Integrating Learning Objects into an Open Learning Environment — Evaluation of Learning Processes in an Informatics Learning Lab

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ABSTRACT
The Didactics of Informatics research group at the University of Paderborn is involved in efforts to design implement and evaluate a web-based learning laboratory for informatics (ILL). The ILL mainly serves the purpose of an open interactive learning environment for software engineering. The poster presentation shows the main components of an ILL and the types of media that are used. A didactical concept, learning strategies and the efforts to create self-organizing learning communities in the ILL are also topics of the poster. Finally, an evaluation concept will be presented including some basic results of empirical research which was done during a seminar held in the summer term 2003.

Categories and Subject Descriptors: K.3.1
[**Computer Uses in Education**]: *Collaborative learning, Computer-assisted instruction*, *Distance learning*.

General Terms: Human Factors, Measurement.

Keywords
Informatics Learning Lab, Learning Objects, Deconstruction of Software, Computer-based exploration environment, Blended learning, Learning communities.

1. INTRODUCTION
Major tasks of the ILL are

- to offer students an interactive web-based multimedia exploration platform to enable constructivist types of blended learning at university.
- to create a forum of didactical open source materials for university courses and classroom work in informatics to which students, university staff, software developers, teachers and pre-service teachers may contribute.
- to construct learning objects and to investigate their integration and their use in self-organized learning processes in an open collaborative learning environment.

2. THE INFORMATICS LEARNING LAB
To meet the requirements listed above and to enable students to realize strategies of self-directed learning we need an interactive web-based learning environment. The design of the ILL demands to take care about the *didactical context* (models and roles of learners, the decision about objectives, the selection of content), the *organizational context* (methodical concept of the learning processes, the use and integration of media, the interaction inside and between learning groups, the creation of learning communities) and the *technical context* (learning platform, groupware content management software, digital media, individual data collection, assessment tools).

The Multimedia Exploration Environment of the ILL consists of several main components: content modules, learning objects related to the topics of computer science, software tools, and last but not least, groupware components which serve as elements of a learning platform. Digital media and documents (e.g. UML diagrams, source code, video clips of use cases) as well as learning objects in software related learning processes should students enable to get acquainted with the various aspects of product process relations of software development. They should also offer different views on the product as well as on the designing and developing process.

Up to now, three content modules have been developed: a small merchandise management and control system that represents the socio-technical information system of a kiosk, a flexible automated storekeeping system with a high rack storage area for media products that will be supplied with boxes by autonomous automated fork-lift trucks and a strategy game. Further on, we will refer to the storekeeping module.
The content module of the flexible automated storekeeping system e.g. consists of a Lego-mind storms model of a high rack storekeeping system (HRSA) with autonomous transportation units. It also offers html-documents which contains embedded video-sequences and animations of the fork-lift-truck movements as well as of the communication system between the autonomous units. In addition to that, students will be provided with information about communication protocols, technical control of the autonomous units, the class and object structure of the storekeeping system and the interaction between hardware, software and mechanics of the system, called mechatronics. At present, the ILL is based on the sTEAM (structuring information in a team) groupware which is developed in the department of computer science at the University of Paderborn

Summarizing these different aspects of learning designs used in an ILL we have to state that the ILL may be considered as an explorative open learning environment.

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3. LEARNING OBJECTS IN THE ILL

To support self-directed learning in addition to the content modules the multi-media exploration environment of the ILL includes different learning objects (LO) with general information about computer science and didactics of informatics as well as special topic-related information units. Learning objects are digital media which partially might be classified as educational software, because they include instructional elements [1].

For the storekeeping scenario the following learning objects are developed: mindstorms brick driven autonomous fork lift trucks as embedded systems, guided exploration of specific technical aspects of the storekeeping system, analysis of communication protocols for the technical data exchange between two bricks, interaction and exchange interface between the different software layers running on the mindstorms brick (Java Code, Byte Code, binary file, firmware, BIOS).

4. PHASES OF LEARNING IN THE ILL

The learning phases for the high storage area content module are:

- 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),
- Co-operative 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.

5. EVALUATION

The basic concept of the ILL was subject of a first evaluation during a course at the University of Paderborn in summer 2003. The course was organized as a presence seminar with weekly meetings. Students also had access to our sTEAM groupware with the multimedia elements to be explored.

The evaluation concept we used is close to the grounded theory from Glaser and Strauss [2]. Its components are initial questionnaires, group discussions, screen videos, a guideline oriented interview, product analyses and also the observation of the students' activities. The main results of the empirical study are:

Most students have already had contact with multi-media based learning material before, but not with material considering the concept of learning by example. Though they had a basic understanding of design patterns and process models of software development they did not have much experience with these concepts. There were positive expectations concerning both, the training in computer science and the transferability of the HRSA to school lessons in informatics. Only if the real Lego model was absent the students regarded the multimedia simulations of the model as necessary. They could also be helpful in the case that complex processes need to be simplified or important information need to be stressed extraordinarily.

After having finished the seminar, the students still rated the quality of the seminar as good in regard to the didactical education and the scientific training in computer science. But they were more critical towards a possible transfer of content and methods into class room work. Half of the students regarded the HRSA in the existing stage of expansion as too complex. The estimation of the methodical concept and the layout of the seminar were in general highly positive. Especially the method of guided exploration was mentioned as helpful. The range of computer science related problems presented in the learning scenarios was denoted as sufficient. Students mainly used the three dimensional Lego Model itself and static drawing encoding (UML diagrams) to gain an overview of the system's components and functionality. In addition, transfer of knowledge happened on the symbolic static encoding level (source code), especially when they went into details of source code construction for the commissioning unit. The tasks of the open and closed learning objects proved themselves as supportive in processes of students' acquirement of knowledge. The animations included in the learning objects which showed some workflow processes of the HRSA were not completely used by the students. Advanced students used class diagrams for orientation in the source code, whereas students with small experience rather searched unsystematically in the Java source code documents. These differences influenced their abilities of analysing the system. The students tended to integrate parts of source code they found in the rack example into their own java source code by 'cut and paste' instead of adapting whole software components. At the end of the seminar the commissioning unit operated well, except for inferior functionalities. One of the seminar's main goals was achieved.

6. CONCLUSIONS

The didactical concept of the ILL and the use of learning objects and digital media by the students proved on the whole to be an appropriate method of learning. Students were highly motivated and reached most of the learning objectives of the course. Nevertheless, more information about the way of constructing and using learning objects should be acquired.

7. REFERENCES

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