Education,* 36, 1-14.

Law, N., Lee, Y. & Chow, A. (2002). Practice characteristics that lead to 21st century learning outcomes. *Journal of Computer Assisted Learning,* 18, 415-426.

Lim, C.P. & Barnes, S. (2002). "Those Who Can, Teach" – The Pivotal Role of the Teacher in the Information and Communication Technologies (ICT) Learning Environment. *Journal of Educational Media*, 27, 19- 40.

Niederhauser, D. S., & Stoddart, T. (2001). Teachers' instructional perspectives and use of educational software. Teaching and Teacher Education, 17 (1), 15-31.

Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.) *Liberal education in a knowledge society* (pp. 67-98). Chicago: Open Court.

Schofield, J. W. (1995). *Computers and classroom culture*. New York: Cambridge University Press.

Windschitl, M. & Sahl, K. (2002). Tracing Teachers' Use of Technology in a Laptop Computer School: The Interplay of Teacher Beliefs, Social Dynamics, and Institutional Culture. American Educational Research Journal, 39, 165-205.

Yin, R. (1989). *Case Study Research. Design and Methods*. Newbury Park, CA: Sage Publications.

Unpublished references

Ilomäki, L. & Lakkala, M. (5.2.2004) Classroom case studies as a part of the evaluation in CELEBRATE (WP7). A working paper of the WorkPackage 7.

Ilomäki, L., Jaakkola, T., Lakkala, M., Nirhamo, L., Nurmi, S., Paavola, S., Rahikainen, M., & Lehtinen, E. (2003). Pedagogical guidelines in CELEBRATE. Principles, models and examples for designing LOs. Unpublished working paper for CELEBRATE.