INVESTIGATING THE USAGE OF LEARNING OBJECTS IN CONTEXT

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Summary

The purpose of the study was to investigate the role and characteristics of virtual learning objects in advanced pedagogical settings in selected classroom cases. The four Finnish cases studied represented pedagogical approaches such as student-centeredness, process orientation, and collaborative inquiry. Through the case studies, it was possible to investigate the teachers' and the students' concrete practices and evaluate the use of learning objects in ordinary teaching and learning sequences in a classroom setting.

The goals of the study were to examine the interrelatedness of the pedagogical practices, the characteristics and the affordances of learning objects in order to better understand how learning objects can support the development of the learning culture in schools. The study was conducted in the context of European CELEBRATE project.

The data of the case studies were qualitative. It included the participating teachers' agendas before and after the observed lessons, and observations and video recordings during the classroom activities. The results indicate that learning objects were mostly used as exploration tools, information sources, assessment models and objects of discussion. It appears that an expert-like use of knowledge was characteristic in the pedagogical settings, especially when the teacher was experienced with using ICT in classroom. However, all learning objects used did not support such practices.

Introduction

It is a widely shared concern that the implementation of technology into teaching and learning practices has not succeeded as well as expected; there are still several, and difficult, challenges to overcome in schools. One of the problems is the lack of learning material for technological intensive learning environments. The learning object approach is

regarded to be one of the solutions; there are e.g. several large projects for creating and delivering learning objects in western countries, e.g. in Canada (see http://www.cmec.ca/releases/2002-10-09.en.asp), and in Europe (see CELEBRATE (Context eLearning with Broadband Technologies http://www.eun.org/eun.org2/eun/en/index_celebrate.cfm).

Learning object (LO) is defined as "any entity digital or non-digital that may be used for learning, education or training" (IEEE LOM v1.0). Learning objects are understood as a standing piece (or 'chunk') of education. The "content" might be text, simulations, exercises, pictures, etc., which has descriptive metadata wrapped around it. In CELEBRATE, learning objects have been classified, on the basis of their pedagogical function, as follows: assessment, drill and practice, applied exercises, data sources, dictionaries, manuals and tutorials, experiments, and tools. The idea in the learning object approach is to produce a large number of independent software components, which are easily, flexibly and economically delivered, implemented and combined for various educational and technical contexts. In educational settings, it is the teachers' responsibility to organise the learning environment, and to guide students' activity and learning according to the pedagogical approach and objectives he or she has chosen to apply; learning objects are neither ready-made courses nor a fixed sequence of lessons.

Challenges in using virtual learning material

An important and actual question in virtual education is how to develop pedagogically advanced learning objects and other kinds of virtual learning materials (Orrill, 2002; Wiley, 2002). According to MacCann (1999), pedagogical goals have not guided the development of virtual learning materials, and the developers have been typically more interested in the newest technology than in pedagogy. Technology is regarded as a tool for delivering material instead of supporting intelligent activity and a mediator of new activities (Mioduser et al. 2000; Orrill 2002; Pea, 1993). A teacher with ambitious pedagogical ideas does not usually get support from the educational materials for his/her ideas of teaching, and, particularly, the materials do not support teachers and other

practitioners in the process of adopting new, innovative approaches to learning and teaching.

The importance of evaluating learning technologies *in context* or taking the pedagogical context into account as one criterion or defining category is often emphasized; (Crosier, Cobb & Wilson, 2002; Squires & Preece, 1999) but teacher's actual pedagogical solutions and arrangements or the usage of material in authentic educational contexts is in existing research only seldom examined directly. For Kozma (2003) the starting point was the nature of activity; in his situative approach, learning is seen as participation in practices of inquiry and discourse that include interaction with others and with the material and tools. His position is that the role of digital learning material is to provide cognitive and social affordances that support the construction of shared understanding, and its usage in educational settings should be embedded in authentic and meaningful collaborative inquiry activities.

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 learning objects mean, in our interpretation, should emphasize that the interaction of learning objects and the method of how they are used should. According to this, LOs have certain kinds of properties, which have a tendency to suggest some specific activities. These tendencies actualize only through use, and in this sense the skills, the practices, and the background knowledge of users influence crucially how these properties come up. LOs do not determine how they are used, and one of the strengths and basic ideas of LOs is that they can be used in various ways depending on the pedagogical activities in question. But still, certain kinds of properties of LOs urge to certain kinds of activities. It can then be maintained that learning objects have different kinds of pedagogical, cognitive, social, or even epistemological affordances. In this respect, the classification of LOs developed for CELEBRATE project (see above) rudely describes the main pedagogical affordances of each type. An in-depth analysis of learning objects in this study on the basis of their affordances is, however, only preliminary.

The pedagogical approach in the learning situation

Affordances of the learning objects are important as are important are those pedagogical goals and objectives to which LOs are used. Affordances and pedagogical goals and

activities interact with each other. 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 knowledge as such 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.

In the present study, we wanted, especially, to examine the usage of learning objects in "advanced pedagogical practices", which 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.

In the CELEBRATE project, for example, the following features were outlined to concretise 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 & al., 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).

In this study, the focus is on the relation of the pedagogical practice and the affordances of the learning objects used in the cases. The goal of the study was to examine the interrelatedness of the pedagogical practices and the characteristics of learning objects in order to better understand how learning objects can support the development of the learning culture in schools. The research questions were the following:

- What was the nature of the activities and knowledge processing in the teaching/learning sequences designed by the teachers?
- What kind of affordances the learning objects brought into the learning/teaching sequence?

The method

Setting

The investigated four case studies were undertaken in the Finnish test sites during the CELEBRATE project. The 'case' in this study meant one working sequence or a pedagogical unit: one teacher and his/her students conducted one teaching/learning sequence, which concentrated on one topic or theme and one working process that had a certain goal. The cases differed significantly from each other. Table 1 presents the basic information about each case.

Table 1. The cases

Title of the case	***School level***	***Grade***	***Age of students***	***Number of students***	***Content***	***Length of the case (weeks * hours/week***	***Number and type of learning objects used***
Case 1. Do you eat healthily?	primary (School 1)	5	11 to 12	31	Natural sciences	5 *1-2 hrs	1 (Exploration)
Case 2. Do You Know How to Eat?	lower secondary (School 2)	7	13 to 14	21	English	3 * 3 h	1 (Exploration)
Case 3. Senses and the brain	lower secondary (School 2)	9	15 to 16	17	Biology	3 * 2 h	9-10, (Information source & Drill-and-practice)
Case 4. Multiple-intelligence and learning objects	upper secondary (School 3)	1	16 to 17	16	Health education	6 x 1-2 hrs / week + virtual discussion 3 weeks	2 mainly (Tools, & Exploration and Guide), additional evaluation of several others (mainly Drill-and-practice)

Case 1. Do you eat healthily?

School 1 is an ordinary elementary school, located in a suburb in the City of Espoo. The male teacher of this case study had 21 years of teaching experience, and he has used ICT for 16 years with students. He is active also outside the school and he belongs to an ICT expert teacher team in his city. He trains other teachers to use ICT at the local level, he has participated in special training about ICT, and he participates in national conferences about ICT. He can be regarded as a key teacher in ICT also municipal level.

The goals of the teaching/learning sequence defined by the teacher were to get students to understand the principles of a healthy diet, and to help them to reflect on their daily eating, even to help them make some changes to it.

The structure and phases of the learning/teaching sequence

The whole process was conducted over a five-week period. First, the students visited the school's lunchroom, where the canteen manager talked about the school food. They also got a leaflet about healthy food. After this lesson, the teacher sent an e-mail to parents about the project. Next, one introductory lesson to the tasks for the students took place (45 minutes). The students were encouraged to keep records of their meals for nine days in a diary. They received a simple template for this, made by the teacher, and the task itself was carried out independently at home. Parents were requested to sign the diary daily, in order to follow the student'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 for the computer class), the students began to use the learning object itself (Healthy meal). They were divided into two groups because there was room only for half of the class at any one time. The students used the learning object by applying the data that they had recorded in 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 students 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.

Case study 2. Do you know how to eat?

School 2 is an ordinary secondary school, located in a suburb in the City of Espoo. It consists of both lower- and upper-secondary grades. The female teacher of this case study had 20 years of teaching experience, and she has used computers for about 12 years in teaching. During the spring, the teacher participated in two long-term, in-service trainings for teachers about network pedagogy. She can be regarded as an advanced teacher in ICT at a school level.

The goals defined by the teacher were to learn food and nutrition oriented vocabulary; to use acquired language skills as well as information on nutritional values and recommendations in a context directly linked to the students' own health and well being; social interaction among students; and to learn to take the responsibility for one's own work.

The structure and phases of the teaching/learning sequence

The unit was conducted over a three-week period, involving three 45-minute lessons per week. The whole sequence included 4.5 lessons related to the learning object, and 5 lessons related to the textbook, which had a big role in the teaching/learning sequence: an essential part of the students' activities was working with the texts related to the theme of nutrition by doing oral or written exercises. All along the students collected vocabulary for their own note books.

In the first lesson, the teacher orientated the students to the new unit by telling them that they would study vocabulary related to food and nutrition, make their own vocabulary and an oral presentation as a final work. She told them that the vocabulary of the LO they would use is more advanced than the students of this grade usually study in school. After

that, the teacher distributed some pictures of food and meals, and drew a mind map on the black board including the main categories of food vocabulary (vegetables, milk products etc.). The students were asked to add words under the main classes highlighted on the blackboard and to write the words in their notebooks. The collection of words under the main categories was given also as home work.

In the second lesson, the teacher divided students into five groups, each of which was responsible for one or two main categories of the food vocabulary. In groups, students shared individually collected words. 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 the blackboard to their personal dictionary in the note book. *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.

The following two lessons took place in a computer room. In the first lesson, the students practiced using the learning object, Healthy meal. The teacher gave instructions about finding the learning object, and assigned the students to work in pairs and to try all choices for constructing healthy meals. The teacher handled some minor technical problems smoothly and peacefully, and, eventually, all the students had gone through the choices in the LO. When pairs of students had completed this activity, they were asked to start planning their final work. In the second lesson, the student pairs elaborated their final work (a healthy meal recommendation, a dictionary, or a piece of drama) using computers and the learning object. The students asked some questions about using the learning object but, generally, they appeared to manage very well with it.

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

Case 3. Senses and the brain

Case 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 a small amount of computers for about 10 years in her teaching. 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 teacher made four papers, including tasks about the parts and the 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 as follows: The students will learn the basic issues about the structure of the eye and ear, the origin of sensation, and general outlines of the functioning of various parts of the brain.

The structure and phases of the teaching/learning sequence

The unit was conducted over a three-week period, involving two 45-minute lessons per week. *In the first lesson,* the students 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 learning objects. Only three student groups had computers with the LOs in their use. Therefore, the teacher gave separate instructions to two groups 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 to search for information. The other group went to a computer classroom. The teacher walked around the classroom and guided each group separately. After finishing the first task, two groups changed computers with each other, and started the new tasks. When the groups had made

the tasks, they started to plan their research work after getting instructions from the teacher.

In the second lesson, the teacher ordered the students to continue their group tasks. The students did not seem to be totally 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 recognising the parts of eye from it. The students 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 students just walked around.

In the next two lessons, the student groups worked on their research work, using Google and writing a text document about their research question. The second lesson was in the computer classroom which had nine available computers. After the groups' document was ready, the teacher instructed the groups to save it in a project folder in a common server. *In the last (fifth)* lesson, each group commented on the work of one other group by writing their comments at the end of the document. Also the teacher commented on each document after the lesson.

Case study 4. Multiple-intelligence and learning objects

School 4, an upper secondary school, is located in a rural community at the Finnish metropolitan area. The male teacher of this case study had about 20 years of teaching experience, and he had used ICT for about 12 years with students. Particularly in the recent years, he has used virtual discussion and collaboration tools. He is also active 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 and a national-level actor of ICT usage in education.

The goals defined by the teacher were as follows: The students will learn to observe that there are different kinds of intelligence, and everyone is gifted in some way; areas of

strength can be developed, and the students' understanding of multiple-intelligence strengthens their self-confidence.

The structure and phases of the learning/teaching sequence

The overall working process was structured by the teacher. The teacher briefly oriented the students to the topic by describing the upcoming period. This happened just before the students went on holiday for a week. 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.

First two lessons (2 x 45 minutes). The work started with a teacher's presentation as an introduction. After that the students 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 students 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 Demo Portal (and later in 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 learning objects for the search to help students in the beginning, but he encouraged the students to use the whole Demo Portal as an LO library. The students linked the learning objects to the virtual discussion forum and commented on them. During *the two following lessons* the students were advised to complete the first mind maps with new ideas and comments, which they got during the process, and to connect the mind maps to the virtual discussion forum. The students also continued the virtual discussion.

After the face-to-face period, the students 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 a pair, gave a short (3-5 mins) 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 other 50 % came from the final exam.

Data collection

The focus of this study, *learning objects in pedagogical settings*, is a complex object to investigate; several actors influence in it, it has a close connection to teacher's values, pedagogical conceptions as well as to his/her technological thoughts and competence. In this study, it was necessary to used different kinds of data.

The data of the case studies was qualitative, and it consisted of the following data types:
1) The participating teachers agendas based on short interviews with the teacher before and after the observed lessons;
2) Observation notes and video recoding of the classroom activities;
3) Varying materials created by the students during the teaching/learning sequence (discussion forum notes, final works etc.)
4) Notes of the discussions with the teacher;
5) Written/discussed evaluation of the teaching/learning sequence by the teacher;
6) Other informal data e.g. emails with the teacher, notes of the informal, preparatory meetings.

The researchers (2) and a research assistant collected the data so that both researchers were responsible for collecting the data from two cases. The researchers were present during the lessons (with a few exceptions), and wrote notes in which the focus was on the pedagogical design and implementation of LOs in the working processes. The researchers were introduced to the students in the beginning of the period. Otherwise the researchers didn't participate in the activities. The research assistant video-recorded the lessons with one camera. The teacher interviews were video-recorded and transcribed.

Table 2 presents a summary of the data used in the cases.

Table 2. The data of each case

Data	***Case 1***	***Case 2***	***Case 3***	***Case 4***
1. Recoded and transcribed teacher interviews	x	x	x	x
2. Written observation notes	x	x	x	x
3. Video recordings of the lessons	x	x	x	x
4. Teacher's material to students	x	x	x	x
5. Students' email notes about the project				x
6. Students' notes in the virtual discussion forum				x
7. Students' final works with comments			x	
7. Other	A letter to parents			

Data analysis

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.

The methods to ensure and increase external and internal validity and reliability were the following: various kinds of data to give a more comprehensive view of the case by

triangulation; participant checks (the teachers of the case read through the description of the case afterwards); video/audit trail, which were used for checking the observation notes when needed, and a common analysis scheme and collaborative analysis checking between the researchers.

Results

In the following, the results of the explorative analysis about the typical features in each case are described concerning the nature of activities, nature of knowledge processing and the relationship between the pedagogical setting and the affordances of the learning objects.

The nature of activities

Case 1

Authentic activities

The basis of the activities was in students' authentic activities. The content of the sequence was based on the students' own, authentic data and during the sequence, they reflected their own behaviour and habits. The use of students' own data created ownership of the task which was obviously a reason for the good working climate: all students were active in doing the work.

Independent work, student's responsibility

The students were responsible for reflection and designing the task/product themselves. The students independently kept records about their own eating habits for 9 days at home. At the computer class, the students worked independently, at their own pace. They asked for help, and helped each other in a natural way, but everyone was responsible for conducting his/her own work.

Teacher’s structuring and guidance

The overall working process was structured by the teacher. He decided the students' activities, and he was the key person in the class at all times. The teacher helped students in problems with the computers and gave technical advice. The teacher didn't really teach the substance (healthy eating); it was left to two other school-related experts and to the learning object.

Case 2

A mixture of structured, small-scale exercises and knowledge creation activities

The sequence included various kinds of successive activities through which the students studied food and nutrition vocabulary from several points of view, individually and collaboratively. Each lesson was planned to include certain activities. The sequence can include two main components within each other: 1) structured, small-scale exercises, which were typical and traditional language learning parts following the textbook; e.g. collecting words, reading text chapters, and practicing pronunciation, and
2) knowledge creation activities, in which the students were individually responsible for creating their own dictionary throughout the whole sequence. The students also worked in pairs and were responsible for the creation, completion and presentation of their final work.

Teacher's structuring and guidance

The teacher was the designer and organiser of the teaching/learning sequence. The teacher gave the students good guidelines about the goal and structure of the whole sequence of lessons at the beginning, and also guided the student groups during the activities in the classroom.

Case 3

A mixture 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.

Collaboration

All the work was planned to be very collaborative because; the students 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 did not work very well and the students were, apparently, not all the time sure what were expected from them. The students were in groups responsible for filling the task papers and making their question-driven report.

Teacher's structuring and guidance

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

Case 4

Authentic content

Students were guided to think about intelligence based on their own "intelligence test" and the elaboration of the mind map.

Collaborative knowledge building

The pedagogical approach emphasized the students' responsibility and activity in thinking and processing the content of the theme. The students were responsible for conducting the reflection process, searching for and evaluating learning objects, and participating in virtual discussions about the theme. The students 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 feedback from the students; they would have liked to have more virtual, in-depth discussion of the topic under study.

Teacher's structuring and guidance

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 chosen beforehand a number of suitable Celebrate learning objects for the students, and he arranged an external expert visit. The teacher was especially experienced in guiding the use of the virtual discussion. His role as a technical support was important, and he could also solve some more difficult technical problems. The teacher didn't really teach the substance (multiple intelligence); it was left to the other school-related expert and to the IQ-Form learning object.

The nature of the knowledge processing

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

Case 1

1) The teacher organized three different perspectives to the content: the expert model in the learning object, the canteen manager's view and the view of the nurse;
2) The LO presented the content through several means, that is, the knowledge was presented from various angles (picture, text, numeral and graphical results);
3) The knowledge that the students 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).

However, because there were no "summary" of the sequence, it is difficult to say how students finally constructed the idea of the topic. Maybe a common discussion or similar would have helped to create a common understanding in the end.

Case 2

1) The LO gave an expert-like perspective to the content: the vocabulary was more advanced than the students 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 through several means (text, picture, and table);
3) The students 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 of the content that was to be learnt, and the elaboration of the dictionary was a continuing, integrative process during the whole sequence;
4) The students were promoted to share their expertise and knowledge of food vocabulary by collaborative tasks,
5) The student pairs were allowed to choose the type and the content of their final work themselves, which supported students' 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.").

Case 3

1) The students were assigned to make their own report in groups, based on their own research question under the main topics.
2) The students used authentic information sources from the Web in the research-like task.
3) The students had a possibility to compare the conceptual knowledge about the parts of the eye to 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 students just copied the right answers from the materials, from textbook or from each others' papers.

Case 4

1) The working sequence aimed at processing the content from various points of view. (The teacher described his approach often as 'emergence'.) The students used various kinds of virtual sources from the net in processing the knowledge.
2) Students used the virtual discussion forum for sharing understanding. In the students' feedback, the possibility for virtual discussion was highly appreciated. Several students thought that by discussion and argumentation they learned more, and became more motivated in the topic.
3) The process 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 relation of the pedagogical setting and the affordances of the learning objects

Case 1

The learning object had several roles in the pedagogical setting: First, it offered ***a tool*** to students 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 gave ***an expert model*** about what constitutes a healthy meal. The learning object offered an ***exploration area***, in which students checked the nutritive value of meals.

The learning object didn't guide the students to do anything, for instance, compare their own ratings to those of the program. In this sense it was an open tool, which offered possibilities for students' own activities but didn't structure the activities in any ways. The teacher decided the structure and the activities of the sequence, which demanded that the teacher had to have an understanding about applying the LO.

Case 2

The learning object had two roles in the pedagogical setting: First, it was an ***information source*** for students in their study of food and nutrition vocabulary. The knowledge (= vocabulary) was given via several means, which facilitated learning and remembering. Then it was an ***expert model*** for using advanced-level vocabulary in a context simulating an authentic situation, which provided a more expert-like situation for learning vocabulary than using only the textbook.

This same learning object was used in case 1 but was used in a very different way for this case. It offered similarly an open exploration area, but the teacher had chosen to use mainly the ready-made nutrition examples, because they offered good vocabulary to learn. Again, the teacher chose how to use the possibilities of the learning object. The teacher had to have understanding about the LO and how to apply it to achieve the learning goals.

Case 3

The learning objects had two roles: First, they were ***information sources*** for students in their study of the parts and functionality of the eye, the ear and the brain. The knowledge was given in several means (pictures, text, animation, drill-and-practice tasks). Then they were ***sources of evaluation,*** with which the students were supposed to check the rightness of their answers in the task papers.

The learning objects that were available in the CELEBRATE Demo Portal (or in the Finnish learning object bank) for the topic at the time of the study, were pedagogically rather low level drill-and-practice learning objects or narrow information-source learning objects presenting only some facts or concepts (mentioned also by the teacher before the case study). Therefore, the learning objects 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 learning objects about the eye, the ear, and the brain were also in English, which was a little problematic according to the teacher. The teacher appeared to have aimed at more advanced, problem-based activities, but she had difficulties in

integrating the ideas of the problem-driven research work to the usage of drill-and-practice oriented LOs.

Case 4

The students used several learning objects and tools during the sequence: The IQ-Learn was used as **an exploration and reflection tool**. It stimulated the discussion and argumentation about intelligence and it consisted of a large knowledge base about the topic. 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. The Mind Manager was **a tool** for making mind maps, which also allowed students to reflect on the nature of intelligence and it helped students to form quickly a visual outlook of their own thinking. The collaborative **discussion forum** offered a possibility to further develop the ideas about intelligence, to share the ideas and to reflect on them. 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.

The LO in case 4 (IQ-Form) fitted especially well for that teaching/learning sequence by facilitating with ***a large expert knowledge base***: its content was large and versatile, even challenging, which supported the students' individual questions and the virtual discussion. It also stimulated the discussion and motivated students by reflective tests. The mind map tool (Mind Manager) in case 4 was also easy to use and useful because it supported ***student's own planning and reflection***. The tool is obviously flexible for various grades, subject domains and learning settings. The collaborative **discussion forum** offered a possibility to further develop the ideas about intelligence, to share the ideas and to reflect on them. It was an essential element of the sequence; it helped in structuring the discussion in the learning sequence. The evaluation process of the learning objects in CELEBRATE Demo Portal (and elsewhere on the Internet) was a kind of extra activity; it was less motivated and didn't actually help to think about the topic - at least in the way how it was conducted in the case. The rather low-level approach to the content and the drill and practice -activities also diminished the value of the activity.

The combination of the LOs was noteworthy in this case; each LO had a special role in the process, and the LOs complemented each other. This was the result of the teacher's way of designing the activities and his understanding to take advantages of the affordances of the LOs.

Conclusions

The goal of the present study was to examine the interrelatedness of the pedagogical practices and the characteristics of virtual learning objects. One part of the study was to analyze, what was the nature of the activities and knowledge processing in the teaching/learning sequences designed by the teachers. The other part of the study was to examine what kind of affordances the learning objects brought into the learning/teaching sequence.

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 idea of three approaches to learning (see Hakkarainen, Palonen, Paavola & Lehtinen, 2004) is possible to apply in understanding the four cases. Case 3 represents (mainly) the knowledge-acquisition perspective. Case 1 can be regarded to represent the participation approach and case 4 the collaborative knowledge-creation approach. Case 2 is a mixture of all three approaches; maybe this is based on the subject: language learning.

The usefulness of the learning objects

In all the cases, the learning objects were used as an important part of the teaching/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 supports a student-centered 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. Maybe the usage of the learning objects was unnecessary in these two cases.

The importance of teacher's pedagogical ICT competence

In the studied cases, learning objects were mainly integrated as natural parts of the teaching/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 mainly low-level drill and practice LOs, or the content of the LOs was inappropriate for the topic; but the idea of students evaluating them 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 actualised nature of the learning activities might be in contradiction with 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-centered* and *task-centered* 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/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.

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.

Discussion

The concept "advanced pedagogical approaches", used in the present study, means learning activities that are based on learners' active participation and collaborative knowledge creation. The role of learning materials in such approaches is not to deliver knowledge or direct the learning process, but to provide "building blocks" for the learners' knowledge work in a versatile way. The idea of learning objects is very adequate for these kinds of approaches. As the present study revealed, teacher's role in organizing, structuring and guiding the whole process in such activities is crucial. It challenges

teacher's guidance competence, technical competence and subject domain expertise. There is apparently a need for more empirical research that could provide teachers and educational practitioner's models and scenarios for designing the "efficient" usage of digital learning material in their teaching. Also the developers and producers of materials have to start examining the criteria for good learning materials from novel perspectives, taking into account the interrelatedness of the characteristics of the materials and the goals of the desirable pedagogical contexts.

Appendix 1

The www-addresses of the learning objects used in the case studies

Cases 1 and 2

Terveellinen ateria (Healthy meal):

http://www.edu.fi/oppimateriaalit/terveellinenateria/

http://www.edu.fi/oppimateriaalit/healthy_meal/

Case 3

The structure of the eye: http://www.perunakellari.fi/silma.htm ,

www.nkl.fi/yleistie/tietopaketti/kalvo3.htm

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

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

The ear - sensory cells:

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

The eye - sensory cells:

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

The Human brain (the type of this learning object is **Drill-and-practice**):

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

Case 4

IQ-Learn: http://iqform.edu.helsinki.fi/iqlearn/

Mind Manager: http://www.mindjet.com/.

CELEBRATE Demo Portal: http://demoportal.eun.org/celebrate_dp/index.cfm,

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