Creating Proper Media Objects for Computer Supported Learning-Environments

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Abstract: In the last three years the research group of Didactics of Informatics at the University of Paderborn has carried out a project called MuSofT (Multimedia in der Software Technik). The aim of the MuSofT project is to produce multimedia learning objects for teaching and learning software engineering. The educational objectives are achieved by means of case studies, especially the model of a high rack storage area. Thus, the idea of an Informatics Learning Lab (ILL) occurred.

The ILL is an interactive web-based multimedia exploration platform to enable constructivist types of blended learning. Students use learning objects in a self-organized learning process in an open collaborative learning environment. This paper describes a method to create learning objects for this scenario and a concept for an empirical study to evaluate their quality:

After deciding about objectives and the learners' roles in a given technical context of the ILL we have to focus on the construction of learning and media objects. Media objects can be constructed on different levels of abstraction from the socio-technical information system of the case study: real world scenario, physical model (here LLGO Mindstorms) or software model. For all levels of abstraction the ILL provides students with different types of media, which should enable them to gain comprehension of relevant facts and structures of the ILL. We also have to distinguish between different types of encoding: symbolic (dealing with signs and symbols e.g. in a text), drawing (abstract mapping of facts in a chart) and picture (lifelike mapping). These types of encoding are cut into two different areas:
respectively static and dynamic types of information representation at the different levels of abstraction.

In this grid of abstraction levels, encoding types and also granularity many different types of media objects are possible. But which are the proper ones to support learning software engineering effectively?

1 The Informatics Learning Lab (ILL)

1.1 Aims and Reasons

The teaching at universities is dominated by teacher-centred lectures which are composed in a domain-specific way - without (or with less) applied context. But this traditional way of learning has several disadvantages which can be attenuated by the use of E-Learning:

- Gruber, Mandl and Renkl asserted in 2000 (by referring to the TIMSS II study[1]) that knowledge without embedded context is inactive. It exists in an abstract way, can be accessed in examinations - but not in practice.

  "'[...] Das gewissermaßen 'in vitro' erworbene Wissen kann zwar im universitätsanalogen Kontext, in dem es erworben wurde, genutzt werden, etwa in Prüfungen; in komplexen, alltagsnahen Problemsituationen gelingt die Wissensanwendung jedoch oft nur unvollständig oder überhaupt nicht. Damit kommt es zu einer Kluft zwischen Wissen und Handeln'." [GMOO]

- Students have different preparatory training - maybe because of different school education or timetables at university. But lectures don't assist individual ways of learning.

- The individual attendance of a huge group of students in a traditional way is costly.

Thus reasons for the introduction of E-Learning at universities could be:

- to adjust the different knowledge of students in learning groups (That implies the question in which areas adjustment will be necessary.),
- to create applied knowledge which can be transferred in a new context,
- to enable self-directed learning and to teach responsibilities for this way of learning,
- to save money while teaching huge groups of students (This aspect demands the existence of adequate learning materials and platforms. Because nowadays E-learning is often more expensive than traditional learning. - One starting point for blended learning concepts.).

These are the principal aims of our Informatics Learning Lab in the domain of software engineering.

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[1] http://www.timss.mpg.de/

1.2 Learning Processes in the ILL

The ILL (Informatics Learning Lab) is an exploration environment to enable self-organized learning processes in learning communities. In consideration of the pedagogical position that learning is an active process - not passive acquisition of knowledge, students can interact with the learning material, teachers and other students. Thus the didactical (models and roles, objectives, selection of content), the organizational (methodical concept, integration of media, interaction between learning groups) and the technical context (learning platform, groupware, CMS, digital media) could be a target of an empirical study. This paper will mainly describe a study about the selection of content - more specific the selection of media and learning objects - and its implementation in a learning process according to constructivist learning theories.

Learning Processes in the ILL

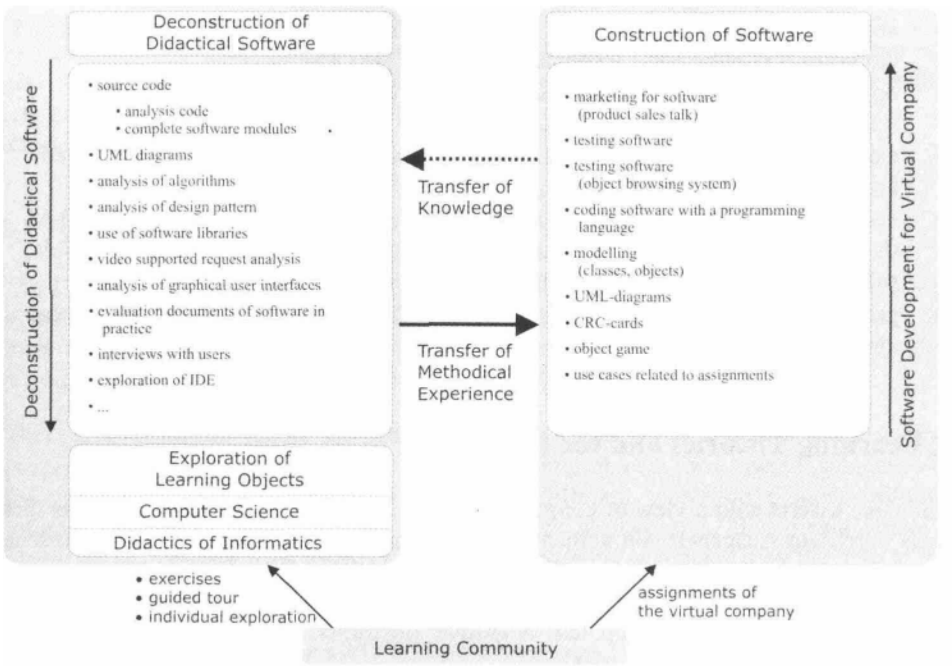

Figure 1: Learning Processes in the Informatics Learning Lab.

Core of the ILL are several case studies, which are dealing with different aspects of software engineering: *school kiosk, media player, computer game 'Ursuppe* ' and a *high rack storage area* (HRSA) have been completed up to now. Any case study consists of didactical software which has to be examined by the students. After and during this the acquired declarative and procedural knowledge has to be used in a constructive way by creating a new or changing the old information system.

The different learning phases in the ILL consequently are [Ma03] (in the scenario HRSA):

- "foundation of a virtual company with students as the owners, assignment to build an automated commissioning unit;
- exploration and deconstruction of the physical and software model (guided, self-directed supported by LOs);
- modelling a software model with CRC-Cards and UML;
- exploration of the modelling concept of the Mindstorms model, comparison and assessment with regard to the model concepts created by the students;
- acquiring a deepened knowledge of the three perception models by using open and closed LOs (source code, technical functionality);
- operating re-engineering tasks related to the Mindstorms model (variation of sensors, different types of racks),
- exploration of the communication protocol used by the bricks and of the layered architecture of the software (using LOs);
- cooperative construction (modelling, encoding, assembling Lego components) of the commissioning unit by the students, transfer of knowledge on different levels, self-directed use of LOs according to their needs of support;
- presentation of the product, quality assessment, reflection on the learning process and self-evaluation regarding the achievement of objectives."

2 Learning Theories and the ILL

Blömeke asserts with a view of constructivist learning theories: "Konkret bedeutet dies, dass durch ein Ausgehen von authentischen Aufgaben, die Einbeziehung authentischer Kontexte, die Einnahme multipler Perspektiven und Modelllernen der Wissenserwerb optimiert werden kann." [B101] This is a reference to cognitive apprenticeship, situated cognition, anchored instruction and cognitive flexibility. The ILL tries to fulfil the consequences of these sub-theories.

The cognitive apprenticeship by Collins, Brown and Newman [CB89] demands the descriptive demonstration by the tutor *(modeling},* increasing activity of the student *(scaffolding)* - simultaneous with decreasing activity of the tutor *(fading out),* until the role of the tutor is limited to guidance *(coaching).* It is important for the success of this approach that articulation and reflection take place at every step of this procedure. The role of the tutor in the ILL is partially adopted by the learning objects: at first by closed objects with strong structuring of students activities - later by open ones for self-directed work and learning.

The case studies of the ILL build up anchors for authentic situations in terms of the Vanderbilt Group [Va94j. Learning in the ILL is problem-based, opened for new solutions. The variety of media objects for the same subject allows individual views in terms of the purpose of cognitive flexibility [Sp92].

3 Media in the Informatics Learning Lab

Media in the ILL can be (among others) classified by granularity, coding type and level of abstraction. Here the categories coding type and level of abstraction should serve as a grid for media objects, which can be bundled in complex learning objects of higher levels. These higher LOs can be classified by granularity - or rather by their function during the learning process.

3.1 Types of Media Objects

The ILL consists of several content modules which are covering different aspects and objectives of software engineering. To categorize a single media object of the case study high rack storage area you can differentiate between coding types (according to Tulodziecki [TH02]), level of perception and abstraction.

This classification of media and learning objects in categories should assist to choose proper media objects for the construction of learning objects for a special subject to be learned. The single media objects symbolize different views on a socio-technical information system - for example on a high rack storage area. If a media object is identified as improper for a learning subject, it is possible to replace it by the help of this grid of categories with an object that deals with the same subject - but with another view on the system. Currently, media objects for several subjects (e.g. communication between the RCX-units of a LEGO Mindstorms model of the HRSA) exist. - Others have to be created or modified for this empirical study.

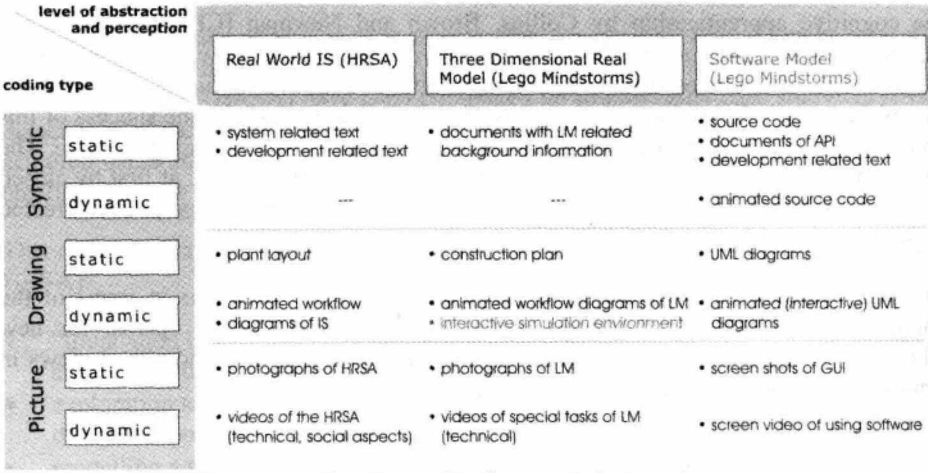

Figure 2: Media objects of the case study *high rack storage.*

3.2 Granularity of Learning Objects

Learning materials in the ILL should be reusable - not only for teachers but first of all for students. To manage learning materials in a technology-supported learning environment we have to build discrete chunks of these materials, the learning objects[2]. But learning objects exist on different aggregation levels with a different influence on methodology, didactical concepts and learning theories.

The LOM-Standard (Learning Objects Metadata) [LOM02] also describes aggregation levels for Learning Objects, but the levels 1-4 only refer to abstract terms like *lesson, course* and *set of courses.* The description of the specific role of these levels is missing. More reasonable is the consideration of a student's interaction with the learning material. According to Koppi/Hodgson [KH01], Kassanke [Ka03] and SCORM [ADL04] we have five different levels of learning objects granularity[3]:

Level 1: Raw Asset

This can be defined as the smallest unit of media fragments with potential use in an educational context. They are multi- or monomodal, but have no inherent educational directives. Raw assets have the highest level of reusability in other didactical, organisational or technical contexts. Examples:

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[2] „Learning Objects are defined here as any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning." - IEEE Learning Technology Standards Committee http://grouper.ieee.org/LTSC/wgl2/index.html

[3] The question about metadata is connected with granularity and hierarchy of learning objects. Butt his isn't topic of this publication.

- A picture of a high rack storage area.
- A video of selling goods in a school kiosk.
- An animation of a rack feeder.

Level 2: Learning Asset

A learning asset is a raw asset, or maybe assets, in an educational context with a small thematic range. The atomic elements of the learning assets are ordered in a sequence, but not supplemented with a task or an exercise. They are passive objects. Learning assets are low affected by learning theories or pedagogical decisions. The reusability in other contexts is high. Examples:

- A picture of a high rack storage area with a description of the capacity of the storage and of the functions the several parts have.
- A sequence of videos from a school kiosk with the reference to use cases.
- An animation of a rack feeder with object diagrams of the subunits.

Level 3: Task or Exercise

A task or exercise demands activities by the students with small thematic range. It can include raw or learning assets to foster these activities. The problem-based tasks or exercises are usually affected by pedagogical decisions because of the order of elements, the character of the initiated activity or the feedback method. As a consequence of this, level 3 LOs have low reusability in other contexts. According to the ideas of constructivism, especially cognitive apprenticeship, and concepts of blended learning it seems necessary to distinguish between open and closed LOs - depending on their position in the learning process.

Closed learning objects are small CBT/WBT-units. They include a problem based task, learning materials to deal with this assignment and a guided tour through these materials - usually finished by a test to verify the learning outcomes. The students are not allowed to choose their own way of learning. These closed learning objects are qualified to approximate the previous knowledge of the students at the beginning of a blended-learning course.

Open learning objects on this level include exploration assignments. At the beginning of the learning process students get an assignment. In order to solve the problem (and respectively achieve the objectives) they have to explore different topic-related learning materials, generate their own answers or methods of solution and discuss them with other students and the tutor. The quality of the learning process and the achievement of learning objectives should be improved by a process of evaluation. These learning objects are suitable for the workshops and seminars in a blended-learning process, but I not in their earlier phases.

Examples:

- An animation of a rack feeder with a task asking the students to identify functional subunits resp. classes with methods and attributes.
- A multiple choice test about concepts of OOP.
- A request to add a class of a user manager to the model of a school kiosk software.

Level 4: Learning Module

A learning module contains one or more tasks, learning or raw assets. It describes one topic with all its pedagogical parameters, including objectives, methodical decisions, previous knowledge of students, sequencing, didactical, organisational and technical context. The complexity is high, the reusability in other contexts low. This is the highest level of aggregation with impact on didactical decisions. The cohesion of the subunits is given by the wider topic of the module. Didactical concepts like cognitive apprenticeship and blended learning are visible in the sequencing of lower LOs on this level. Examples:

- A module about Java coding in a LEGO Mindstorms high rack storage.
- A module about design patterns in a school kiosk software.
- A module about database design in an online news agency.

Level 5: Thematic Web

A thematic web bundles different learning modules with different topics to a curriculum for a predefined graduation - e.g. all courses to reach a master degree at university. The reusability in another context is minimal.

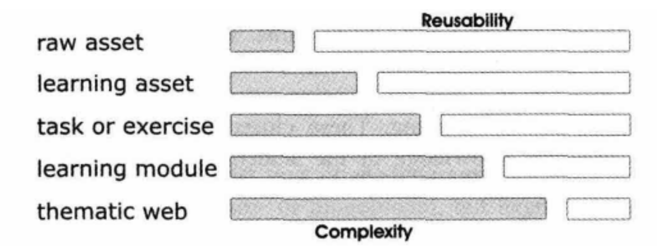

Figure 3: Reusability vs. complexity of LOs.

Reusability as the opposite to complexity is important for the adaptability of the LOs in the evaluation process.

4 Concept of Evaluation

The basic concept of the ILL was subject to a first evaluation during a course at the University of Paderborn in summer 2003. This was a preliminary study - close to the grounded theory from Glaser and Strauss [GS67] - in order to prepare a second one which will be described beneath. Topic of this evaluation was the testing of the instruments and the searching for adequate research questions.

Because of the small groups of students and the impossibility to pro-produce all media and learning objects it is necessary to make the empirical study in various passes. Each part of the study will be followed by a phase of material production for the next part. Currently we are estimating three years of research - including specification of research questions, production of media and learning objects and interpretation of results.

The main research interest is to find out which type of media support (abstraction level, encoding type, sequence and structure of learning objects) will be necessary to optimise students learning success. The components of the study will be questionnaires, group discussions, screen videos, guideline oriented interviews, product analyses, screen videos and also the observation of the students' activities (process analyses).

4.1 Instruments Questionnaires and Interviews

One objective of the ILL - and above all a condition for the collective work at the case studies - is the adjustment of the students' different practical and scientific knowledge of the students. A grading test has to be made at the beginning of the course to evaluate the previous knowledge of the students in the different relevant areas of software engineering (e.g. practical experiences with UML, coding or design patterns). The students will be sorted by experience levels (beginner, advanced learner, expert) in this area. Assigned to these levels of experience the system will offer the students (mostly) closed learning objects to approximate previous knowledge.[4]

At this early state of the survey the areas of students' deficits are unclear. Because of that it is necessary to add a guideline-oriented interview on this questionnaire at the first rounds.

After that it might be useful to search for patterns (like UML-type, source code type) in order to gain a simple classification of learners. The ambition is to ascertain which type of student can benefit the most from which types of learning objects.

[4] This is a problematical procedure because of lack of time to produce missing media and learning objects.

When the students have finished the course we have to introduce another questionnaire to check the achievement of objectives. Such a questionnaire can (mainly) proof declarative knowledge. To test procedural knowledge a process evaluation is necessary. The questionnaire should also clarify the students' satisfaction and self-assessment in regard to the learning process.

Product Evaluation

During most of the phases of the learning process the students are expected to produce something (e.g. a program or class diagrams). Thus, concrete products, which can be analysed with criteria of professional software engineering, are supposed to exist. These outcomes can conveniently be used to detect (individual) deficits even during (not only after) the course. If such deficits exist new learning objects have to be created - or rather existing objects have to be modified for later rounds. This modification can be made by exchange of media objects about the same subject areas or by converting lower level learning objects in objects of level 3 or higher.

Process Evaluation

Product analyses can't create insights in the process of its creation. But procedural knowledge will be visible in the students' working process.

Screen videos of the students' work with computers can represent a part of the learning process. So in each instance two students are expected to talk about their activities in front of a computer and about each of their simple clicks on the screen.[5] This communication is more important than the mute screen image. A software like Videograph[6] is useful for a precise category-based analysis of the screen videos.

The computer-supported process analysis should be completed by the conscious observations of the tutors.

4.2 Research Questions and Realisation

As mentioned above the evaluation should take three years. The first year should serve the production of learning objects, the expected types of students and a first pass for testing research questions, instruments of evaluation, tools and the learning platform[7]. The second and the third pass will each be realised in a course one year later. Each time only one parameter of the learning design will be changed. We don't want to evaluate the role of the tutors' activities in these courses, because we suppose that the 'fading out' will be the same in each pass.

Research questions which have to be stated more precisely at this time are:

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[5] The tutor also should stimulate the communication between students because of the methods of cognitive apprenticeship.
[6] http://www.ipn.uni-kiel.de/aktuell/videograph/htmStart.htm
[7] We will use a sTeam server, http://steam.upb.de/en/

- How must learning objects be built for such a scenario in the computer science education at university? How must we integrate the LOs in a learning process which is organised in orientation according to the concept of cognitive apprenticeship?
- Are closed learning objects only convenient at the beginning of the learning process or also in a later phase?
- Which coding types and levels of abstraction are eligible to enhance the learning success in regard to the learning issues (case study) and the common educational objectives of university courses in software engineering?
- Does the insertion of interactive animations and videos assist the learning outcome? - The creation of animations (e.g. in Flash) and videos is very complex and expensive. A pass with only static drawings and pictures without animations and videos will show the difference.
- Which case studies are appropriate to increase the acquisition of knowledge in the area of software engineering? How do they assist the domain-specific and general transfer [Eb96] of knowledge?

References

[ADL04] Advanced Distributed Learning Initiative: SCORM 2004 Content Aggregation Model Version 1.3., http://www.adlnet.org/index.cfm?fuseaction=rcdetails&libid=648, last visit: 2004-08-01,2004.

[Bl01] Blömeke, S.: Zur medienpädagogischen Ausbildung von Lehrerinnen und Lehrern. Folgerungen aus der aktuellen lern- und professionstheoretischen Diskussion. In: Medienpädagogik, http://www.medienpaed.com/00-2/bloemeke1.pdf, last visit: 2004-07-01,2001; pp. 6.

[Eb96] Eberle, F.: Didaktik der Informatik bzw. Einer informations- und kommunikations-technologischen Bildung in der Sekundarstufe II. Sauerlander, Aarau, 1996; pp. 201-208

[CB89] Collins, A., Brown, Newman: Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. In Resnick, L. B. (eds.) Knowing, learning, and instruction. Hillsdale. NJ: Erlbaum, 1989; pp 453-494.

[GM00] Gruber, H.; Mandl, H.; Renkl, A.: Was lemen wir in Schule und Hochschule: Träges Wissen? In: Die Kluft zwischen Wissen und Handeln - Empirische und theoretische Lösungsansatze. Göttingen 2000; pp. 11-26.

[GS67] Glaser, B.G.; Strauss, A.L.: The discovery of grounded theory. Chicago 1967.

[Ka03] Kassanke, S.: Ontologiebasierte Strukturierung von Lernobjekten in der Domäne Operations Research/Management Science und Einbettung in ein hypermediales Lernsystem - Konzeption und Implementierung. Paderbom 2003.

[KHOl] Koppi, A.J.; Hodgson, L.: Universitas 21 Learning Resource Catalogue using IMS Metadata and a New Classification of Learning Objects. In: Proceedings of ED-MEDIA 2001 - World Conference on Educational Multimedia, Hypermedia and Telecommunications, Tampere, Finland, 2001. Tampere, 2001; pp. 998-1001.

[LOM02] IEEE Learning Technology Standards Committee: Draft Standard for Learning Object Metadata, http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_vl_Final_Draft.pdf, last visit: 2004-07-01,2002.

[MS04a] Magenheim, J.; Scheel, 0.: Using Learning Objects in an ICT-based Learning Environment. In: Proceedings of E-Learn 2004 - World Conference on E-Learning in Corporate Government, Healthcare & Higher Education, Washington, 2004 (about to be published).

[Ma03] Magenheim, J: Demands on Digital Media in an Informatics Learning Lab – Medial Aspects of an interactive Learning Environment for Software Engineering. In: Proceedings of the 7th World Multi-Conference on Systemics, Cybernetics and Informatics SCI 2003, Orlando, 2003.

[MS04b] Magenheim, J.; Scheel, 0.; Integrating Learning Objects into an Open Learning Environment - Evaluation of Learning Processes in an Informatics Learning Lab. In: Proceedings of WWW 2004 - The Thirteenth International World Wide Web Conference, New York 2004. New York, 2004; pp. 450-451.

[Sp92] Spiro, R. J. e.a.: Cognitive flexibility, constructivism and hypertext: Random access instruction for advanced knowledge acquisition in ill-structured domains. In: Duffy, T.; Jonassen, D. (eds): Constructivism and the Technology of Instruction. Hillsale, NJ, Erlbaum, 1992.

[TH02] Tulodziecki, G.; Herzig, B.: Computer & Internet im Unterricht. Medienpädagogische Grundlagen und Beispiele. Cornelsen Scriptor, 2002.

[Va94] Cognition and Technology Group at Vanderbilt: Multimedia environments for enhancing student learning in mathematics. In: Vosniadou, S.; De Corte, E.; H. Mandl (eds): Technology based learning environments. Psychological and educational foundations. Berlin. Springer, 1994; pp. 167-173.