e-Learning has survived a number of phases: the initial tentative fully on-line courses: the dot.com hype that e-Learning was going to result in a ‘shake out’ of learning providers, and result in a small number of global giants, making huge profits; and the inevitable disillusionment that followed. And where are we now? We are now in a typical new technology consolidation phase, in which the financial hype is discarded, and the serious players in the business - of teaching and learning – are focusing on the value of e-Learning, and consolidating its basic building blocks. The key value that the “e” adds to learning is networked, interactive, collaborative learning. And the key building block is the Learning Object.

Learning Objects, like the rest of “Internet” education, have gone through a similar new technology growth cycle. First it was thought that Learning Objects would provide the financial holy grail for university administrators – the first fully commoditised learning packages, that could not only be exchanged across courses, institutions and countries, but could be rearranged in any way you liked: a global currency of global ‘intellectual capital’.

That too has passed. Learning Objects are very useful, but they are generally not that exchangeable, and they have to be re-versioned, if not re-designed even for similar courses. They also can’t just be added together, and expected to make up a ‘course’ – a lot more thought needs to go into how courses are designed, and what kinds of learning objects are best suited to what kinds of teaching and learning tasks. We might usefully differentiate between Discussion, Information, Skills, Research, and Assessment Learning Objects. And above all, as Stephen Downes says, doing e-Learning is much more like conducting an orchestra than managing a linear process – good e-Learning should take advantage of the flexibility of Learning Objects and networked interaction; it should expect the unexpected, and welcome it; it should be far more like a participatory workshop of peers than a formal induction into predetermined ways of thinking and applying ideas by ‘experts’.

So the challenge is to make Learning Objects work – primarily for teaching and learning. Adams et al provide an interesting application of the principles of collaborative (paired) learning to the design and development of Assessment Learning Objects, applying peer-review, and just-in-time learning, with rapid, interactive feedback. Schneider discusses ways in which assessment in a virtual university environment can be achieved at scale, using sophisticated testing techniques. Stav et al discuss the detailed design and application issues in what is the heart of Learning Object systems design and management – the management of Learning Objects using metadata formats, which provide powerful ways to categorise Learning Objects not by their content, but by their use, within a learning context. This still has a way to go, and various formats are discussed. But it heralds a possible revolution in the way in which learning and teaching repositories are structured. Tavangarian et al explore one of the consequences of ‘commoditised’ learning tendencies, namely that the learner becomes homogenised. They also pick up
on the metadata issues, and emphasise that “XML based document description languages have been proven tools for a time to achieve reusability and media independence of learning materials” They operationalise these ideas in their Multidimensional Learning Objects and Modular Lectures Markup Language or “ML³”, (“em-el-three”), which enables them to the create learner specific documents. Tsalapatas et al discuss a e-content management platform, for the publication and management of educational content, which provides services for all user groups, specifically for asynchronous e-Learning process. Vossen and Westerkamp report on their experience in providing e-Learning facilities via the growing platform of web services. They too, like Adams et al, apply the principles of modular Learning Objects to break down the “central functionalities of an e-Learning system”into several stand-alone applications, which can then be accessed as Web services. This allows learners to access, compile, and navigate through a variety of resources, to construct their own learning path.

These papers explore some of the key issues in both the potential benefits and pitfalls of an object-oriented approach to learning design and development. As I said above, we are now in the painstaking consolidation phase – there are clearly solid, useful, tools and frameworks here, which will contribute to the consolidation and further development of e-Learning.

Roy Williams
Editor.
ECMS: Educational Contest Management System for Selecting Elite Students

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Abstract: Selecting elite students out of a huge collective is a difficult task. The main problem is to provide automated processes to reduce human work. ECMS (Educational Contest Management System) is an online tool approach to help - fully or partly automated - with the task of selecting such elite students out of a mass of candidates. International tests like the PISA study revealed the need for such new methods in extracting better students out of collectives and to offer new online based tools for knowledge gaining processes.

Keywords: ECMS; Educational Contest Management System; Elite Students; PISA Study; LMS (Learning Management System); e-Learning; Test & Assessment Tools

1. Introduction

The problem of selecting elite students out of a collective is the need of massive human resources to organize and operate such a process. Automating these processes is an essential task to reduce time and human efforts. The need for such tool applications increased after several statistical studies and publications like the PISA Study (Stanat 2000; OECD 2004a). Since the national results of the PISA Study (OECD 2004b) have been a shocking event, a widespread discussion broke out about how to solve such educational problems and what tools would be necessary to teach and test scholars and students more efficiently.

Unlike many existing test and assessment tools (TA) or LMS (Learning Management Systems) - like the Blackboard Learning System (Blackboard 2004), ILIAS (ILIAS 2004), Moodle (Moodle 2004), Claroline (Claroline 2004), LRN (Bartle 2002; MIT Sloan 2002) or the Whiteboard Courseware System (Whiteboard 2004) - the introduced ECMS (Educational Contest Management System) provides not only an e-Learning platform. It also gives opportunities to offer simple multiple-choice tests and homework problems (Schneider 2004a). An essential part of ECMS is the semester-based structure of exams to be sat by the students. This allows for the scenario that not all students will pass each semester (exam) and join the next semester (exam). ECMS is now developed as version 2.0 and is integrated into the Universitas Virtualis (Virtual University Environment) project (Schneider 2004b). A previous version of ECMS 1.0 ("The Reverse-Engineering-Academy (REA)") (REA 2002; Schneider 2004b) - with focus on software-protection (SP) and Reverse Code Engineering (RCE) - shows the success of the ECMS sieving process in the time range of a long-time survey of 2 1/2 years using very hard problems increasing in difficulty (see section (III)). The ECMS has its own connection to the Universitas Virtualis Bibliotheca Server (Schneider 2004c) which uses GDL 4.0 (Ganesha Digital Library Project) (Fahmi 2004) as its core platform and provides additional access to learning material and ECMS related publications.

2. System description

ECMS is based on MySQL 4.0 and PHP 4.3.0. It is not dependent on third-party packages and can be installed easily on local machines or any servers using the Apache Webserver System (Behlendorf 2004). The ECMS can be accessed via standard web-browsers (See figure (2)). Figure (1) shows the UML layout of the database scheme.
As a basic principle ECMS is capable of offering an unlimited mixture of multiple choice tests and homework. It is therefore open for any type of exam content. ECMS 2.0 currently offers a free and anonymous registration process for students, which is capable of extension and cross-link to third-party authorisation systems. Students have access to multiple provided course material which can be attached as original file (e.g. .doc or .pdf) or as a package file (e.g. .zip or .tar.gz) by the exam moderator. To prevent students from being non-active after the registration process, ECMS automatically bans all students not finishing the first exam after 30 days and deactivates the account to prevent re-registration with the same userdata. The current grading and ranking table can be viewed by every registered student. The ECMS can only be used by registered students using an self-set password. Extending ECMS to accept additional user registration data or using a different password system is made easy and there is an option to adapt the system for individual needs.

To give granted access to the administration and moderation area, ECMS uses a simple but effective security concept using .htaccess and .htpasswd files. Adapting the administration authentication process to database driven variants can be done quickly and easily.

### Figure 1: UML Diagram of the ECMS database scheme

### Figure 2: The ECMS Web-Frontend offering a multiple choice test.

#### 2.1 Multiple choice exam layout

The core of each Multiple Choice Exam is the XML based template which definition can be seen in figure (3). The template defines the name and a description for each given exam to add additional information about the topic or similar. `<MINCORRECT>` defines the minimum number of correct answers to pass the exam. Failing the exam will result in an overview page.
showing which answers had been wrong but without any information about what was wrong. ECMS protects itself against cheating via history- back-button brute force attacks. 

<TRIALS> defines the maximum tries which are allowed for the student. Exceeding the maximum number will lead into automated failure and results in automated banning from ECMS. After the general exam information each multiple-choice question is defined by <TESTITEM> and a unique identifying id. Using these id's ECMS can build dynamic forms for the web front-end. Each test item consists of several node informations. <QUESTION> contains the question the student will be asked. <ITEM> defines over unique id's the possible pre-set answers of the student. To identify the correct answer the <CORRECT> tag connects to the corresponding <ITEM> id. The XML structure gives the possibility to add unlimited questions to each exam. The XML is stored in the database and will be loaded dynamically with each form called by the student. <ATTACHEDFILE> defines using id an unlimited number of attached files of non-restricted formats (.pdf, .zip, .doc,) which can for example contain files with courseware or lectures. To offer additional information the <ATTACHEDIMAGE> tag contains a link to attached images related to the exam.

```xml
<TEST>
  <NAME>File Knowledge Exam</NAME>
  <DESCRIPTION>
    This exam contains questions about...
  </DESCRIPTION>
  <MINCORRECT>8</MINCORRECT>
  <TRIALS>6</TRIALS>
  <TESTITEM id="1">
    <Q>
      <QUESTION>
        How many sections can...
      </QUESTION>
      <ATTACHEDFILE id="1">
        courseware1.zip
      </ATTACHEDFILE>
      <ATTACHEDIMAGE id="1">
        question1.gif
      </ATTACHEDIMAGE>
      <CORRECT>2</CORRECT>
      <ITEM id="1">4,294,967,295</ITEM>
      <ITEM id="2">65,535</ITEM>
    </Q>
  </TESTITEM>
</TEST>
```

Figure 3: XML template for multiple choice exams.

### 2.2 Homework system

The homework feature consists of giving the student the problem and needed material which may be needed to solve the problem. The solution will be uploaded by the student and can be accessed by the administrators and moderators in the administration area of ECMS. Homework will be checked manually by any moderator registered. Since each homework is correlated to one exam constructor (moderator) an automated mail information will be send to the moderator about the new incoming homework. If the homework fails, the moderator marks the homework as failed and uses the ECMS mail functionality to tell the student why the solution had been denied. To accept the solution the moderator clicks the hyperlink "upgrade" and the student will be automatically set one exam higher including an automated mail about the accepted status of the solution. Denying a homework will activate the same process with difference that the moderator can enter the reason of the negative answer. Since students can not be banned automated within the homework process, the moderator has the option to ban and unban the student from ECMS directly. The number of failures is stored in the database and is shown to the moderator.
2.3 Gathering of elite students via statistical functions

ECMS 2.0 offers an extendable possibility for evaluating the running sieving progress. Since all data is collected in the main ECMS database, statistics can be easily extracted from it. Possible evaluation modules can contain histograms, scatter-plots or other statistical related methods. From such statistical methods the contest manager can gain an overview on how the progress of the contest and the exams is and may react on the problems occurring with the exam contents.

3. Evaluation and results of ECMS 1.0

ECMS 1.0 was first introduced in 2002. It’s exams were focused on software-protection, cryptography and Reverse Code Engineering (RCE) topics. ECMS 1.0 included 19 main exams which had been all declared as homeworks. Additionally there had been 10 correlated homeworks to improve the student knowledge. Another 39 exams with topics mathematics and cryptography had been added as fun part to give students more tasks to solve. Solving these 39+10 exams had no influence on the sieving process. ECMS 1.0 gave the possibility to register anonymous via an existing e-mail account and an username. After 2 years of running the system counted 6361 registered students in the ECMS system. The automated sieving process lead via auto-ban functionality in banning 4998 students who had not been able to solve the first main exam within 30 days. Therefore 78.57% of the students failed the first main exam. The rest of 1352 (21.25%) students were capable of solving the first main exam within the 30 days limit. From the remaining 1352 students only 9 students had been able to solve all 19 main exams. This is 0.14% of the registered 6361 students and 0.67% of the 1352 active students. The average solving time of all exams was a 3/4 year. The set of increasing difficulties was well chosen for the contest focus (See figure (4) and table (1)).

Figure 4: Statistics of the sieving process during 19 exams.

Table 1 shows the statistics of the sieving process during 19 exams including percentage of total registered students and of students passing exam number 1.

Table 1: Sieving process statistics

<table>
<thead>
<tr>
<th>Exam-Level</th>
<th>No. of Students</th>
<th>% of total</th>
<th>% of after exam 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>9</td>
<td>0.14</td>
<td>0.67</td>
</tr>
<tr>
<td>18</td>
<td>21</td>
<td>0.33</td>
<td>1.55</td>
</tr>
<tr>
<td>17</td>
<td>32</td>
<td>0.50</td>
<td>2.37</td>
</tr>
<tr>
<td>16</td>
<td>44</td>
<td>0.69</td>
<td>3.25</td>
</tr>
<tr>
<td>15</td>
<td>45</td>
<td>0.71</td>
<td>3.33</td>
</tr>
<tr>
<td>14</td>
<td>60</td>
<td>0.94</td>
<td>4.44</td>
</tr>
<tr>
<td>13</td>
<td>83</td>
<td>1.30</td>
<td>6.14</td>
</tr>
<tr>
<td>12</td>
<td>93</td>
<td>1.46</td>
<td>6.88</td>
</tr>
<tr>
<td>11</td>
<td>96</td>
<td>1.51</td>
<td>7.10</td>
</tr>
<tr>
<td>10</td>
<td>113</td>
<td>1.78</td>
<td>8.36</td>
</tr>
<tr>
<td>9</td>
<td>150</td>
<td>2.36</td>
<td>11.09</td>
</tr>
<tr>
<td>8</td>
<td>155</td>
<td>2.44</td>
<td>11.46</td>
</tr>
<tr>
<td>7</td>
<td>162</td>
<td>2.55</td>
<td>11.98</td>
</tr>
</tbody>
</table>

4. Possible Scenarios

There are many scenarios possible for using an ECMS. One field is the company aspect where companies try to evaluate the knowledge of their employees or to offer pre-selection tests for new employees. Another aspect is the university aspect, which offers capabilities to pre-select new tutors or employees. Additional the ECMS can be used for special educational tasks, like supporting
students in self-testing their knowledge in bioinformatics, medicine, law or economy. ECMS can be used for scholars as well. One example are school-contests containing math-contests or similar.

5. Conclusions and future work

ECMS differs from existing e-Learning, test & assessment tools. As difference to common e-Learning solution ECMS is not thought only for educational purposes. It is correlated to a sieving process for the gathering of elite students out of a huge collective. Future Improvements of ECMS will include time limits for each exam. Next there will be support for automated exclusion of students after failing n homework. Additional the support for displaying LATEX2edocuments including LATEX- and LATEX2e-style formulas should be included within future work. Enhanced statistical functionalities for better automated processes is a necessity. Counting wrong given answers will be included. A library containing multiple choice tests and homework with sorted difficulty have to be build. The average solving time for all 19 main exams described in section (III) was fast for the given software-protection, cryptography and Reverse Code Engineering (RCE) topics. For other topics like algorithms in bioinformatics, exams in medicine or math exams there should be a careful preselection of the used exams to prevent long sieving times. To protect the multiple choice tests from brute forcing attacks a randomisation of questions should be implemented.

6. Acknowledgments

This work, including access to the data and technical assistance, has been supported by the Universitas Virtualis (Virtual University Environment) project. Our special thanks for longtime support goes to "Pegasus" who administrated the ECMS 1.0 for over 1 year. Last we want to thank the software-protectionists and Reverse Code Engineering (RCE) community who joined ECMS 1.0 so numerous.

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Open, Dynamic Content and e-Learning Management Infrastructure for Engineering and Natural Sciences

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Abstract: NS-eCMS is developing an open web-based content management, communication, and collaboration eLearning platform that addresses the specialized requirements for distance education in natural sciences. The federated architecture enables straightforward development, exchange, and publication of material through open standards like XML/MathML. The system will provide an open communication platform for dynamical information exchange and management in a pedagogical framework. Time effective communication during the educational process for undergraduate learners and under-graduate academic institutions, is obtained by exploring new interfaces as light pens and electronic blackboards.

Keywords: distance education, e-Learning, content management, learning management, mathematics, physics, natural sciences, engineering, XML, MathML,

1. Introduction

Distance education programs on natural sciences combining asynchronous e-Learning with synchronous AV-learning have been used with success in recent years. Universities use new developments such as live-sized multi-point videoconferencing over IP with integrated AV and data environments, such as shared applications and Smartboard technology, with great success to incorporate distance learning into their ordinary on-campus programs (sebra 2003). However, although both asynchronous e-Learning overcomes geographical and temporal constraints transforming learning into a process that can occur at the independently determined convenience of instructor and learner (Harris D., DiPabolo A., Goodmann J., 1994), asynchronous e-Learning is recently being used as a complementary educational tool in traditional classroom education (e-Learning 2001), demand has been developing for asynchronous and synchronous authoring, presentation, and collaboration tools that promote use of standard mathematical and scientific notation. The Xmath project (Xmath 2001) was one of the first projects addressing such topics in mathematical education. Such tools must overcome the increased requirements for time-effective and interactive communication during the educational process enabling efficient interaction among administrators, educators, learners, and researchers through the exchange of media rich documents containing information in a standard format. The typical content of such documents are text based material supported with formulas, graphs, sketches, animations, (interactive) simulations and support for online calculation through Computer Algebra Systems (CAS) in sophisticated combinations.

Vendors of Commercial e-Learning Distance Learning Platforms have not supported dynamic representation of standard mathematical and scientific notation because distance learning on most generic subjects have not required it. On the other hand, lack of standard mathematical and scientific notation and simple integration of, for instance sketches and drawings that are imperative, have limited the utility of distance learning whenever there is a strong technical component in the educational material.

Engineering educational programs at graduate level use a wealth of new, advanced, and standalone scientific calculation and construction tools, while typically many students at the undergraduate level hesitate to use advanced software tools due to time limitations related to heavy academic schedules and a limited number of available computers at the universities. During the last couple of years have several advanced commercial CAS introduced web-based learning alternatives. The last version of the scientific calculation tool Maple (Maple 2003) offers for instance mechanisms for direct publication of scientific content on Web. Such advanced calculation tools have traditionally been tailored to a large extent to research oriented development at a graduate or higher level, and they use as a rule their own information representation. The existing solutions are characterized by lack of integration with a learning and/or content management infrastructure, whereby these systems work best as standalone courseware
management tools for scientific computations. As a result, CAS constitute useful tools but not complete solutions for undergraduate distance learning programs in natural sciences.

Commercial Courseware Management Systems (CCMS) have during the last year evolved significantly through the emerging open XML standard. CCMS such as Blackboard® (Blackboard 2003) and WebCT (WebCT 2003) will soon integrate MapleNET (MapleNET 2003, sebra 2003) content ranging from links to fully integrated features through dedicated windows applications like Maplets. Open courseware and MapleTA (Maple 2003), a web-based assessment system, are expected to work similarly. WebMathematica (Wolfram 2003) supports the addition of interactive calculations and visualization to a website by integrating Mathematica, the world leading competitor to Maple, with the latest web server technology and server based computation. These CCMS claim at the "shipping level" to address a range of explorative working methods by providing web extensions for the use of standard mathematical and scientific notation, the inclusion of scientific calculation tools, and Open courseware delivery.

However, there are several unsolved questions for their appropriateness to natural science education in general and to the usefulness and importance of such tools in distance teaching at undergraduate level in particular. It is for instance not quite clear how numerous standalone scientific calculation and construction tools, which indeed uses their own information representation, are going to interfere with the open XML standard for information representation, including delivery, exchange, up- and downloading of documents. Of particular interest are the new frameworks for separation of concerns and component-based web development.

It becomes apparent that institutions in Europe have been often forced to use unsuited tools and web solutions in an effort to upgrade content that contains natural sciences and engineering components. This practice highlights the need for an educational service for natural sciences that addresses all aspects of the educational process from entering media rich data in a time efficient way for both learners, teachers and tutors, including mathematical formulas, graphs and sketches/drawings into the system, educational content management, exchange and retrieval of learning material through international standard formats, inclusion of scientific computations, and learner knowledge assessment. Standardization and system interoperability with present and forthcoming e-Learning portal initiatives, and existing Learning Management infrastructures, are desired.

The NS-eCMS project, which is partly founded by the Socrates–Minerva programme in the period 2003-2005, is designing and implementing an open web-based content management, communication, and collaboration e-Learning service that addresses the specialized requirements for distributed distance education in natural sciences. The system will be an extension of the existing web based eCMS federated content managements system for support of distributed teaching, founded by the European Commission’s Minerva-Socrates program in the period 2001-2003. Media rich content management will be achieved through a federated architecture enabling straightforward development, exchange and publication using international standards, specifically XML and MathML. The proposed infrastructure will support the integration and interaction with mathematical tools for the execution of computations. Additional user interfaces, e.g. light pens and electronic blackboards that facilitate time efficient interaction with the system for various user groups, will be explored.

The proposed system will mainly benefit undergraduate learners and undergraduate academic institutions involved in natural science teaching/instruction by providing services that addresses the entire educational process in natural sciences, from information exchange to information management.

2. The basic features of the NS-eCMS infrastructure

The 5 partner institutions in the project (NS-eCMS 2003) have complementary experiences from net based learning activities at university level, as well as from national and international collaboration. From previous projects the partners knew that joint ventures between traditional universities and net-based collaboration, are possible at national and at limited international levels. The current project aims at extending these activities to a Pan-European level, establishing it with a true European dimension. Concentration of the content to natural science related services implies an implicit contribution to the ICT
literacy and exploitation of technology and services adopted to technical education and amongst the general public. The dissemination is going to focus on joint efforts and collaboration to create a European network for higher technical and scientific education, applying experiences and findings from this and previous work.

NS-eCMS aims at supporting distance learning of undergraduate learners by providing an open communication platform for dynamical information exchange and management in a pedagogical framework. The communication system (Stav J. B. and Tsalapatas H 2004) handles rich multimedia content and offers interfaces containing tools for online execution of computations, plotting, online examinations, and tests. The system supports time efficient interaction through light pens, electronic blackboards, tablet PCs, etc. Mathematical objects are exchangeable from the web interface to MathML standardized supporting tools and editors.

Component based web development involve four concern areas for a successful web-presentation, i.e. production of content using open standards like XML, inclusion of external calculation tools through application logic, design of various presentation styles which easily could be adapted for various web-environments, and presentation of the complete learning material on web. Such a selection will remove the historical troublesome contract between application logic and presentation (Apache Cocon 2003).

Figure 2 displays how MathML standardized web output can be transferred from the web page into a MathML supporting editor. For instance might a web-page provide an advanced calculator (CAS systems) giving the results in standardized MathML format. Mathematical interactive tests can through MapleTA be provided online with automatic grading of results. The teacher submits and exchange content with the eCMS system through a standardized format. The student will interact with course modules which might interact with various services like MapleNET, MapleTA, eCMS etc.

Figure 2: Basic overview of the NS-eCMS functionality, and the location of the previous eCMS system.

Use of XML based technology ensures that the course material, i.e. learning objects, might be adapted to future needs, as XML is well adapted for database transformations to new standards. This includes for instance simple adjustment to new ICT solutions that will emerge and new design of web pages and course management systems. A knowledge base containing XML documents might be recycled into new presentations by using XSL transformations (XSLT).

The main outcome is going to be services offering time efficient mechanisms for communication in distributed distance teaching of natural sciences. The services and system will be evaluated through user trials and courses. Feedback from internal and external groups of students will evaluate the quality and relevance of the services.

3. Objectives for the NS-eCMS services

The project vision is the design and development of an adapted open web-based content management, communication, and collaboration infrastructure for the support of eLearning of natural sciences, which will make these fields more attractive to a broader
undergraduate student population. The infrastructure to be developed is going to address all aspects of the learning process on natural sciences from introducing information into the system, including dynamical representation of mathematical formulas and easy implementation of hand made sketches/drawings, which are imperative in natural sciences. Moreover, the dedicated infrastructure will contain features for managing the educational content, facilitating the educational process through effective communication and collaboration, executing computations on-line, and assessing learner knowledge through exercises, tests and examinations.

The specific objectives of the system are

- Single point of access to possibly distributed content and services including compatibility with present or forthcoming eLearning initiatives, for administrators, learners and content providers.
- Efficient educational content management, emphasizing use of standard mathematical formalism in natural sciences and internal information representation using open standards like XML and MathML.
- Flexible internal representation of content (XML and MathML) that can be transformed to several existing and forthcoming formats. User interfaces enabling easy introduction of elements related to the teaching of natural sciences, including mathematical formulas, graphs and sketches/drawings, into the system. Multiple interaction methods will be explored, including web technology, light pens, electronic blackboards and digital document cameras.
- Integration of mathematical software tools (CAS servers) for on-line execution of computations and visualization of results, and integration of legacy code developed at the participating institutions will be explored as proof of concept.
- Minimal requirements for installation of client tools. Services for the support of cheap online web-solutions for large groups of learners based on the above-mentioned infrastructure. Services to be implemented include on-line learner assessment through examinations and exercises.
- Efficient collaboration and communication that facilitates the learning process through asynchronous tools (chat-rooms, forums, collaborative space sharing) and synchronous applications as video-conferencing through desktop units.
- Online structured course development and editing. Organized state of the art educational content for natural sciences that takes advantage of the proposed infrastructure and MathML for effective information presentation.
- Autonomy of providers through distribution of material and metadata descriptions.

4. Envisaged results and outputs

The project aims at a federated, distributed organization of content provided by educational institutions across Europe. The challenge is going to be to cover all aspects of the eLearning process in those fields, from the introduction of information into the system, to the management of the information (publication, dissemination, discovery, retrieval, presentation, indexing, etc), to the execution of computations required by the educational process. This infrastructure will ensure autonomy to content contributors and it will be transparent to learners, who will have access to the system, services, and content through a single point.

Specifically, the following outputs are envisaged

- The adaptation of an existing eCMS content management infrastructure
- Development of a limited amount of educational content material for natural sciences by using international standards, specifically XML and MathML, and implementation of MapleNet. MathML will be used for the internal representation of mathematical formulas to ensure compatibility with other (forthcoming) initiatives and tools.
- A straightforward user interface enabling easy introduction of elements related to the teaching of natural sciences, including mathematical formulas, graphs, and sketches/drawings, into the system.
- Assessment tools and services
- Reports on system design, implementation and evaluation.
- The above will result into a repository of services and content for eLearning on natural sciences. Access to the repository will be provided through a single-point of access portal. New developments will be achieved through open-source tools to
ensure cost effectiveness in the mass deployment of the services. Figure 3 outlines a high level overview of the NS-eCMS system and services to be developed. The existing eCMS infrastructure (Tsalapata H., Stav J., Brna P., Kalantzis C., 2003), which will be adapted and extended with new services for the needs of this project, is displayed on figure 1. Additional information can be found which provide more details and key features of eCMS services can be found in the eCMS Design and Implementation Reports (Tsalapata H., Brna P., Stav J., Tsalapata H., Kalantzis C., Brna P., Stav J., 2003). The existing eCMS metadata and content repositories will be redesigned to take advantage of XML and MathML technology. Furthermore, the examinations databases and services will be upgraded to support MathML as well as random question generation. The statistics database will be updated to hold and analyse additional information as necessary. Additional services and interfaces will be implemented as displayed.

Figure 3: The NS-eCMS system architecture

Users are going to interact with the NS-eCMS Content Learning Management services through a web-based interface providing customized library views targeting the needs of learners, content providers, course managers, and repository administrators.

The integrated metadata scheme take into account earlier work in this area (The Dublin Core, (ETB), (Learning Technology Standards Committee 2000), (Nikolaou C., Georgakopoulos G., Tsalapatas H., 2000) and (eCMS 2001).

5. Pedagogical and didactical approaches in natural sciences

Teaching of natural sciences have - more or less independently of ICT developments - always called attention to a wider context of the educational process by maintaining two crucial topics:

- To train students in logical and abstract thinking
- To build up physical comprehension by applying mathematical knowledge to all types of natural sciences and engineering fields.

However, advanced scientific calculation and constructions tools have been developed over the last few years. They easily do tedious work calculations in a second and extend continuously the physical limits and barriers of complex problem solving in research. They have in a sense have achieved status as “generic public property” in engineering and natural science education at higher university level.

Nevertheless, from a historical point of view have students usually obtained a significant part of such qualifications and experience by doing a tremendous amount of (tedious) work, exercises, and projects by hand in order to drill use of exact notation and unambiguous communication which are generic for natural sciences. In the academic communities, lessons on traditional blackboards and various amounts of deep and/or formal exercise solving on paper, partly through the help of calculators and computers, are still going to be important basic components in the daily life for an undergraduate student in the forthcoming years. Both these old European traditions, which call attention to a wider context of the educational process than the final examination, and the natural requirements for exact and unambiguous communication are going to be the premise provider for the pedagogical goals of successful distance eLearning goals of programs of natural sciences. The communication and collaboration environment proposed in this project would address these challenges more effectively than existing solutions.

The project is not primarily aimed at development of new pedagogical and didactical models. It will instead use existing models for learning environment tools used in ODL which usually provide four main areas, presentation/lecture area, working area, knowledge-area and private area (Haugen H., Ask B. and Hjeltnes T., 2002), and direct its actions more towards the organisation dynamics that apply for previously obtained results in natural sciences, i.e. by establishing bridges between the old teaching traditions and the new flexible interactive features. The project intends to turn the student into a “player” with dynamical natural science expressions, rather that he should act as passive viewer. It should as well at the same
time stimulate the teacher to act more as an instructor that has the ability to monitor students working though the distance learning services in a host of new ways, i.e. through various mechanisms connected with student-student, student-teacher, and teacher-teacher communication. Services that support learners, teachers, and course organizers to retrieve previous course material, structure new educational material, and deliver high quality communication support (assessment, feedback, discussions, and course management) are going to be of particular interest of those pursuing eLearning of natural sciences. State of the art methods and systems will be applied, in line with the experiences at the partner institutions. Special attention must be given to stable and scalable uploading and downloading of content, which should be represented in a standard format, selection of time efficient formula editors and online distribution through high quality videoconferencing in distance teaching.

In the present situation the main tools for large number of undergraduate students still consist of writing their solutions on ordinary paper, partly by some help from calculators. One of the main outcomes of the proposed system is going to be the design and implementation of a sensible adapted communication and collaboration distance learning environment, which will greatly enhance undergraduate students possibilities for writing digital solutions of for instance their exercises or project work using standard mathematical and scientific notation in an easy and time-effective way at any time and at any place. Although the system should tolerate a range of explorative ways of working, only a limited number of digital sources adapted to the special needs of the targeted group, are going to be available in order to lower the user threshold to an absolute minimum. This includes interfaces for light-pens, electronic blackboards, digital document cameras, exchange of multimedia rich content, accessing of a limited amount of functionalities from advanced Computer Algebra Systems, online assessments, etc. Furthermore, an effective distance learning educational program at the undergraduate level, which contains a "very smooth and adapted" introduction to Computer Algebra Systems, definitely promotes and simplifies the use of the standalone Computer Algebra Systems at the graduate or higher level. Content management is an essential ingredient to the delivery of these user-oriented services in a pedagogical framework, which supports learners, teachers, and course organizers to retrieve previous course material, structure new educational material and deliver high quality communication support (assessment, feedback, discussion, and course management) for the benefit of those pursuing eLearning. The work program is designed to provide state of the art management services which have been developed with the end users in mind. Thus, the focus of the work emphasizes delivery via easily available current technologies for the delivery of various mechanisms connected with student-student, student-teacher, and teacher-teacher communication.

6. Proposed design of natural science course modules

Each course is supposed to consist of several modules where the content actually are produced by using a range of different digital sources, including the possibility of using high quality videoconferencing and application sharing in distance educational courses. It is expected that each module might contain a wealth of different types of course material as lecture notes (from digital blackboards), resumes, examples, calculations, training exercises, compulsory exercises, interactive animations and simulations, video, etc. The system is designed in such a way that previous developed material is stored in a similar manner as the online production of material during the course lectures. It is expected that the natural science learning material at least is grouped together into 5 classes consisting of:
- Different types of online material from the lectures
- Pre developed course material in form of learning objects
- Different types of exercises
- Different types of self tests and evaluations
- Portfolio assessment

It is also desirable to use the natural science learning modules in combination with new real time collaboration technologies and audio-video-data learning environments. This includes both asynchronous and synchronous communication services such as streaming video, use of technology transparent studios with integrated AV and shared data environments (documents, whiteboards, high quality multi point fluid video and crisp audio solutions on H264 etc.), and remotely managed virtual conferencing services over reliable networks.

Figure 4 displays the dependence of the different technologies in an interactive natural
of obtaining time efficient distance teaching processes. Topics included are organization, publication, delivery, internal information representation through emerging open standards such as XML/MathML, course development, user-friendly and dynamic interfaces for submitting and reviewing technical multimedia rich content such as server based interactive simulations, integration of scientific calculation tools, on-line self-assessment / examinations etc. Currently, no comprehensive services that address the above issues in a user-friendly manner tailored to undergraduate- and graduate higher education students exist.

The NS-eCMS project proposes an infrastructure and services for the mass deployment of eLearning initiatives in natural sciences. While the project does not aim to change the traditional educational processes of academic institutions in those fields, it is expected to have a positive impact in the eLearning processes by facilitating close collaboration and more time-efficient communication between learners and instructors by enabling the efficient exchange of media rich content, which currently is addressed inadequately by available tools. Rather than altering educational processes, the above two aspects of the proposed solution are expected to make on-line initiatives more effective and promote the launch of new eLearning programs where none exist due to the lack of effective and cost efficient solutions.

A comprehensive platform service does not yet exist with a number of desirable pedagogical characteristics adapted to the needs of natural sciences. Such characteristics include: (i) user-friendly interfaces for the organization, submission and retrieval of documents containing scientific and mathematical formulas (ii) dynamic presentation of such formulas through MathML (iii) flexible internal information representation through standards that ensure portability of content between commercial and open source tools (iv) effective synchronous and asynchronous collaboration tools (v) inclusion of scientific computations (vi) effective presentation of problem solutions (vii) minimum requirements for installation of client tools on behalf of the user (ideally no requirements except of the use of an Internet browser) (viii) real-time information presentation through high quality multipoint videoconferencing (ix) inclusion of virtual laboratories (x) cost and time effectiveness for the deployment to a large number of learners (xi) easy administration.

7. Pedagogical characteristics of the services

A wealth of distance education infrastructures, including tools for content development and delivery, have been developed over the last few years aiming to overcome geographical and temporal constraints in the learning process. Such tools include content publication mechanisms, course development tools and course delivery systems including virtual classroom functionality and collaboration. However, existing commercial as well as open source tools for eLearning management focus on the delivery of course on generic topics while at the same time they lack key functionality and infrastructure for supporting time efficient communication in the eLearning process in natural sciences.

Faculty time is a limited resource and online teaching increases the workload and take time from research. Many universities and professors demand interactive facilities, not complex distance teaching services that are “killing the instructor.” This community, which includes students, educators, and information managers, will benefit from services that address the needs
8. Implementation considerations

The system will be implemented as a 3-tier web-based application. The back end (or server side) of the architecture will be a commercial relational database (Oracle 8i) that will serve as metadata and statistics storage. Metadata information will be published on the web through a commercial Application Server (Oracle Application Server 9i). The middle tier will be developed as servlets and JAVA classes. The front end (or client side) will be developed as JSP applications.

The use of JAVA ensures that the infrastructure is portable to any operating system. The web access ensures that the requirements from the user for accessing the system will be minimal, and specifically a simple web browser with MathML plug-ins.

Figure 5 displays the 3-tier implementation. As shown in the figure, independent services will be developed for each of the 4 identified user groups: Public Services aimed at learners, Provider Services aimed at content providers, Management Services aimed at course managers, and Administrator Services aimed at repository administrators.

Performance and scalability are of key importance for the adoption of the system in a wide range of applications. The NS-eCMS architecture ensures that the system is scalable in terms of the amount of information managed and that performance does not deteriorate as the managed information grows in volume. Scalability and performance are ensured through distribution of metadata and content, and multi-threading of connections.

The NS-eCMS system supports a network of independent information management nodes ensuring the installations can grow while maintaining autonomy for participating parties. For example, large institutions may opt for a number of NS-eCMS nodes, each managing the needs of particular departments. The nodes communicate with distributed search protocols to ensure that the underlying complexity is transparent to the users, who access information uniformly from a single point on the web. Users do not need to know where the information they access is managed.

Database connections are established through shared servers. While shared servers connect to the database, users connect to the shared servers. This indirect database connectivity ensures that the system resources are preserved and well managed as the number of users connecting to NS-eCMS increases. Given the fact that NS-eCMS is a web-based application that could potentially be accessed by hundreds or possibly thousands of users, system resource management is critical for scaling and performance purposes. Multi-threading ensures that resources are well managed even under stress. The shared servers automatically perform connection load balancing.

9. Target groups

The project focuses on the academic community in the areas of distance teaching of natural sciences. This community has varying needs due to the pedagogical methods used in different circumstances. For example, use of highly specialized notation is essential for the transfer of knowledge at undergraduate- and graduate level in higher education. Specifically,
the following target user groups in those academic areas are identified:
- Higher education undergraduate students
- In-service training of engineering professionals
- Undergraduate academic institutions
- Educational content providers
- Tutors of natural sciences
- Educational repository administrators

Engineering and science institutions throughout Europe would benefit from the proposed services for the support of eLearning by deploying the platform to enhance existing programs and launch new ones. Professionals and higher education students will benefit from the single point of access to a wealth of content and the easy interaction services. Given the size of the academic community in engineering and natural sciences, the project results will have a large dissemination audience. Furthermore, given the challenges in eLearning of such subjects, the potential impact of the proposed easy access and low cost infrastructure is large and European wide.

10. Conclusions and future work

This paper presented the NS-eCMS educational content management, collaboration and communication system for the support of distance teaching and learning of natural sciences. The proposed system will benefit undergraduate learners and undergraduate academic institutions involved in natural science teaching/instruction by providing services that addresses the entire educational process, from information exchange to information management, computation execution and examinations. The purpose of the system is to provide more time efficient communication services and an open scalable platform for the homogenous publication, management, and dissemination of possibly distributed, heterogeneous educational material developed by educational content providers across Europe while maintaining the autonomy of participating organizations. In addition to providing services for the publication and management of educational content, the system provides services for all user groups participating in the asynchronous eLearning process, namely learners, content providers, course managers, and repository administrators.

The presented architecture are currently implemented in the context of MINERVA-SOCRATES action project 110159-CP-1-2003-1-NO-MINERVA-M “Content Management and collaboration System for eLearning of Natural Sciences” (NS-eCMS 2003).

Forthcoming work will focus on how the developed services could be extended to support distance teaching in more general engineering disciplines like for instance electrical and mechanical engineering. It is expected that these subjects will give additional challenges for the development of dynamic and interactive web-presentations containing large amounts of media rich educational content, which could be distributed synchronously in real time on broadband networks through integrated AV and data environments.

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Is e-Learning the Solution for Individual Learning?

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Abstract: Despite the fact that e-Learning exists for a relatively long time, it is still in its infancy. Current e-Learning systems on the market are limited to technical gadgets and organizational aspects of teaching, instead of supporting the learning. As a result the learner has become deindividualized and demoted to a noncritical homogenous user. One way out of this drawback is the creation of individual e-Learning materials. For this purpose a flexible multidimensional data model and the generation of individual content are the solution. It is necessary to enable the interaction between the learners and the content in e-Learning systems in the same manner.

Keywords: constructivist learning model, learning objects, e-Learning system, document generation

1. Motivation

“Learning through ‘discovery’ is best supported through the ‘interactive’ media of the field trip […]. This is the richest mode of learning and, of course, the most expensive, requiring both the intimate involvement of the teacher, and the ‘teacher-constructed world’” (Laurillard 1995).

Already in the nineties a change in learning methodologies began to emerge in the US. Constructivist approaches started to replace instructional methods; the focus went away from the teacher and moved to the individual learner. A large number of trend reports and Delphi studies accompanied these discussions about e-Learning. In this golden age of e-Learning a lot of consulting companies presented a never-ending series of rather optimistic studies to the public. During this hype the primary motivation is a profitable motive. The acceleration of the ROI (“Return on Investment”) of e-Learning projects was moved into the centre instead to optimise the learning process. Mostly the e-efforts are reduced to the equation “e-Learning = e-business”. The usually quoted cost reductions should be the proper raison d’être of e-Learning. Also, the focus of activity has been mostly on mapping traditional educational processes one to one into a digital environment. Considerations of the learning process requirements and the needs of the individual learners have been mostly absent in practice. But, learning can only take place when heeding the specific context out of which learning activity is going to happen as well as making allowances for individual skills, interests, mental attitudes and abilities. Therefore we will suggest a learner centric point of view for all e-Learning investigations. Learning in this sense is an active, self-regulated, constructive and situated process (Duffy et al. 1992, Bransford et al. 2000) as well as a social one. That means learning has a procedural and active character, which must lead to construction of knowledge by the learner on the background of the learners individual experience and knowledge (Mandl et al. 2002, Sun et al. 2003). We will henceforth refer to this model as the constructivist learning model (Piaget 1977, Maturana et al. 1987, Clement 1989, Papert 1992). Furthermore, we will develop a new definition of e-Learning which takes this approach particularly into account.

A multitude of definitions of e-Learning already exists in literature. For many authors the adoption of electronic media in a learning scenario is already sufficient to constitute e-Learning (see e-Learning Consultant 2003). This definition is clearly too broad. For example the use of a microphone during a lecture should be excluded by a proper definition from being e-Learning. So, the simple use of electronic media is not enough. A proper definition should demand that the electronic media give specific support to the learning process itself, which probably could not be achieved by other media (else we would have a case of electronic media just emulating traditional media).
Many e-Learning projects seem to subscribe to the definition we just characterized as being too wide. Their program of action is just to import existing standalone mechanisms of content distribution and communication into a didactical environment without ever truly justifying their relation to and benefit for the learning process. Using hyperbole to make our point, we are tempted to say that a conflict which is being slugged out by throwing books does not constitute a literary contest at all.

An alternative definition of e-Learning has been that e-Learning is aggregation of all kind of learning which use the computer for medial support of the learning process (NRW Medien GmbH 2003). Similarly, Baumgartner, Häfele and Maier-Häfele (2001) suggest that e-Learning is the general term for all kind of software supported learning. Both attempts are not very useful because they are also too loose and do not demand enough.

In contrast, others only see e-Learning where all real business process of learning, teaching and organization has been migrated into the digital environment. According to Rosenberg (2001) e-Learning depends on internet technology and is typically a networked form of learning based on a more general concept of learning which transcends the traditional paradigms.

We suggest the following definition to emphasise the new and different aspects of e-Learning as compared with traditional learning:

We will call e-Learning all forms of electronic supported learning and teaching, which are procedural in character and aim to effect the construction of knowledge with reference to individual experience, practice and knowledge of the learner. Information and communication systems, whether networked or not, serve as specific media (specific in the sense elaborated previously) to implement the learning process.

Thus, our definition is based on the constructivist learning model. Knowledge is no artefact and thus can not be conveyed to anyone. It must be constructed by the learner herself/himself. The paradigm of the moderate constructivism in which instruction and construction complement each other, seems to be especially appropriate for e-Learning. Here learning should be understood as a generative process which nonetheless needs to be initiated guidance by the teacher. In this reference frame constructive, autonomous learning always needs also instructional interludes coming from the outside.

Generally the following four issues suggest themselves as being profitable as starting points for considerations about the requirements e-Learning systems must meet to support individual in the learning process.

- How can the teacher be supported in producing teaching material for standardized profiles?
- How should the material be presented to learner and which kind of interaction with the material will support learning?
- Which kind of feedback is useful and possible?
- How should teachers and co-learners be represented within the system?

We will now try to derive some desiderata for e-Learning systems from the constructivist approach we presently favour. It can be already perceived from our present state of discussion that we cannot focus exclusively on the learning process. In the moderate constructivist approach, the learner needs to receive additional instructions. To be in accordance with the constructivist idea these must be specific to the learner. So if we talk about a process supporting learning according to moderate constructivist theory, it stands to reason to extend our considerations to the question how the learner specific teaching material could be obtained or produced. We also need to consider the teaching process to certain extent.

Therefore, this work will elaborate especially the production and interaction with learning material for individuals. The paper is divided in three parts. First we will talk about the necessities of marking up texts according to target groups. Then, we will talk about synthesis of material from smaller components and reuse of components in this process. Last we will outline what interaction is necessary to enable the user to create an individual information landscape.

2. A multidimensional data model for learning material

Empirically the majority of existing e-Learning content has been produced by just transforming traditional “established” content into a digital representation. While the reason for this was usually lack of financial and
temporal resources, this also implies that differentiation for different types of learner and adoption of constructivist philosophy could not take place. In consequence, this content does not offer any added value in comparison to traditional learning material.

To support the constructivist learning theory the learning material must be customized to the individual learner. Complete individual content is of course not viable. A coarse grouping of the learning community into various stages of advancement is necessary to reduce the number of learning material versions which need to be produced. Possible criteria could be the ability to concentrate, previous knowledge and interests. Dreyfuß (1986) and Baumgartner (Baumgartner 1993, Baumgartner et al. 2001) offer a system of classing learner into five levels.

![Figure 1: Learner Levels (Dreyfuß 1986)](image)

The levels differ in various grades of intellectual and practical mastery of the subject in question. So systems to grade learners into various levels for defining target groups for the deployment of instructions of different difficulty degrees are already well known in the e-Learning community. The model quoted provides a one dimensional classification. In contrast we assert that a one dimensional model is not enough, i.e. more than one criterion is necessary in various degrees of intensity to characterize the specificity optimal to any given learner (Lucke 2002).

Multidimensionality, even when balanced against a low number of coordinates on each axis results in a huge number of potential variants of documents or learning objects deployed to the learner. Thus tool support is necessary to maintain all variants in a common source, mark-up sections of text or parts of learning objects for the intended target groups and extract the desired variants automatically. We will now introduce a document description language with associated tools to facilitate this process.

XML based document description languages have been proven tools for a time to achieve reusability and media independence of learning materials. The Multidimensional Learning Objects and Modular Lectures Markup Language (short `<ML>`³, pronounced ‘em-el-three’, see `<ML>`³ 2003) is such an XML based description language geared towards e-Learning content which specifically provides methods of content markup supporting the creation of learner specific documents. This innovative document description language was developed by the German government project „Wissenswerkstatt Rechensysteme“ (in Engl.: „Knowledge Factory for Computer Systems“, see WWR 2004). Within this project twelve German universities are using this language to support teaching and learning in the field of computer engineering. The primary goal is to offer numerous fine-grained teaching and learning modules to combine easily with each other in order to fit on concrete educational objectives. These should provide for the matter that in many fields, several multimedia presentations for computer science have been created, but the combination of material is complicated by different presentation styles or just missing references (Lucke 2002). When using `<ML>`³ the subject matter will be structured into separate thematically self-contained modules. Every module could be structured subject specific as well as according to didactical considerations. The subject structure of a module provides the base for the content implementation proper and is equivalent to structuring in chapters and sections. The didactical structure is a complement to the subject structure. Its purpose is to divide the subject matter into parts, which can be easily handled by the learner. To achieve this, the module is being divided into lectures and learning steps independent from its subject structure. The latter are being classed into introductory, motivating, knowledge procuring, summarizing and applicatory learning steps. The classification of content into didactical structure is done exclusively by referring to content sections which have been implemented during the subject structuring. It must be emphasised that a given module can be furnished with more than one totally independent didactical structure. Furthermore, the given didactical structure template of lectures and learning steps can be replaced as needed by other suitable structuring schemas so that any module can be equipped with multiple structures, perhaps based on different structural schemas.
But only the scaling concept integrated into the <ML>³ data model allows the definition of learner specific content and enables, in combination with the features previously described, the production of high-quality content for e-Learning. A module can be scaled within three dimensions: intensity, target group and usage scenario. The first dimension, intensity, takes three possible values. These are according to the steps in figure 1 novice, competence and expertise and mainly mark the complexity of the subject matter and thus the amount and depth of material produced. Presently the second dimension, target group differentiates only between learner and teacher. Using this parameter it is possible to define content section specific for a target group. This is useful in example for self-testing exercises, interactive components or virtual experiments from which mainly learners can profit, whereas teaching assistance and sample solutions are mainly of interest to the teacher. Finally the third dimension, usage scenario determines how the material is going to be presented. Presently documents can be produced to be used as a slide based presentation (e.g. within a lecture), as a printable version (e.g. lecture notes) and online version.

3. Generation of individual learning documents

This data model has been introduced as a pretty good example which offers the options to allow for the individual needs of the learner. The flexibility of <ML>³ is restricted by the variability of the content. To achieve this flexibility the reuse of learning objects is an often quoted buzz word. Essentially this would mean to be able to create new learning objects flexibly, adapted to the individual experience and knowledge of the learner. Baumgartner question this idea by asking exaggerating, why anybody should book an online course of some hours if 15 minutes could be sufficient?

This criticism must be considered founded insofar as the idea of reusing learning objects has not had the desired results yet. The original idea has been to modularize documents into single building blocks which can bereassembled to documents again similar to the children’s toy LEGO (see Fig. 2). The IEEE has recently formalized this idea by the defining a learning object as „any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning“ (IEEE, 2003). According to this definition, a learning object could be almost anything: a single picture, some graphics, a text, flash animation, a short tutorial text or a multiple-choice-test (Baumgartner 2001).

![Figure 2: Building blocks principle applied to learning objects](image)

Consequently, „what has followed since the introduction of the term learning object has been a flurry of technical activity, financial speculation, and international standards efforts. What has not followed is a flurry of principled instructional design work utilizing the new instructional technology“ (Wiley et al. 2000, p. 1).

Designing such a system of building blocks makes it necessary to take some decisions which have fundamental implications. The choice of a granularity, that is the size of the smallest components, is such a decision. It brings about the controversy between the proponents of the constructivist and instructivist paradigm. For example, if the smallest component encompasses a full course its reusability would then be rather restricted and context specific. This would mean a reification of the knowledge in question and would emphasis the instructivist element. In the other extreme reducing the granularity to single sentences would be rather nonsensical. It would be quite difficult to present in coherent way anything meaningful in such an atom of information.

Constructivist learning models depict the context of a learning scenario that is situated learning, as one prerequisite that meaning can be constructed (Brunh et al. 1996, Bannan- Ritland et al. 2000). The best choice of granularity should therefore lie somewhere between two extremes. A size too small would let the learner loose herself/himself in the information nirvana, i.e. the granularity is too small to allow a constitution of meaning within the single element. A size too large would mean a fixed sequence of segments of information which would allow neither retrospection nor preview and would also be much too inflexible in a constructivist learning process.
AMG (Automatic Manuscript and Course Generation, see AMG 2003) is a project which is building on <ML> and consequently has chosen the <ML> module as the unit of granularity. Accordingly, a module is a composite of textual sections and other media objects. The automatic composition happens in several processing steps. The first step finds modules suitable for the generation process. The result of this search is a graph of relations, which will be used in two ways. Firstly, to create learning documents for standardized profiles (like novice, competence and expertise). Secondly, to synthesize an individual document for a single learner. Since standardized profiles can only describe a learner in a rather general way, a certain minimum mismatch between the actual abilities of the learner and the presumed target group necessarily results. Furthermore, the teachers have additional work generating all necessary document variants. Therefore within the second scenario every single user can herself/himself generate documents adapted to her/his personal profile.

Using the user profile and a given learning objective, the system can selectively determine an appropriate learning path. So, single nodes can be removed from the graph either because they are providing instruction that is already being covered by previous knowledge or because they are not imperative to the objective. On the other side, some nodes can be weighted more heavily to cater certain user interests. Even more, generation of personalized documents could adapted to the learner with respect to content, form of presentation, time needed, difficulties and arrangement of subject matter.

One advantage is, that in this way personalized documents, which lead the learner without needless detours directly from her/his current base of knowledge to the desired learning objective, can be generated automatically and every time. A further point to consider, which might seem less essential but nonetheless might prove rather disruptive when not heeded, could be the use of heterogeneous data formats for the fundamental building blocks. It might be a desirable vision to bring together any kind of data formats but the resulting differences in presentation and handling might also distract the learner from learning. Therefore the separation of content and layout is a necessary prerequisite. Since <ML> is a semi-structured data format it is possible to compose content first and only then decide on a uniform representation by selecting a stylesheet.

4. Interaction with learning content

In the last two chapters the focus has been on the creation of learner specific content. But only the creation of content, how good ever it might be, can not be a purpose of itself. Everyday handling of such content in the communication to the learner is a significant part of the learning process. We will now undertake a short survey of the state of practice as found in contemporary e-Learning systems by an evaluation at the University of Rostock, criticize that practice and from that derive some requirements for how e-Learning systems should interact with the user.

As part of the project Notebook University Rostock (NUR 2003) more than 15 e-Learning systems have been checked against a previously compiled catalogue of criteria in spring 2003. In summer 2003 three selected systems have been evaluated against each other in actual operation to test the suitability for long-term usage at the University of Rostock. Whereas a system could be selected which caters for the (currently primarily organizational) needs of the users, none of the systems has any significant support for the constructivist aspects of the learning process. Mostly these systems serve only as data containers into which the teacher or tutor can upload files. But such files of arbitrary format must remain opaque to the system and therefore can not be filtered during the rendering process according to the users profile and history. The user can not leave traces in the document. Basically, all investigated systems just try to map traditional learning objects of the physical world like a book or lecture notes into a digital environment. But only certain major properties of these objects are actually modeled, like that books are made up of pages, can be read etc. Other more accidental properties of the physical counterpart got only minor importance attached by the systems designers and were lost in the digital world, but are actually essential to constructivist learning. For example, books and lecture notes in the physical world can be annotated, but their electronic counterparts can not be. Any effort to create a personal portfolio of documents is also badly supported. The learner find herself/himself restricted to static folders created by the teachers, his only option to group documents differently is, to download them. But then e-Learning does not happen in
the system anymore, the e-Learning system degenerates simply to a distribution platform for electronic documents.

Learning with “real paper”, that is text books, lecture notes and photocopies provide an opportunity for autonomous and self-controlled learning. The learner can put together her/his own reference library, their own portfolios and folders for every topic. She/he can annotate and cross reference documents and thus forge a knowledge and information landscape in which she/he is at home and can navigate expertly. In this point the digital environments provided by all the investigated e-Learning systems fall short of their originals, since they model the paper objects only incompletely, and must thus be considered rather useless when judged from a constructivist perspective.

In the criticism just voiced from a constructivist point of view some corner points of requirements to a useful e-Learning system become already apparent. The e-Learning system must enable the learner to create the aforementioned personal information landscape while working with the provided learning materials. The means are individual compilation and topical rearrangement of learning material, creating “pools” of especially important documents as well as the possibility to annotate and cross-reference material.

5. Conclusions and further works

As we pointed out despite the fact that e-Learning exists for a relatively long time it is still in its infancy. The focus on technical gadgets and promising business models have influenced the development into the wrong direction, at least as perceived from a constructivist point of view upon learning.

To provide a new point of orientation we first suggested a new definition of e-Learning and than tried to at least partially derive requirements for e-Learning systems from the necessity to support constructivist learning processes. We found that individual content and learner specific interaction are the media specific value software based systems could contribute to learning. Methods to maintain and reuse learner specific content have been introduced with the Multidimensional Learning Objects and Modular Lectures Markup Language (<ML>³) data model and the AMG project. This data model was developed in context of the WWR project. An XML based approach was deliberately chosen in order to achieve for e.g. interoperability, reusability, human-machine understandability, ease of use, etc. The foundation is therefore a modular, scalable description format that enables the separation of content, presentation and didactics. That means parts can easily be exchanged. Based on this features in combination with the generation of individual learning materials a maximum of individual content is possible. The automatic generation of documents is the subject-matter of the AMG project. Obviously a better understanding of the learning process can provide a strict reference frame for designing e-Learning systems.

From that experience our demand to designers of e-Learning systems can only be to drop their occupation with technical gimmicks and instead try to achieve a true understanding of the learning process. Fortunately this insight has already arrived at least at a part of the e-Learning systems designers community, as evidenced by some reviews of the last e-Learning trade fair LearnTec at Hamburg in spring 2003 (Schneller 2003).

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References


Content Management Middleware for the Support of Distributed Teaching

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Abstract: eCMS is a web-based federated content management system for the support of distributed teaching based on an open, distributed middleware architecture for the publication, discovery, retrieval, and integration of educational material. The infrastructure supports the management of both standalone material and structured courses, as well as the integration of existing organized external repositories. The infrastructure is complemented with services targeting the specific needs of user groups involved in the e-Learning process, namely learners, content providers, course managers, and repository administrators.

Keywords: e-Learning, distributed teaching, content management, middleware, integration, content reuse, metadata, information discovery, federated, autonomy, services, scalability, 3-tier architecture, structured courses, examination development, statistics analysis

1. Introduction

Asynchronous e-Learning overcomes geographical and temporal constraints transforming learning into a process that can occur at the independently determined convenience of instructor and learner (Harris D., DiPaolo A., Goodman J. 1994). Demand for asynchronous e-Learning has been developing driven both by corporations and professionals striving to remain competitive in a constantly evolving job market and by individuals seeking degrees, typically at the higher education and post graduate level, but facing time and location constraints. Furthermore, content management infrastructures are recently being used as a complementary educational tool in traditional classroom education (e-Learning 2001) for the publication and dissemination of course related material.

The success of asynchronous e-Learning relies on the effective management of the wealth of available educational content. Recognizing the importance of educational content management in distributed teaching, the eCMS project focused on a web-based federated content management system for the support of the distance education process. The system is implemented on state-of-the-art digital library technology for the management of heterogeneous, possibly distributed content located locally or on remote servers and managed by independent content masters. The core of the system is open, distributed middleware for the publication, discovery, retrieval, and integration of educational material. The infrastructure is complemented with services targeting the specific needs of user groups involved in the e-Learning process, i.e. learners, content providers, course managers, and repository administrators. eCMS supports standalone as well as distributed configurations, allowing installations to evolve into educational content portals and ensuring the autonomy of institutions participating in an extended eCMS educational network.

eCMS services for learners include information discovery through metadata keyword searches, navigation through organized content, participation in self-assessment examinations, educational module reviews, and on-line collaboration tools. Services for content providers include optional content hosting, metadata authoring wizards, and support for the on-line development and management of structured courses as well as multiple-choice examinations. The system supports the reuse of content, possibly developed by peers, facilitating the creation of value-adding educational entities under the control of the owning organizations and with respect to the intellectual property rights of content developers. Services for repository administrators include publisher and user management, easy to use educational content metadata indexing for information discovery purposes, and transparent gathering and analysis of system use statistics aiming at the constant improvement of services and published material.

eCMS recognizes that course structuring often reflects the pedagogical practices and internal organization of academic institutions and thus may differ significantly from one organization to
another. In addition, educational content contributors are typically professors who have already well developed pedagogical practices, existing material, and limited time to restructure content or teaching methods. Course managers wish to convert material used in traditional classroom settings to on-line content with as few modifications as possible. For the above reasons, success of an on-line educational content publication service depends on its flexibility on course structuring. Rather than enforcing a predefined structure, eCMS allows providers to organize course content in a manner that best fits their academic practices through the support of flexible tree-like course hierarchies with no additional limitations. Course content is developed in private workspaces controlled by the publishers. Thus publishers have the discretion to make content available to the general public when they feel that it is mature. Content can be published either as complete entities, e.g. an entire course including several lectures, handouts, exercises, etc, or in parts. This flexibility is necessary for the support of current teaching practices, which often involve the periodic publication of material. For example, instructors often publish reading lists before a lecture so that students can prepare for class discussion. Instructors publish class presentations after the lecture as reference material. This process ensures that students reach their conclusions through class participation instead of being fed information by the instructor.

On the other hand, while organizations recognize the benefits of on-line content dissemination they are reluctant to publish material through a system that they do not fully control. The federated nature of the eCMS middleware allows institutions to install and locally manage an eCMS node that may optionally be connected to a larger eCMS network. Thus, educational institutions enjoy maximum autonomy through the distribution of metadata and content. eCMS nodes can be installed at the institution or the department level. That is, the separation of content into logical repositories is flexible and can be decided by the educational institutions.

Finally, eCMS supports the integration of existing organized repositories through metadata importing and mapping agents, a feature not currently supported by available e-Learning management systems (Blackboard 2003), (WebCT 2003). eCMS can be configured to periodically import external repository metadata in a manner that is transparent to each repository’s normal operations. This feature stresses the federated nature of eCMS networks as opposed to standalone content management configurations.

To facilitate the on-line learning process eCMS offers a basic collaboration environment that enables learner-learner and learner-instructor communication. Given the wealth of relevant software and the fact that eCMS focuses on federated content management infrastructures the collaboration environment is implemented by taking advantage of available off-the-shelf tools.

External learner groups consisting of secondary school teachers and higher education learners in the north and south of Europe have tested the system with positive results. However, the proposed infrastructure is independent of the targeted learner group and may be used in a wide range of e-Learning initiatives, such as higher education, post graduate education, life long learning of professionals, training of trainers, etc.

2. eCMS Educational Content Management Middleware

Figure 1 displays the eCMS educational content management node. Information is logically organized into separate data stores for metadata, content, and system statistics. The business logic is separated from the data and is implemented in a separate service layer to ensure flexibility in educational offerings, software updates, and interface improvements.

The Metadata Store holds a description record for each published educational module. The system supports optional hosting of material into a designated Content Hosting Area. Material is uploaded into the system through the Hosting Service. It is expected that this mechanism is typically used for the publication of standalone educational units originating from institutions that do not currently offer organized distance education programs or the infrastructure and know-how to manage content independently but still wish to publish educational content through external services. Finally the Statistics Store holds transparently gathered statistics on system use. Analyzed statistics are available for review by both system administrators and course managers, who may use the information to evaluate their practices and identify points of improvement.

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Users interact with the eCMS Content Management Node through a web-based interface providing customized library views targeting the needs of learners, content providers, course managers, and repository administrators.

Content providers can publish educational material in one of the following ways: (i) through the eCMS Metadata Submission and Editing Wizard, a facility that guides publishers through the step-by-step generation of metadata descriptions for educational entities. (ii) Through the eCMS Course Developer, which supports the publication of structured courses through the development of metadata descriptions for educational modules as well as the definition of parent-child relationships creating tree-like hierarchies of content. (iii) Through the Metadata Importing Wizard for the transparent integration of external repository metadata, thus enabling the publication through the system of entire collections of information in a manner that does not interfere with the external repository normal operations.

Learners have access to published content through search and navigation interfaces that support text-based queries against the educational metadata. The system is extensible to support text-based queries against content, for example the content of a text file or a file stored in a proprietary format such as PDF. Content may be retrieved through the Information Delivery Service and presented to the learner in an appropriate format depending on the storage method and the intended use of the module (image, text, video, etc).

The Statistics Gathering and Analysis service automatically collects statistics on the use of offered services during the regular eCMS operation. Statistics include information on keywords used in queries, metadata records matched through queries, reviewed metadata records, and user information. The goal of this operation is the constant improvement of the system functionality and content, as described in more detail in section “System statistics”.

Finally, a collaboration environment developed through off-the-shelf tools facilitates communication between learners (e.g. group work) as well as learner-instructor interaction (e.g. office hours) thus aiding the learning process. The tools consist of chat-rooms, forums, and application sharing modules.

Additional Content Management Nodes are supported to ensure scalability of the system as the amount of managed information increases. Each eCMS node manages a distinct metadata collection and corresponding content. As described in more detail in section “Support for metadata distribution and distributed queries”, distributed information is periodically and transparently synchronized to ensure that users have access to the entirety of the distributed content through an interface that hides the underlying system complexity.

The system is designed as a 3-tier web-based application to ensure modularity of offered services and minimum requirements on the user side. The back end (server side) of the architecture serves as metadata, content, and statistics storage. Metadata and content is
published on the web through a commercial Application Server. The middle tier implements the business logic as servlets for specific services. The front end (client side) is developed as JSP applications. The 3-tier structure disengages the logic from the interface, which ensures easy adaptation of services and user screens for addressing the needs of additional target groups.

Figure 2 displays the 3-tier implementation. As shown in the figure, independent services and interfaces are developed for each of the identified target user groups that participate in the asynchronous e-Learning process: Public Services aimed at learners, Provider Services aimed at content providers and course managers, and Administrator Services aimed at repository administrators, who manage the eCMS nodes.

Figure 2: The 3-Tier implementation

3. Course structure

One of the key difficulties and hindrances for publishing content, particularly already existing modules, into e-Learning libraries is the fact that many systems support a very specific course-structuring model. At first glance this may seem as a feature that simplifies the publication process and guides publishers through content development. However, this choice may prove to be a significant disadvantage when academic institutions wish to create distance education programs based on existing content and educational practices. These programs are typically developed by professors who on the one hand have very limited time and on the other have already well developed teaching practices that they wish to transfer to e-Learning courses. Furthermore, in a lot of situations the structuring of courses may represent a larger view on the educational process adopted at an institutional level.

It becomes apparent that for the success of any open federated library for educational content flexibility in the structuring of courses is a vital feature that encourages content publication. For this reason, the eCMS system allows maximum flexibility to content providers on the structuring of material. eCMS achieves this flexibility by imposing the least possible}

structuring constraints. A hierarchical approach has been adopted. The providers may decide the types of educational modules they will use for course structuring purposes. Examples of currently supported module types include course, module, section, and subsection. However, the supported educational module types are dynamically managed by eCMS administrators, as opposed to being hard-coded into the system, and may be easily extended through straightforward on-line services. Thus, an institution that wishes a different structure, for example lecture driven as opposed to the current book-content index table inspired one, can easily implement it.

Figure 3 displays the representation of structured courses in the eCMS system. In the presented example a number of independent modules are displayed, interconnected with “contains” parent-child relationships. Thus, modules published through the system may be reused, provided that the owning organization permits. This example displays two courses: “Computing” which includes “Computer Architecture” and “Desktop Tools” (e.g. a lab), which in turn includes “Imaging”, “Doc Editing”, and “Spread Sheets”. “European History” includes a module for a historic period and is reusing parts of “Computing” to provide learners with basic desktop skills. Reuse of educational modules is a value-adding function that takes advantage of the federated distributed library nature of the eCMS system, which is not available in standalone systems. Information reuse can result in the dramatic increase of content published through the system through combinations targeting the needs of different learner groups.

4. Educational content metadata

Figure 4 displays a high level overview of the eCMS Educational Module metadata schema. The metadata schema has been developed taking into account earlier work in this area (The Dublin Core), (ETB), (Learning Technology Standards Committee 2000),

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Past work on metadata definitions has been extended to support detailed descriptions of structured courses and examinations, as well as course hierarchies.

The information is organized through relational database tables. Each published educational entity corresponds to a record in the Metadata table and is uniquely identified. Information is also maintained on Publishers (e.g. the Department of Computer Engineering) as well as the Institutions the Publishers belong to (e.g. the University of Thessaly). More than one Publisher may be associated with each Institution, thus creating a hierarchy of Publishers in the organization of published educational modules. This hierarchy allows additional granularity in the organization of content in local collections within an academic institution.

Information is organized in Thematic Areas for navigation and information discovery purposes. The supported Thematic Areas are kept in a corresponding table, which is easily updateable through available on-line services for repository administrators. Managing dynamically information on thematic areas allows the creation of user-friendly information discovery interfaces. The value of such flexibility becomes clearer at the face of growing educational repository content leading to the need of effective interfaces for information discovery.

Security information is held in a separate space in the schema and includes user accounts and groups that control access to content and metadata in the system repositories.

In order to support distribution of metadata, a feature that supports the autonomy of participating organizations as well as efficient queries against the entire content space, the eCMS system maintains a directory of available repositories connected into a wider eCMS network. The directory is used for metadata synchronization and caching as described in more detail in section “Support for metadata distribution and distributed queries”.

Finally, text-based indexes are built on the Module Metadata to allow free-text search. Indexes are built on a set of metadata fields defined as searchable, while regular SQL queries are supported against the entire metadata record description. Examples of searchable metadata fields include a course’s title, author, summary, and keywords. Non-searchable metadata fields are the ones that describe details about an educational module, such as course prerequisites, class-meeting schedules, recommended bandwidth for accessing the material, required course examinations, etc.
5. Summary of eCMS services for the support of distributed teaching

The following sections provide a high-level overview of the eCMS services implemented on the educational content management infrastructure described in earlier sections. Services are customized for each targeted user group, namely learners, content providers, course managers, and repository administrators.

5.1 Services for learners:
- Querying support:
  - Free-text search, which is the most common and easiest to use information discovery method.
  - Search with options, used for increased search result accuracy by matching user-entered keywords against specific metadata fields as opposed to the entire metadata record description; for example matching particular keywords against an educational module’s title.
  - Search by eCMS record ID, useful for the quick access of frequently used records.
- Navigation:
  - By publisher, for example by academic institution or by department.
  - By thematic area.
  - By author or course instructor.
- Collaboration environment:
  - Chat-rooms for real-time quick communications.
  - Forums for the support of discussions.
  - Application sharing, for the collaboration on common projects. Examples include collaborative work (modification and review) on shared files by users in different locations.
- Participation in self-assessment multiple-choice examinations.
- Educational module reviews, which can be useful to other students wishing, for example, to participate in a course:
  - Submission of module ratings on a predefined scale of 1 to 5.
  - Submission of text reviews with the student’s opinion on the quality and applicability of a module’s content.
- Management of personal record in eCMS:
  - Learner registration to the eCMS system.
  - Personal data and personal eCMS account editing.
- Feedback forms on the eCMS services:
  - On-line eCMS service questionnaire.
  - Email-based feedback.
  - Services manual.

5.2 Additional services for educational content providers:
In addition to the above services for learners, the following are available for content providers:
- Private workspaces for content development.
- Management of educational content metadata (editing, deleting).
- Optional content hosting.
- Access to learner educational content reviews and ratings aimed as an aid to the instructor for the constant improvement of the published material.
- Search by eCMS record ID, useful for the quick access of frequently used records.

5.3 Additional services for course managers:
- On-line structured course developer and editor.
- On-line multiple-choice examination developer and editor.

5.4 Additional services for repository administrators:
- User account and group management.
- Supported educational module type management.
- Institution and publisher management.
- On-line text-based metadata indexing.
- Importing of organized external repositories and mapping of external to eCMS metadata.
- Support for the efficient distribution of metadata and content through remote metadata caching.

The following sections provide more details on key eCMS services and features. Additional information can be found in the eCMS Design and Implementation Reports (Tsalapata H., Brna P., Stav J. 2002, Tsalapata H., Kalantzis C., Brna P., Stav J. 2003).
6. Course developer and editor

The eCMS Course Developer and Editor utilities are part of the eCMS content and metadata publication services. Since they constitute an important aspect of the eCMS system, they are discussed as separate entities.

6.1 Course developer

The eCMS Course Developer facilitates the on-line construction of structured courses. This value-adding functionality enables providers to make the most of published content by supporting the creation of new structured entities either using new modules or based on already published content. The service complements the eCMS Metadata Submission and Editing Wizard for the publication of standalone educational modules to create a complete on-line content authoring environment.

To ensure maximum flexibility on course structuring the eCMS Course Developer adopts a recursive top-down construction approach for the creation of tree-like hierarchies. In addition, the tool supports the possibility of information reuse. The approach is displayed in Figure 5. To gain access to the service, providers must log into the eCMS system with their user account. The first step of course creation is the submission of a general metadata description for the course that documents the course title, the thematic area, the covered topics, the targeted audience, the required background on the learner’s behalf, the required effort for completing the course work, examinations, hand-ins, instructor availability, and other information. Subsequently, providers are requested to add educational modules to the course.

Course sub-modules may be:

- New entities that the provider creates recursively at the time of course creation, or
- Existing entities already published through eCMS, which the provider reuses.

In the case of a new entity, the provider creates a metadata description for the module and either associates the module with a remote content address or optionally uploads the corresponding content into the eCMS repositories.

The provider may reuse an already published entity as a sub-module of the course under development by selecting the entity’s title from a drop-down list. Reusable entities may be:

- Entities that are owned by the provider, in which case the provider has by default full rights, or
- Entities that are owned by other providers and have been marked by their owners as “available for reuse”.

Once the sub-module has been created a parent-child relationship between the existing node and the newly created sub-module is automatically inserted into the eCMS Course Structure area, extending the course hierarchy.

The above process is repeated recursively in a depth-first manner until the course is completed. Upon completion the provider may review the structure and use the Course Editor to make any necessary changes/improvements.

![Figure 5: Course developer and editor](image-url)
6.2 Course editor

The eCMS Course Editor complements the Course Developer to form a complete structured-course authoring tool. Through the Course Editor providers may perform the following operations:

- **Edit the metadata description of a node in a course hierarchy**: Both the top level “course” description and the inner “course module” descriptions can be edited.
- **Upload new content and associate it with a node in a course hierarchy**: This function allows the update of the content itself, and complements metadata updates.
- **Publish a node**: This function moves a node and all its children to level “public”. Upon completion the sub-tree rooted at the node is visible by the general public.
- **Hide a node from the public**: This function moves a node and all its children to level “complete”. Upon completion the sub-tree rooted at the node is visible only to the owner / publisher.
- **Allow reuse of a node**: This function moves a node and all its children to level “reuse allowed”. Upon completion other publishers may reuse the sub-tree rooted at the node for the development of value-adding educational entities.
- **Delete a node**: This function deletes a node and all of its children. Also, it deletes all parent-child relationships between the node and its children and between the node and its parents and repeats this operation recursively for each child. Upon completion the sub-tree rooted at the node is deleted.
- **Detach a node**: This function detaches a node, i.e. removes the corresponding parent-child relationship. The difference with the delete operation is that no nodes or other relationships are deleted. Figure 6 displays the result of detaching Node B from Node A.

![Figure 6: Node Detachment](image)

**Add a node**: This function inserts a new node in the course hierarchy at a specific location. The new node can be added before or after a specific node in the existing course hierarchy. Figure 7 displays the result of adding Node C before Node B.

![Figure 7: Node Insertion](image)
All actions described above are allowed on nodes that are owned by the publisher. During the recursive execution of the operations on a sub-tree only nodes that are owned by the publisher are affected. Nodes that are part of the sub-tree and are not owned by the publisher, i.e. they are reused, are not altered in any way.

7. Examination developer and editor

The eCMS Examination Developer and Editor is an on-line authoring tool that supports course managers in the development of multiple-choice self-assessment examinations for learners. The examinations may or may not be associated with courses or other content published through eCMS and may be incorporated into a course hierarchy.

In a manner similar to the one used for course development, examination development is achieved through a top-down approach. A general description of the examination is created first, in which the developer may document the scope of the examination, the knowledge being assessed, the educational material it is associated with, and other information. An eCMS metadata record is automatically created for the examination and may be used as a handle for optionally incorporating the examination into a course hierarchy.

Once the general examination description is complete, the eCMS Examination Developer guides the user through the addition of multiple-choice questions to the examination through the Examination Question Wizard. For each question, the wizard prompts for the following information:
- The question text, to be presented to the learner taking the examination.
- Up to 5 possible answer texts.
- The correct answer.
- An optional hint for the correct answer, to be presented to the learner.
- An optional eCMS address (URL) of the educational module where the correct answer may be located, to be presented to the learner.

This process is repeated for each question to be added to the examination.

The Examination Editor supports the editing of examination metadata description fields, the deletion of questions, and the insertion of additional questions through the Examination Question Wizard.

8. Support for metadata distribution and distributed queries

In order to ensure autonomy of participating organizations, eCMS supports the installation of more than one independently managed eCMS nodes optionally interconnected into a federated digital library of educational content. Thus, institutions may install an eCMS node in their premises and manage it through the provided Repository Administrator services. Remote eCMS nodes may be easily connected into a wider eCMS network through the support for Metadata Distribution and Distributed Queries. This feature ensures that publishers may get the best of both worlds: autonomy in the management of the content, scalability with respect to metadata volume, and participation in educational networks.

eCMS hides the complexity of the federated content management infrastructure from users, who may submit a query through an eCMS entry point and receive merged results of query hits from all eCMS nodes. Users may review query results from a single list without being required to know details about the nodes that manage individual records.

Two approaches were considered for the implementation of metadata distribution and distributed query support:
- **Distributed queries**: This approach involves the propagation of a user query, which has been entered through an eCMS entry point, to all eCMS nodes, the execution of the query locally at each eCMS node, the collection of query results from all nodes, the merging of results, and the presentation of a single, merged result list to the user.
- **Metadata caching**: This approach involves “synchronization” of eCMS metadata repositories. Specifically, it involves caching of remote eCMS metadata, which results in equivalent eCMS nodes, i.e. into eCMS nodes that hold the same metadata information, some of which is local and some replicated from remote servers.

The second approach, i.e. metadata caching, has been implemented in the eCMS system to alleviate the need for remote queries, thus resulting in faster query responses.
The Repository Synchronization service is available on-line to repository administrators, who may invoke it through a simple click of a button. It may also be programmed by administrators to be executed periodically, e.g. nightly. Repository synchronization is achieved through the following steps:

1. Identification of the addresses of all remote repositories connected into an eCMS network.
2. For each remote repository:
   a. Deletion of the locally cached information that originates from the specific repository.
   b. Importing of the remote repository’s metadata records.
   c. Importing of the remote repository’s course hierarchy structures.

To facilitate the above actions eCMS stores, for each metadata record, information on the eCMS repository of origin, i.e. the repository where the record is stored and managed. Other repositories simply cache copies of the original records, thus ensuring the integrity of metadata information.

9. External repository integration

External organized educational content repositories, which have their own educational metadata definition sets, may be integrated into eCMS through the Metadata Importing Wizard. The wizard operates transparently to the external repository’s normal operation as a background demon that may be configured to poll the external repository periodically, e.g. nightly or weekly. The wizard imports external metadata records, maps the metadata to the eCMS metadata definition set through a mapping scheme that is specific to the external repository, and stores the mapped metadata into the Metadata Store as eCMS records that are subsequently indexed through the eCMS metadata free-text indexer.

This functionality requires cooperation between the eCMS and external repository administrators, who must provide the mapping of the external repository metadata fields onto the eCMS metadata definition set.

This functionality allows eCMS installations to evolve into e-Learning portals for the access of information originating from independent sources.

10. System statistics

Gathering and analysis of statistics can lead to valuable feedback on the system infrastructure, the organization of content, and the costs and benefits of the provided services to the users. For this reason, in addition to gathering user input through questionnaires and email, statistics gathering and analysis mechanisms have been developed that operate transparently and gather information on system use.

Gathered statistics currently include the following:
- Query keywords entered by users, for both basic search and search with options
- eCMS identifiers of records matched by queries
- Reviewed metadata records of educational modules
- User information
- Date of statistics record entry

The above information is gathered by automatically inserting records into a designated Raw Statistics area of the Statistics Store each time a user enters a query or reviews an educational module. Once analysed, the statistics information is moved to a corresponding Analyzed Statistics area of the Statistics Store. The analysed statistics provide views and summaries of the gathered raw information in a format that can be easily interpreted by repository administrators and course providers and can provide valuable feedback leading to system and service improvements, such as more accurate metadata information and interfaces that are easier to use.

Table 1 displays examples of analysed statistics and possible improvements they can lead to.

<table>
<thead>
<tr>
<th>Analyzed Statistics</th>
<th>Possible System and Service Improvements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occurrences of a particular keyword in basic free-text queries</td>
<td>Adjustment of the navigation interface according to frequently used keywords.</td>
</tr>
<tr>
<td>Occurrences of a particular keyword in particular fields for queries with options</td>
<td>Rarely matched records may imply unintuitive metadata descriptions. The metadata descriptions of such records may have to be modified to ensure easier discovery.</td>
</tr>
</tbody>
</table>

Table 1: Analyzed statistics and resulting possible system improvements
11. Conclusions and future work

This paper presented the eCMS educational content management system for the support of asynchronous e-Learning. The purpose of the system is to provide an open scalable platform for the publication, management, and dissemination of possibly distributed, heterogeneous educational material developed by independent educational content providers while maintaining the autonomy of participating organizations. In addition to providing a platform for the publication and management of educational content, the system provides services for all user groups participating in the asynchronous e-Learning process, namely learners, content providers, course managers, and repository administrators.

The presented architecture has been implemented in the context of MINERVA-SOCRATES action project “Content Management Middleware for the Support of e-Learning across Europe” (eCMS 2001).

Current work focuses on services for the support of distributed teaching in engineering and natural sciences, which addresses the additional challenges for the development and dynamic representation of media rich educational content including mathematical and other formulas, graphs, sketches, etc through the latest standards including MathML XML, and CML. This work is currently being implemented in the context of the MINERVA-SOCRATES action project “Content Management and Collaboration Environment for Natural Sciences” (Stav J.B. and Tsalapatas H. 2003, NS-eCMS 2003).

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Maintenance and Exchange of Learning Objects in a Web Services Based e-Learning System

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Abstract: Web services enable partners to exploit applications via the Internet. Individual services can be composed to build new and more complex ones with additional and more comprehensive functionality. In this paper, we apply the Web service paradigm to electronic learning, and show how to exchange and maintain learning objects in a corresponding e-Learning system. We start from a perception of core e-Learning activities as processes, which enables us to break central functionalities of an e-Learning system down into several stand-alone applications; these can then be accessed as Web services. However, building a decentralized system by composing suitably chosen Web services to achieve a functionality similar to that of a traditional e-Learning system leads to a variety of challenges, two of which are discussed in detail: (1) Storing learning content in a distributed fashion, and (2) dynamically exchanging content when necessary or appropriate. The paper also discusses some of the problems arising from storing data on different servers.

Keywords: e-Learning, Web Service, Learning Object, Repository, Distributed Storage

1. Introduction

By moving offline activities online, the emerging paradigm of Web services promises to enable partners to exploit vastly arbitrary applications via the Internet. In a nutshell, a Web service is a stand-alone software component that has a unique URI (the Uniform Resource Identifier is a unique address), and that operates over the Internet and especially the Web. The basic premise is that Web services have a provider and (hopefully) users or subscribers. Web services can be combined to build new ones with a more comprehensive functionality. The benefits of a Web Services Architecture (WSA) are well-understood in the area of business-to-business (B2B) applications, where companies use it for enterprise application integration; even in business-to-customer (B2C) scenarios, Web services are of growing importance. In this paper, we apply the Web service paradigm to electronic learning and discuss some of the realization problems that arise.

Clearly, Web services need to be interoperable, since individual services typically are restricted and limited in their functionality. Moreover, they have to be independent of the underlying operating systems, they should be usable on every Web service engine regardless of the respective programming language, and they should be able to interact with each other. To achieve these goals, Web services are commonly based on standards; currently most used are the XML-based specifications SOAP (Simple Object Access Protocol), UDDI (Universal Description, Discovery and Integration), and WSDL (Web Services Description Language). Even for the composition of Web services, XML-based languages are being introduced or even used already (e.g., XLANG, WSFL, or BPEL4WS, see Leymann (2001) and Andrews et al. (2003)).

As has been discussed previously, electronic learning (“e-Learning”) is also taking the shape of a Web service in many applications these days. Here the idea is that learners can, for example, search for content suitable to their needs, book it, pay for it, and finally consume it, all by composing appropriate lookup, payment, and presentation services, resp. The basics of a platform called LearnServe providing this are the subject of this paper. LearnServe starts from the perception that a typical learning system is a collection of activities or processes (Vossen et al. 2002) that interact with suitably chosen learner and learning objects (Vossen and Jaeschke 2002, 2003); these processes can be broken down into suitably chosen components which can then be realized as services individually (Vossen and Westerkamp 2003).

Building a decentralized system by composing Web services to achieve functionality similar to that of a traditional e-Learning system clearly leads to a variety of novel challenges, among them that of managing the content for the learner. Indeed, in a distributed system organization learning objects cannot simply be imported into a particular learning management system. Instead, content needs to be stored on distributed servers and be called on demand. This paper will show how these aspects can technically be combined...
with recent standardization efforts that aim at content exchangeability and efficient reuse, and how it is even possible to exchange content for courses vastly “on the fly.” Our repository for learning object publication and search essentially adapts the UDDI framework also used for commercial Web services (Newcomer 2002) to an e-Learning context. Its main features are that the repository itself contains centralized data about learning objects, i.e., all meta-information, while the actual content that it refers to can be arbitrarily distributed. We are thus able to tackle some of the problems arising in the realization of a service platform, including
1. storing learning content in a distributed fashion, and
2. dynamically exchanging content when necessary or appropriate.

Using LearnServe, content can be published and organized for exchange, and content can be accessed in a service-based environment. We also discuss some of the problems arising from storing data on different servers, including quality of content, availability of content, and security problems.

Once a platform such as LearnServe is in place and ready to operate, the usage of Web services will enable the integration of e-Learning functionality directly to business applications (e.g., CRM\(^1\) and ERP\(^2\) systems), since it will become possible to directly interact with applications, processes, and other information sources. This could provide benefits for a number of learners particularly in secondary and tertiary education, who are mostly following a learning-on-demand approach driven by their professional needs. Indeed, in a society where on the one hand it becomes more and more common to change jobs several times during a work life, and service provision based on the Web becomes more and more mature on the other, it is more than feasible to bring these two developments together so that one can benefit from the other, and flexibility for the learner is supported as far as current technological developments allow. We emphasize that the system development reported in this paper is not intended as a replacement for any form of electronic learning scenario. Moreover, even for an on-demand learning application it might not be the only choice available. However, as technology advances towards Internet2, and as Internet access and computing devices become more and more ubiquitous, the flexibility offered by a Web service approach to learning will become attractive for a growing number of people.

The organization of the paper is as follows: We first describe the basics of e-Learning as Web service in Section 2. In Section 3 we present the architecture of LearnServe as a result of the decomposition of learning-related processes, and we discuss the challenges that need to be met for realizing such a platform. In Section 4 we show how content can be organized for exchange, how content publishing can be done, and how content access can be managed in a distributed platform. Section 5 concludes with a discussion of some of the problems that deserve further study.

2. Exploiting web services for electronic learning

In this section, we describe the basic assumptions and ideas behind the creation of an e-Learning system based on the Web services paradigm. Essentially, we need to distinguish the learner (or client) side and the provider side, where the latter includes all the functions of a learning system other than those pertaining to learners. We discuss each side individually in the following subsections. For both we focus on content aspects since we later want to illustrate the handling of content in a distributed system.

As has initially been discussed by Vossen and Westerkamp (2003), in an e-Learning system a variety of features and components can be perceived as processes and consequently be realized as atomic or composite Web services; examples include content authoring, content configuration into classes or courses, learning object management, content updating, learner registration and management, content adaptation, learner profiling and tracking, testing of acquired knowledge, tutoring, virtual classroom setups, organization of chat rooms, and last, not least, the search for and presentation of content itself. Thus, we imagine that the entire functionality of an electronic learning system is decomposed into individual activities or groups of activities which can be implemented independently and offered as services, in such a way that the original functionality can be “reconstructed” through a suitable service composition. Notice that this is an application of the core Web services paradigm as described, for example, by Alonso et al. (2004) or by Newcomer (2002), to the area of e-Learning.

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\(^1\) Customer Relationship Management  
\(^2\) Enterprise Resource Planning
In such a scenario, all learning objects, classes, and courses may be stored on different servers, and they need to be registered in a central repository together with meta-information. An individual learning object (i.e., content) is not stored in this directory. To “use” a class, the underlying service platform needs to call the desired learning object, which is then accessed by a presentation service and delivered to the learner. The particular Web service used depends on the metadata, which should be provided by the author of the course and which should fit the profile and preferences of the learner (see below). Figure 1 shows the service subsystems that we will later describe in detail. In particular, we make a distinction between three kinds of services:

![Figure 1: e-Learning as a web service.](image)

1. **Content Services** provide the learning material in form of learning objects, courses or classes.
2. **Discovery Services** are used to search for content (content repository) as well as for additional functionalities that can be added to the system (UDDI).
3. **Further Web Services** can implement a huge variety of functionalities. This can include typical e-Learning activities and third party services that are worth to be consumed by both learners and teachers. These services also encompass payment and certification services.

We mention that the choice of subsystems we discuss here is not exhaustive, and that various additions may be feasible. We also mention that this architecture allows for a variety of implementation choices, i.e., which part of the system is implemented in the central platform that is used by the client and what parts just call upon external or remote Web services.

**2.1 Provider side**

The provider side is split into different sections that can be handled by individual services. There are authors who create learning objects (LO), authors who build courses or classes from such objects, and trainers who communicate with learners. Authors creating content do this for a specific group of people or just for an anonymous circle of learners. The first step in building learning material is to create individual learning objects which may afterwards be configured into classes and courses, as we have described in Vossen and Jaeschke (2002, 2003). We assume that authoring tools are made available as appropriate Web services, so that an author can choose between different services to select the one which is best suited for his or her situation. At the end of a content creation session, an author registers the new content in a content repository; in addition, the LOs produced are stored on a selected server of the content provider (see Figure 1).

The creation of classes and courses can even be done by users or persons who are not themselves authors of LOs. To do so, they use existing LOs from other suppliers and combine them into a class or course. This creates a kind of added value by plugging the LOs together and cutting development time. New classes are also stored on a server and registered in the repository, without storing the LOs again, because the latter are reused from the

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publisher. Even the action of publishing may be handled by the same Web service as the publication of the LO as described before. The provider side also has to offer Web services to deliver and represent the content to the learner. The presentation of the material depends on the technical requirements of the LO and is not discussed in detail here.

Special services, also on the provider side, need to be available for handling trustworthy actions, such as the collection of payment from a content user or the transfer of royalties to the respective content author, the certification of classes for special exams, or the storage of user profiles. Even the execution of tests and exams or the tracking of a user can be handled by corresponding services. A tracking service is designed to check for completion of assignments, determination of degrees if applicable, and updates to the learning allowances or charges in the account of the learner. Importantly, all these services can be implemented as Web services. As shown in the example of the Petri net (Reisig 1985) in Figure 2, content certification is typically a strictly defined process that includes searching, reviewing, and certifying of specific material. Each of these sub-processes can straightforwardly be implemented as Web services (encircled actions). Afterwards these services can be composed to a complex Web service “Content certification”.

Figure 2: Web services in a content certification process.

Note that the “syntax” of a Petri net as the one shown in Figure 2 is such that rectangles represent activities which may be atomic or composite, and that circles represent “states” of the system (which may be initial, intermediate, or final states) or documents that are consumed or produced. For example, the “Certify LO” activity, which is a composite one (indicated by the double bars), has as input one or more LOs that have been checked already and that are now ready for being certified, and that has as output the certified LO or LO collection. Additional processes of this type have been described by Vossen et al. (2002) or Grüne et al. (2004).

2.2 Learner side

As mentioned earlier, different kinds of learners will want to access and use an e-Learning system with various motivations and perspectives. In a Web-based system the learner ideally just needs a Web browser to use the system, and he or she does not have to bother about what part of the platform is part of the server system and what part is actually a Web service that gets included from a remote site. A personal login ensures that a profile can be created for each user, in order to adapt the system to a user’s preferences.

A learner usually logs on to the system with a clear intention of what to learn. Often a learner has already been assigned a course and can start working on the material right away. In our vision of future learning scenarios, the typical learner searches a content directory and “orders” learning objects, classes, or courses that match his or her requirements. Such a search may be driven by needs, prerequisites, budget, client hardware and software, preferences, age of material, author/provider, and the profile of the learner. Upon presentation of search results, a learner can choose and “book” the content he or she wants to use or consume. Suppose the choice is a class which is generally composed of several learning objects that will be presented to the learner in some sequence. The learner just uses the presented material as it would be in a
centralized runtime system of an LMS. In fact, each presentation of material technically consists of a search in the content repository, a call of the learning object, and a call of the corresponding Web service to present the material.

During a learning session, the executing platform has to decide whether or not a learner has passed given test sections and, based on the outcome, whether and which learning objects to present next. If the learner fails such a test, the system has to decide whether to repeat the presentation or to switch to an alternative, where the latter can be done by a dedicated Web service based on the content, the learners' preferences and the authors' prerequisites as mentioned above.

Figure 3 shows a high-level Petri net in the same syntax as before where possible application areas for Web services in the booking of content are again circled. The search for content is done by a search service, which in turn uses another service for querying the user profile and for selecting an appropriate learning object for a learner. Since not every such object can be used without charge, a payment service is also included in the process. At the end, a special service is used for updating the user’s profile. Clearly, also the activity of learning can be associated with various services.

Learners typically need assistance during their work on the material. Help can be provided in an e-Learning system using asynchronous techniques like email or message boards or by using synchronous techniques such as chat with a tutor or video conferencing with virtual classmates. Clearly, all these functionalities can be included in an e-Learning environment by calling upon respective Web services of special vendors, as is currently done in business environments for virtual meetings and video conferencing; details are omitted.

3. LearnServe: Making learning offerings available as services

In this section, we provide an overview of LearnServe, a system under development at the University of Muenster; specifically, we show how its functionalities are identified to be built as Web service.

Clearly, it is a crucial design decision which part of a platform should be “outsourced” and hence be included as a Web service from an external provider and which part is not. We mention that a realization of an e-Learning platform as a collection of Web services can basically use an existing service platform and its development tools (e.g., HP Web Services Platform, Microsoft .NET, Sun ONE, BEA WebLogic Enterprise Platform, IBM WebSphere). However, as the discussion about “standards” in this area is far from converging, we are currently experimenting with our own prototypical implementation that grew out of our XLX learning platform (Hüsemann et al. 2002) as well as out of e-Learning workflow studies done in the context of the INCOME Teacher project (Vossen and Jaeschke 2002, 2003; Vossen et al. 2002).

As has been indicated, the idea behind LearnServe is to take the functionality of an e-Learning system apart, specify its major
components and activities as processes (cf. Figure 2) that can be executed as workflows, and group the result into atomic and composite Web services, for which UDDI as well as WSDL documents are then prepared. The prototypical implementation independent of a commercial platform, which is discussed next, renders it possible to study various aspects specific to learning environments and scenarios; its overall architecture is shown in Figure 4.

From a logical point of view, LearnServe is divided into two parts: a client software and Web services provided by several vendors or providers. All core components of LearnServe are gray shaded in Figure 4. The LearnServe client is the web-based “access point” for a user that enables her or him to consume and use the learning services. These services are implemented on distributed servers and in particular include authoring, content, exercise, tracking, and discovery services as well as communication services such as email and message boards. Usage of these services is not limited to our own clients, because the implementation of the entire functionality as Web services enables an integration of the e-Learning functionality directly into any business application, in order to interact with applications, processes, and information. The learning Web services can also be used on mobile devices if there is an appropriate client for that device.

As mentioned, the LearnServe system is based on XLX3 (Hüsemann et al. 2002), which has already been used by different German universities and other customers to train graduate level students in various scientific courses. XLX is implemented using a typical three-tier architecture consisting of a client, an application, and a data layer, resp. Students need an Internet connection and a Web browser to access the system, but no special client software or plug-ins. On the server side, XLX uses an Apache Web server with PHP as well as a Java servlet engine, and stores all necessary data in an IBM DB2 UDB database or in a system with similar functionality. To include third-party systems (such as an XSLT or an XQuery processor) for training purposes, XLX also provides an external interface.

For LearnServe, XLX is currently being enhanced for Web service support (see light

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3 See http://dbms.uni-muenster.de/xlx for more information as well as a guest account.
gray shaded box in Figure 4) to reuse the already implemented exercise and training sections. XLX now serves as a provider of Web services to be used in our LearnServe client. All services are registered in a UDDI directory which provides all necessary information to use the functionality of the remote service within our platform. If one of these internal Web services of XLX is called, the corresponding listener module recognizes this and executes the service. Upon execution, the services are able to communicate with different data sources to read or write the information as needed to (e.g., learning objects or data of a user profile).

Additionally we are implementing services for the usage of learning objects in the LearnServe client. These are based on the one hand on the well established SCORM standardizations and on the other hand on the already mentioned Web services standardizations. Of course this content can be combined with the exercises provided by XLX to build comprehensive courses.

The strict modeling and analysis by cutting the process models in parts delivers a detailed to-do list of what to implement as Web services. In the next section we will focus on the services and requirements in the area of content usage and offering and the potential that service orientation provides.

4. Content management in a web services based system

This section is to show how learning objects are handled in a Web services based system, with both advantages and disadvantages. Several problems newly arise in a distributed system when compared to a centralized learning platform, which require specific solutions.

Content for e-Learning can be composed of miscellaneous items such as text, pictures, videos, animations, diagrams, XML and HTML files, etc. Moreover, content should be designed in a way so that it can be exchanged between different learning management systems, in order to enable efficient reuse. To this end, the IMS Content Packaging Information Model (IMS 2001) specifies a technique for storing and exchanging learning object content using XML and a suitable bundling of files and is part of the SCORM standard (ADL 2001). There are three steps in preparing given content for being exchanged:

- First, a so-called Manifest document, which is an XML document, is created; this document is then validated in the second step. Finally, the XML document is bundled with physical files which contain the actual content to form a package. Thus, a package is a logical directory and consists at least of two major elements:
  - a special XML file (the Manifest, always called "imsmanifest.xml") describing the content organization, metadata and recourses in a package in conjunction with any XML control document that it references, and
  - the physical files being described by the Manifest file organized in subdirectories.

This IMS Package represents a unit of (re-) usable content and can be combined or composed with other packages; for an easy exchange and storage it can be incorporated into a single file (using standard archive formats, e.g., zip, jar, or cab), too, which is henceforth called a “Package Interchange File” (PIF) as indicated in Figure 5. PIFs can be sent over the Internet or be exchanged via CD-ROM.

The Manifest can include an identifier for labeling purpose and a version which refers to the IMS Content Packaging version number. As seen in Figure 5, the Manifest is subdivided into four parts which contain a meta-data section, an organizations section and a resources section as well as an optionally additional Submanifest:

- The metadata of the learning content in the meta-data section is embedded into a metadata tag and follows the specifications of the IMS Meta-Data Information Model (IMS 2001). The metadata describes the Manifest (and thus the learning object) as a whole.
- The organization segment contains information describing the structure of the content in the package, e.g., the table of contents or a custom structure.
- The resources reference the actual content. This can be a physical file in the
package or even a reference to another Manifest file. Each resource can be additionally described by metadata following the specification of the IMS Meta-Data Information Model (IMS 2001).

- Any nested Submanifest describes the content at the level to which it is scoped, such as a course, instructional object, or other.

The objective of the IMS Content Packaging Information Model is to define a standardized set of structures that can be used to exchange content. These structures provide the basis for standardized data bindings that allow software developers and implementers to create instructional materials that interoperate across authoring tools, LMSs, and runtime environments that have been developed independently. Further information can be added to the structure of a Manifest document, like IMS Simple Sequencing (IMS 2003) for defining the behavior and a set of rules for content selection within a course.

Since content cannot be stored in a central place in our distributed environment, we provide a repository that is based on the information provided in the Manifest documents of the PIFs. The repository is made up of several Web services to use its functionality from a remote system, as well as a relational database to store the information about a learning object. The object itself is not stored in the repository; instead, a cross reference is provided in the repository which points to its actual location. For example, this location can be a Web server of the author which has a unique address. The main idea when publishing a learning object is that a Web service can be employed to read the object’s metadata of its Manifest document and to store this information in the database provided by the repository.

Notice that this approach has several advantages: For one, calling the described actions can be made very flexible using a dynamic call of Web services, such as the one introduced by Keidl et al. (2002) and described for an e-Learning scenario in Vossen and Westerkamp (2003), by querying the UDDI directory of all available services that are based on the same technical model; in addition, the use of learning objects can become dynamic. Traditional systems have to import learning objects to their own data pool in order to make use of them. This makes learning object availability dependent on the local database system only, at the expense of limiting reuse (in particular in other learning communities) and exchangeability. Using a central content directory enables authors to reduce the workload of creating courses by reusing content from other authors. Because content is stored on distributed servers we have to transfer the dynamic call of Web services to the call of learning objects.

As an example, think of an online course to become a database certified engineer (DCE) as shown below in Figure 6. A learner may first look up the requirements, which are published by the database system vendor, then registers for the course, obtains a to-do list, and starts with the first learning object. The system knows how to assemble learning objects of a particular type, thanks to the authors’ class (and course) definition. Let us have a closer look at a “schema tuning” object, which is called after a successful processing of the class for “database administration” as well as after the “query tuning” object. The platform triggers the call of the object by using the definitions the author has made while building up the class. In fact, the author has defined different objects for “schema tuning” to be possibly used in the class. Depending on the preferences of the user and on the (time or cost) allowance, the system selects the object that fits the learner’s needs and profile best. Hence, different learners can receive different objects on the same topic if working on the same class, depending on their personal data and preferences. Let us now assume the system has chosen an object for submission to the student. Based on the metadata of the object, a Web service is called that computes the optimal presentation of the material to the learner and delivers the result of the computation. This is not a static call either, but a dynamic one for the presentation of the object. Restrictions and preferences of learner, author, and client trigger the choice of the Web service to present the material.

Building a system of dynamic selection of learning objects has the advantage of an increased flexibility and adaptability. A learner does not even have to notice an exchange of learning objects for the purpose of updating or adapting the course material to his or her needs, or for exchanging content in case of a learning object being offline and hence unavailable. Critical, however, are the facts that reusing learning objects and storing data about them in a central content directory require a use of generally accepted standards. Today, many e-Learning systems do not care much about standards and use their own way of handling content, what makes this material difficult to be reused for a system based on
Web services. This lack of interchangeability can be solved by using Web services to create the content, which are implemented carefully to use corresponding standards; we mention that this is not yet generally the case today. On the other hand, the dynamic call and flexible exchange of learning objects leads to the problem of being able to evaluate and compare them. To use different objects on say, “schema tuning” in a database course, they must have a comparable and similar content to ensure that all learners can learn the same topics, reach the same level of knowledge, yet do so in different ways. This problem can, for example, be solved “manually” by the author of a course or by a special instance that certifies learning objects. The latter has the advantage that certified content can be used to confer degrees after passing an (online) exam.

In addition to the dynamic exchange of learning objects during ongoing learning activities, an author can exchange an object without changing the definitions of the respective course. The main advantage of distributed storage of content is an easy upgrade and correction of content, because the author just has to replace special (commonly just small) parts of the package without changing anything in the repository, if the metadata of the content remains unchanged. Clearly, the repository has to provide a versioning of learning objects since major changes may confuse learners. A disadvantage is that potentially dead links are stored in the database. To resolve this problem, the repository needs to scan stored links regularly to detect registered, but already erased learning objects. The usage of Web services enables developers of an LMS to include the functionality of the repository straightforwardly into their own systems and hence opens them up for a larger diversity of content. This can reduce the authoring of content tremendously, as content can be much easier reused. The learner has a choice of much more content to use - he has now even a choice of similar content of different authors.

Another problem concerns security aspects on the client side. Since learning objects might execute programs on the client’s computer, it is difficult to ensure that no attacks will take place to that machine, since normally everybody can build content and provides it for download. Finally, all repositories independent of the type of storage and access properties face the problem of having to verify or at least check the quality of the registered content. To a large extent, this problem can only be solved by human supervisors. The LearnServe repository provides a Web service for reviewers to certify content to allocate LOs of a certain quality to learners.

5. Discussion and conclusions

In this paper, we have described how content can be handled in a Web services based electronic learning platform. Several positive aspects such as a dynamic exchange of learning objects during a learning process as well as an easy updatability of content are provided by distributed storage in connection with a central repository which keeps metadata about the objects. Moreover, a consequent modeling of learner, author, trainer, administrator, and system activities as processes enables us to break down the functionalities of traditional centralized learning platforms into many small components and individual applications that can be "outsourced" and hence be realized as Web services.

We mention that we are not claiming a general replacement of present-day e-Learning systems and scenarios by systems based on
the Web services paradigm. Instead we envision what we have described in this paper as one of several forms in which future learning will take shape. The Web services approach seems particularly suited for learners seeking secondary or tertiary education on demand, due to changing or new job requirements, personal interests or necessities, or other conditions. What has been described in this paper is only a first step in this direction.

We conclude by mentioning several approaches that are related to our work. Sadiq and Orlowska (2001) have introduced a workflow based e-Learning system, where content can be exchanged in the workflow model, and plans can be defined to enable different pathways through the learning content in a centralized system. A similar approach is the COW system under development in France, see Vantroys and Peter (2001). Its goal is to develop a workflow based system for e-Learning purposes which is supposed to support personalization and adaptation as well as a sequencing of learning activities. On the other hand, there are several different repositories in the area of e-Learning: iLumina provides a centralized register and references content on distributed servers; however, it is not based on the IMS Content Packaging and on Web services, which makes an integration of content difficult. The LORAX repository provides a central content management facility ("The Exchange") to store and publish content. A detailed specification is given how to access this repository via Web services to search for and retrieve learning objects. Learning objects are delivered in the form of PIFs from the central "Exchange". Finally, OLR (Open Learning Repository) follows the idea of not storing content within a repository, but it is not accessible via Web services; for details, see Dhraief et al. (2001).

Among the issues that deserve further studies are on the one hand technical ones, such as the provision of easy-to-use interfaces for Web service composition. Indeed, if a learner is faced with the task of composing a course by herself or himself, this should not have to deal with, say, integrity or plausibility checks; instead, whatever is offered as possible composition parts should indeed be composable. Another study area, from a more conceptual perspective, needs to deal with the provision of pricing models. Here we envision strategies similar to those currently used by telecommunication providers, including flat fees, “call-by-call” fees, or base rates plus fees based on usage. Pricing schemes not only need to consider what learners have to pay, but also, for example, what authors can make in terms of royalties. We expect to report on these issues in the near future.

References


Context, Content and Commodities: e-Learning Objects

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Abstract: This paper is about one of the central dilemmas of e-Learning: can we separate content and context, and how should we manage the relationship between the two? Or to put it another way, are Learning Objects just commoditised learning? With the growth of e-Learning over the past few years, learning objects have come into their own. They are the component units of e-Learning, and in principle can be combined in a myriad of ways into many different courses: Learning Objects are the commodities of e-Learning – they are exchangeable across courses and contexts, and should provide a new and efficient common currency for teaching and learning. If they do, they might be the answer for the administrators and managers of education and training. But will they be the answer for the learners and teachers? e-Learning provides quite new affordances and learning environments which can be understood with help of complex adaptive systems theory.

Keywords: Learning Objects, content, context, granules, meta-data, meta-content, meta-competencies, affordances, complexity.

1. Introduction

e-Learning has come to mean different things to different people. For the purposes of this paper e-Learning will be broadly defined to include e-courses, e-training, e-spaces, and e-publishing (on-line and off-line). However, Learning Objects (‘LOs’, or as I would call them ‘LOdules’) will be the focus of this paper, and they are mainly to be found in on-line courses of some sort. Learning Objects are often defined as ‘chunks of learning’, but as Stephen Downes says, “people should stop thinking of learning objects as though they were classes or lessons or some such thing with built-in intent. It is preferable to think of them as a greatly enhanced vocabulary that can be used in a multidimensional (as opposed to merely linear) language” (2003). This is more useful, as it shifts the emphasis from the level of the LO to the level of the course, which is where the value is, and where learning occurs, and it shifts the emphasis from sequence and bits to connectivity, networking and context. But how can LOs be designed, constituted, stored, accessed, and processed so that they can indeed become this “greatly enhanced vocabulary” for teaching and learning? That is what this paper will explore.

2. Learning Objects

2.1 What are Learning Objects?

Learning Objects are:
- Units of learning that include learning objectives, content, competencies, activities and even assessment.
- Units that are formatted as content, which is separated from information about its presentation and its description. This information is captured in meta-content tags, in XML. Importantly, these meta-content tags describe the uses of the LOs, rather than their content. Because content and meta-content are separated in this way, the same content can be presented in more than one way, on more than one display technology, and the content and meta-content can be changed and updated independently of each other.
- Units that can be re/arranged to fit the context and the needs of learning – even down to individual learners - to deliver just-in-context learning, or learning which is just-in-time, just-for-me, and just-enough.
- Stand-alone units (or events as I will describe them below) that can be arranged in a whole spectrum of ways: from what could be called a random grazing approach where you proceed from any LO to any other LO right across to a lock-step sequential approach, possibly with the addition of a tiered hierarchy of LOs, modules, and the ‘course’, as we will see below.

Downes (2003) reminds us however that “the content is not contained in the parts, it emerges from the combination of the parts. The use of learning objects consists not in stringing them together in a narrative, but in arranging them, like a painting, an orchestra, [or] a sand castle”. Downes focuses our

1 Random grazing is borrowed from the Ugandan AIDS campaign, which advocates zero grazing, or keeping to one partner – keeping to the straight and narrow.
attention on the inter-relatedness of meaning – the well established semiotic principle that meaning is to be found in the relationships between words, sentences, or Learning Objects. He extrapolates this to the content itself, which might seem like he is stretching it a bit, but he makes a useful distinction, as we will return to in 1.2.

2.2 Granules

What then are the components of Learning Objects? Learning Objects are combinations of what are generally called granules. These include photographs, texts, animations, graphics, matrices, statistics, spreadsheets, workshop exercises, assessment questions, articles, video and audio clips, through to case studies that might be quite substantial. These are even more stand-alone, without being 'designed' to be stand alone - they occur in the same form in other contexts, and are highly amenable to combination. They do not generally have any assessment, learning, or pedagogic implications embedded in them. They appear quite sensibly in many other 'non-learning' contexts. By the same analogy above, granules could be said to be the atoms of the chemistry of learning. Granules are clearly 'content' or 'raw content', and need to be described in repositories as such – as content. They have to be specifically situated within a particular learning context (for instance a LO) to be directly relevant to learning.

Learning Objects, in contrast to granules, are not learning content in the same sense at all. We can distinguish LOs from granules by calling them learning activities, or even more broadly, learning events. In these learning events, learners are introduced to a (micro?) topic, given tasks to carry out, asked to interact with several sources, form some opinions, views, and perspectives – and then to engage with other learners. Learning Objects always have assessment and pedagogic implications embedded in them, including interaction with other learners. They may be formally assessed on their own. They have to be very specifically designed as 'stand-alone' units, and in contrast to granules would look quite out of place in non-learning contexts.

2.3 e-Learning modules and courses

An e-Learning module is a set of LO’s, within a theme &/or sequence, lightly or firmly linked, and specifically assessed on its own. Module assessment may or may not be the sum of the assessment of several learning objects. Modules are combined to form courses. Course assessment similarly may or may not be the sum of the assessment of several modules. Courses often have an end of course assignment as an overall and summative assessment, in addition to the module assignments. This often takes the form of a meta-assignment, which is a commentary and analysis of some of the module assignments, presented in a portfolio. Of course this tiered hierarchical structure would restrict what I referred to above as a random grazing approach, in which the learner is entirely in control of how they proceed from one LO to another. What is at issue is not how open or hierarchical the learning environment is, but what the balance is - for particular learners - between opportunity and confusion, and between intuitive navigation and embedded structure.

3. Context and content

3.1 Commodification

It has often been said that Learning Objects are just part of the further commodification of learning, and that this represents the end result of continued attempts to strip any context from content, for purely financial reasons, to the detriment of all quality and in-depth learning. In other words, it is said that learning managers separate content from context and delivery only because that makes the work of materials designers easier and cheaper - as they can literally transcribe content from one course (and contract) to another - and because it enhances the rationalisation of the production of educational content and learning, as well as the further casualisation of educational professionals. But pedagogically we have to ask the questions from the learner’s point of view: do the LOs 'add up' to anything? Do LOs increase the opportunities for creativity, exploration, and effective learning, or do they restrict and impoverish the learning?

3.2 Information and knowledge

There has been a long and interesting debate as to whether you can separate content and context (see for instance Snowden 2002). One way to approach this is to take an “each to its own” approach – i.e. to distinguish between procedural information/algorithms which are by their very ‘scientific’ nature decontextualised, on the one hand, and strategic knowledge which is about how we fit procedural algorithms to specific contexts on the other hand. ‘Fit’ includes institutional, financial, technical, social, cultural, and personal factors.
‘Fit’ is all about context. In this way we can distinguish between two different domains of competencies – on the one hand a set of competencies which are decontextualised, and on the other hand a set of meta-competencies which find, design and operationalise the fit between these decontextualised competencies and particular contexts. That gets rid of the false dichotomy between contextualised and decontextualised competencies, by demonstrating that the relationship between procedural information and strategic knowledge is cumulative and iterative, and not a dichotomy at all.²

If we follow this line of thought, we can distinguish between those procedural-information-type algorithms and their associated competencies, which are in principle decontextualised on the one hand, and on other hand the competencies which match and fit procedural information to contexts, as strategic knowledge. Knowledge in this sense is about strategy, design, appropriateness, risk assessment, risk management, and executive decision making, all of which are about relationships, alliances and contexts. Procedural information is in contrast about skills, administration and compliance, which are portable across contexts and relationships (they may not be appropriate in all contexts, but that’s a separate issue). Knowledge is then a meta-competency: cumulative and super-ordinate to skills and procedural information.

3.3 Skills Objects and Knowledge Objects

The distinction between procedural information and strategic knowledge enables us to distinguish between those kinds of LOs that could quite reasonably be decontextualised, (commodified if you will) and those that certainly can not. This distinction enables us to examine the nature and purpose of particular LOs, to see to what extent a substantial degree of contextualisation will be necessary within particular LOs before we get to Downes’s issues of orchestrating the component LOs into a composite learning event. It might be useful to subdivide Learning Objects into Skills Objects and Knowledge Objects along these lines. If we do, we can, broadly, divide these learning activities into those Skills Objects which are probably amenable to formats such as Computer Aided self-Instruction [CA(s)I], and those Knowledge Objects which probably require an interactive discussion forum format. However, taking into account the complexity of applying skills in any context (which includes as I said above, factors such as: institutional, financial, technical, social, cultural, and personal fit), it is likely that in most cases even the most narrowly defined Skills Objects will also benefit from the addition of some measure of a discussion forum format as well, where that is possible.³ These distinctions allow us to operationalise learning in stages, and to arrange the best blend of learning objects (Skills Objects and Knowledge Objects) as well as the modes of learning (interactive and self-instructional) accordingly.

Commodification is built into most of what we do, and who we are: science and technology, as well as finance, is premised on decontextualised algorithms, information systems, credit, techniques, and technologies. It is a very powerful meta-discourse, which allows for unprecedented levels of efficiency, commerce, sharing, and global interaction. We are very good at it. What needs some attention is the strategy and relationship part – knowledge: how we use procedural information within relationships and contexts: what might be called intelligent management rather than just strategic knowledge.⁴

² And this distinction does not relate to the tacit/implicit distinction at all. A lot of knowledge is implicit or ‘tacit’ because it is knowledge which ‘fits’ from a personal perspective, which by definition is difficult if not impossible to share.

³ This is one of many points in the design and management of learning events and environments at which you need to decide whether to follow the money or the pedagogy. Financially, CA(s)I is cheap to administer – the cost of distributing on-line or CD based courses is minimal, whereas the cost of providing interactive learning is certainly not cheap. This applies to both face-to-face and virtual learning, although virtual learning can achieve some economies of scale that will never apply to face-to-face learning. Blended learning is one way to try to get the best of both worlds.

⁴ There is of course another layer beyond algorithms and strategic knowledge, namely programming. Lash (2002) points out that society is currently best described in terms of configurations of networks, many of which are virtual and, along with Drucker (2002) and Castells (2002) he points out that we are already moving beyond the networked economy into the programmable economy. Programmability offers further potential and further challenges, beyond algorithms. Programmes offer the possibility of unlimited access to potentially free copies of fully operational programmes which when fed into the right machine could produce, for instance, a gene sequence of your choice, or eventually even a clone of your choice. It is a whole set of operational competencies that are commoditised within programmes – an quantum leap up from mere algorithms, with a flavour of strategic knowledge embedded too. A totally new level of commodification, and new challenges and opportunities for learning and for society.
In more practical terms, we might also distinguish other subsets of 'learning objects', according to their purposes: Information Objects, Assessment Objects, Networking Objects, etc. The point is that we need to have an understanding of the degree to which it is appropriate to decontextualise some learning activities and competencies, and not others. And it is a matter of degree – much as I have argued that there are many competencies that can in principle be treated as decontextualised, I would also argue that the application of any competency is a highly contextualised matter. Which means that the deployment of LOs remains a matter of orchestrating them within a learning context and, following Downes, a work-life context too, which is even more complex. The question is: How?

4. e-Learning courses

4.1 Courses and events

The prevailing discourse of education and training is very instructive. We talk of courses, and ask people to register for a course. The metaphor is that of a race, or a rite of passage – probably with obstacles along the way which you have to overcome or endure, and for which you will rewarded if you complete or run the course from end to end. Key embedded concepts are: sequence, pre-determined route, and end point or finish.

Educators seem to be somewhat confused and caught between paradigms: most of us still talk of constructivist approaches to courses, which is an extended oxymoron as we will see below.

Downes (2003) presents a refreshingly radical alternative perspective. He contrasts a narrative structure with an arrangement “like a painting, an orchestra, [or] a sand castle”. The orchestral metaphor is useful, although the sand castle has interesting potential too. Much of the design and even vocabulary of e-Learning, and connected learning more broadly (on and off-line), has changed. We talk of ‘e-moderation’ and even ‘e-tivities’, and in the process have moved on from facilitated learning to moderated learning.

So what is it that has changed in the modes of teaching-and-learning? (They are now inextricably intertwined, just as information and communication are). For lack of a better term, e-Learning – and certainly discussion-forum-based e-Learning – is now ‘run’ as learning workshops. They are partly like orchestrations or performance, but they are even more like participatory workshops in music, drama or art.

These learning workshops have the following characteristics:
- They are performative and inclusive.
- The ‘audiences’ or ‘clients’ are the major performers, not the designers, moderators or ‘providers’.
- The role of the moderator is to create a learning environment, to set up the initial group dynamics, and then literally to ‘moderate’ it – to shepherd it – to watch the way it develops and grows, to nudge and stimulate it, and offer ‘corrective suggestions’.
- The development and interpretation of the learning programme or score (to use the musical metaphor) is best seen as the exploration of a set of complex affordances than a set of tasks – even if there are very specific milestones and signposts. Modern musical scores might be instructive for e-Learning designers and developers, particularly the more experimental music of the 1970s and beyond.
- The performance of an e-Learning workshop is, like all good participatory performances, unpredictable, even though it might be very clearly recognisable as an instance of a particular ‘course’. Just as every performance of a musical score (particularly modern scores) is different, and is often designed to be different, so too each iteration of a learning workshop should be different. The design of the learning environment should maximise this potential for surprise and creativity where possible, as learning is about personal and collective growth – both intellectual and social, above and beyond the skills that are learnt. The moderating and management paradigm for learning workshops is more one of watching for emerging properties within a complex self-adaptive systems framework, rather than checking for compliance with benchmarks in an administrative framework.
- It is much more appropriate, then, to invite people to participate in a learning event rather than market the opportunity to register for a course, and it would be an interesting benchmark of how on-message educational administrators and marketing departments are (or are not) to see if and when they agree to this change of register, if not a change of discourse. The ‘learners’ might more usefully be referred to as
participants’, doing away with the terms ‘learner’ and ‘student’ altogether!

- A useful introduction to a participative learning event would be to talk about other participatory events that people have experienced and valued before, and what worked best for them, regardless of whether these events had anything to do with education.

- Assessment tools need to be developed to value even the micro contributions that spark off emergent properties rather than (just) valuing large chunks of predetermined ‘assignments’. In principle a single generative (micro) intervention in a learning workshop should be able to be validated as sufficient to indicate competence across the ‘course’ as a whole based on the value of the emergent properties that result.

4.2 Absences
Part of good design - typographic design anyway - is about the design of the ‘white space’ – the absences in the layout. It is possible to design a course which uses LOs as content ‘nuggets’ within a carefully designed set of absences – the spaces between the LOs. That would be something different from the ‘clunkiness’ of random LOs knocking about an over-commoditised course. So one should keep in mind that the absences could/should be part of the design of the learning environment.

4.3 Constructivism
Part of the debate around LOs in a ‘course’ which I am currently e-moderating at the OU (H806) was clarified for me in the discussions on how one could map out the content of one of the modules. One way is to construct a personal perspective (schema/mindmap) of the module from your point of view as a participant. The course in question groups LOs in themes, and these are grouped into modules, which make up the course. This tiered hierarchy offers a course structure, or framework. However, this did not necessarily offer too many pointers as to how the participants could contextualise the LOs within their own work/life concerns. Two of the participants created mind-maps of the module that were very different. One participant said that he had found it exceedingly frustrating up to that point (the last of four modules in the course) as he had until then been unable to see how the whole course fitted together. It was only when he created this ‘fit’ for himself, which reorganised the LOs in quite a different framework that he was comfortable with engaging with the course.

This is an example of what I would call ‘enticed constructivism’ (or even ‘enforced constructivism’). The participants are in a sense ‘set up’ in a situation where they have to construct a context to fit all these bits and pieces, in order to make sense of them at all. An ‘enticed constructivism’ design follows Seymour Papert’s notions, in his very interesting work in designing LOGO as a learning environment, in that it presents a series of tasks, information, learning events etc in a way that in a sense ‘begs’ to be organised by using a super-ordinate or meta algorithm, which is not provided until the learner has ‘constructed’ it in their own mind.

There are a number of possibilities for such ‘enticed constructivism’:

- The tiered-hierarchy and sequential structure may provide a satisfactory framework or perspective – a ‘course’ or ‘learning’ perspective - which might satisfy some participants.

- Other participants might find this very unhelpful, but might already have the competencies and confidence to ‘construct’ their own framework.

- Yet others might be confused, and have no idea as to even what it would entail to ‘construct’ their own framework.

- If the brief for the designers is just to develop a ‘course’ then the course framework will be deemed to be satisfactory, and the question of context and framework will hardly even arise.

- If the design brief is to develop a ‘participatory learning workshop’ then clearly the participants’ work/life contexts do matter, and if their contexts do not coincide with the course framework, they should be encouraged and enabled to create frameworks that are satisfactory for their contexts.

4.4 Content and Meta-content
These frameworks or perspectives create a context for learning. They can and should be
created as metadata, or metacontent, in which case numerous frameworks can be created relating to any particular set of course content – within and outside of a particular module/course/learning workshop. It should be possible to exchange these frameworks too – either in text or in some map/mind-mapping form, and to create profiles of learner types – preferably based on their contexts as users of the learning, or simply as members of a community of practice.

The texts created in discussion forums are a mixture of content and meta-content, as they include both new texts, and comment on texts within the course material. If knowledge is about context, or meta-content, then it follows that the creation and sharing of knowledge within such a course will be enhanced to the extent that meta-content is articulated and shared. In the particular course referred to above, there was some comment and discussion on why particular mappings of the fourth module were done in a particular way, and why certain things were emphasised or left out. But the discussion did not progress from there.

4.5 Blogs

Another form of meta-content is blogging – writing weblogs, which are used increasingly in learning environments, although with mixed levels of enthusiasm – from allegations of ‘vanity publishing’ and voyeurism to overblown claims that blogs are the next frontier in free speech (which is some senses they are). Blogs are diaries of comments – people tracking events on a chronological basis, whether this is tracking their personal lives, or activities around them – from the Iraqi war to what’s happening in a local learning environment.

What is interesting about blogs from an e-Learning point of view is that they do provide a different mode of participation in a course. The bread and butter of Virtual Learning Environments (VLEs) is a set of discussion forums, based on a series of LOs. These discussions succeed if they manage to develop a ‘group voice’ – a mode and tone of discussion that is supportive and safe for people to explore issues relating to the course, and which is comfortable for all the participants. It depends on how coherent and homogenous the group is as to whether this ‘group voice’ develops a recognisable context for learning or not. It often remains quite abstract, and lacking in particular context. This can be very useful for an academic, intellectual, or reflective practice type discussion, which is often what is required in e-Learning courses.

However, it is now generally accepted that blending learning remains the best way to create a learning environment, and using different media and modes of communication can add to the learning event. What is it that blogs can add?

Blogs succeed or fail to the extent that the person writing a blog finds and maintains an interesting ‘voice’ – i.e. interesting content as well as an interesting way of presenting it, or just ‘saying’ it. This provides a personal reference-context for the comments of the blogger, albeit one that develops incrementally as the blog progresses and the ‘voice’ gets established. This is useful, as it provides a contextual basis for comments, which can interface with the main discussions in the discussion forums of a course. As Winer says:

A blog is not a mail list or a discussion group, where many parties can participate equally. Indeed this autonomy of voice gives blogs what is a distinct advantage. Mail lists often grind to a halt because they have to get consensus. Blogs don't have to get consensus. The magic of a Weblog is that it can move. (Dave Winer 2003 http://www.scripting.com/dwiner/, quoted by John Cox in the OU course I referred to above).

The modes of blogging and the modes of discussion forums can form a useful blend too. Discussion forums are places where participants can articulate their thoughts, with as much time as they like to write, reflect, and re-edit a contribution before it is posted to the discussion. Blogs on the other hand are as informal and whimsical as you like – they are not posted anywhere, people have to actively seek them out to read them. They provide unique affordances to try out your thoughts, within your own context, without necessarily relating these to any particular discussion or group dynamic.

There is also another form of blogging which can provide participation in a different mode in an on-line learning workshop: a blog written by a participant who tracks ‘alongside’ the course, in a blog, with little participation in the discussions themselves’. Some of the blogs

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7 Such a person would be a ‘lurker’ in e-learning terms – a ‘non-participant’. The challenge is not to find ways to force
written as part of courses take on a life of their own, and participants start writing very extensively on one particular issue within their own blog, something which would contravene the discussion forum etiquette which requires everyone to be more mindful of turn-taking protocols, and mindful of nurturing the group dynamic. This too might add new content, even on quite new issues, or it might be ‘tracking’ commentary, which would be meta-content. Either way, it is provided within a personal context, which is not always polite to maintain or to profile within a group discussion forum.

5. Designing for online learning workshops.

5.1 The Humpty-dumpty Dilemma

I have already dealt with this at some length: the dilemma of putting the pieces together, not only after modularisation, but even more so after the commoditisation of LOs and their exchange across contexts. But to emphasise again: there is a great deal of learning to be done at skills level, much of which can be dealt with in this way, but equally there is a great deal of learning which even at skills level can only be learnt within a context, and within its application – obviously in a context. Then there is the generating, sharing and using of ‘strategic knowledge’ which can only take place within context/s – it’s all about context. And that means LOs have to be particularly well ‘arranged’ within the ‘score’ of a learning workshop. There is also the dilemma of how the ‘enticed constructivism’ is designed, enabled and managed, and whether the ‘learning’ context is sufficient for the participants who are not primarily ‘learners’.

5.2 Richness and elegance

In a world of hyper-links and global Internet sites, it is possible to add numerous links to LOs. Links are now key parts of ‘connected’ learning: on-line or off-line. In fact good teaching has always been about creating links and ‘opening windows’ for learners – long before the Internet. However, good learning materials have to do more than ‘point’ the learner to a resource - however interesting that resource may be, whether it is a website or an article in text format. Its how the ‘connection’ to the resource is structured, designed, guided, mediated and works that is the key value added. That is the difference between ‘rich’ and ‘cluttered’ learning materials, and inspiring and disordered teaching. Inter-textuality and 'inter-resourced’ learning is part of the richness that connected learning requires, but the lines of thought have to be clear.

Elegance is the complement of richness, and is basically ‘economy of line’ or ‘economy of expression’. Anne Lennon (OU course referred to above) defines it as: “Simplicity of content & interaction in relation to objectives (getting to the objectives in a streamlined way), clarity of objectives, and ease of passage through material." Elegance does not, however, preclude some embellishment, and does not have to fight against richness. The film Babette’s Feast for instance, is all about a sumptuous dinner, which is nevertheless a single, elegant gesture, and this is reflected in the cinematography. Similarly when playing Baroque chamber music, you are expected to add some embellishments, of your own choice, but without detracting from the clarity of the harmony and counter-point – the ‘line’ as it were.

I would define richness as: a set of activities which offers you the opportunity to explore a new field in many, related directions, and which enables you to relate your own experience, and your own knowledge of the context, to the issues you are exploring. More specifically richness in an LO could be defined as offering choices of resources you can use to explore the topic, providing opportunities for different ways of solving the same problem, and links to related materials and topics. And lastly, richness needs to include some links to theory – particularly for developing knowledge. Theory is by definition meta-content, as well as a sounding-board and validation domain for what goes on in strategy and operations. It therefore adds another layer to the learning material.

6. Conclusion

Content and context are in many ways inextricably linked. There are however types of procedural information and strategic knowledge which can be differentiated as context-dependent or decontextualised. The design and management of Learning Objects needs to take this into account, but it must also recognise that it is always preferable to include

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everyone to participate, but to find a sufficiently broad range of modes of communication (including audio-conferencing and audio-blogs) for everyone to find their own ‘voice’.

A person who writes a parallel ‘tracking blog’ alongside a course could be likened (within the metaphor of the learning workshop as ‘orchestration’) to someone staying outside the room, playing an independent line of counterpoint.

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context and application in learning. The hypermodularisation of LOs can serve learning and training in procedural information very well, but it can also be used creatively for generating, sharing and using knowledge, if the requirements of contextualisation and ‘fit’ and ‘enticed constructivism’ are kept in mind.

e-Learning provides a mode of communication and interaction which is very different from traditional courses. E-Learning courses could usefully be termed learning workshops or learning events, and the people who enrol for these workshops could usefully be termed participants rather than students or learners. The design of LOs and e-Learning courses should be seen as a similar activity to writing a score for the performance of modern music, which is often arranged to encourage a certain amount of creativity and surprising outcomes, and certainly designed for emerging and new properties of interaction, tone, colour, harmony/disharmony and so on. To paraphrase Downes’ terms, LOs should be the ‘musical’ vocabulary for continuously new and creative performances of learning events/workshops.

References and Resources


An Exploratory Study of Adoption of Course Management Software and Accompanying Instructional Changes by Faculty in the Liberal Arts and Sciences

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Abstract: The study investigated liberal arts and science faculty's (1) overall adoption of WebCT, a course management software, (2) use of different WebCT functions, (3) perceptions of technology's impact on teaching, and (4) demographic factors that might explain the differences between WebCT adopters and non-adopters. Only 37% of respondents reported using WebCT. The most frequently used WebCT tools were the content and syllabus tools, grade book, and e-mail. WebCT adopters versus non-adopters indicated that technology saved them time on daily tasks and enabled them to improve their teaching. No significant differences of demographics factors were found.

Keywords: WebCT, course management software, IT adoption, higher education, technology, diffusion of innovations

1. Introduction

Over the last decade, course management software has become increasingly popular with educational institutions. Course management software provides a wide variety of Web-based teaching tools including e-mail, content and syllabi posting, resource pages, chat groups, form builders, bulletin boards, grade books, online testing, and interactive exercises. Much of the literature (Courtney and Talaong 2002; Dean 2003; Esptein 2003; Lyons 2000; Xu and Sloan 2002; Zhao 1998) reports case studies of how educational institutions introduce course management software but few authors report empirically-based evaluations of the adoption of course management software (Bai, Chuvesiriporn, and Lehmann 2002; Piguet and Peraya 2000).

Despite the apparent widespread adoption of course management software, online teaching methodologies are not mainstream. Lammers and Murphy (2002/2003) reviewed the literature on teaching methodologies and reported that studies over the years still found that lecture was the primary classroom instructional methodology. Lammers and Murphy also conducted an empirical study of classroom methodologies at the University of Central Arkansas, and found that lecture remained the predominate instructional methodology.

2. Setting

In the spring semester of 1998, our university, a Carnegie Class One Research Institution with more than 20,000 students and more than 50 academic departments, adopted WebCT as the course management software of choice. By late 2003, the university had established a support staff that included a WebCT administrator, a part-time staff member handling policy questions and administrative issues, a part-time multimedia developer, a part-time graphics artist/ animator, photo and video production staff to aid in course development, and a half-time network administrator supporting the technical aspects of WebCT. The university has promoted WebCT through annual seminars and workshops. The focus of early workshops and seminars was to demonstrate WebCT's functions. In the past two years, workshops have provided hands-on, targeted practice on specific WebCT tools such as using the discussion board, using the quiz function, or uploading course content. In recent years, the university’s Office of Instructional Services (OIS) has provided about 60 short courses each year on different WebCT tools.

3. Research questions

Though WebCT is used in 1300 courses annually, little is known about WebCT’s adoption rates among faculty and the demographics of WebCT adopters versus non-WebCT adopters. Additionally the perceptions of WebCT adopters and non-adopters on the impact of WebCT and of technology in general on teaching have never been explored.

To guide our study, we posed the following research questions: (1) What percentage of the faculty adopted WebCT for classroom
usage? (2) How frequently did faculty use the different tools of WebCT? (3) When comparing WebCT adopters and non-adopters, were there significant differences in their perceptions of the impact of information technology on their teaching? (4) Were the demographics of WebCT adopters significantly different from non-WebCT adopters? and (5) Were there significant differences between WebCT adopters and non-adopters on their perceptions of the effects of information technologies on their annual merit evaluations, promotion and tenure evaluations, and post-tenure evaluations?

4. Methods

4.1 Participants

While the university has nearly 1500 faculty members, a limited budget necessitated that we focus our exploratory study of WebCT adoption. Therefore, we selected faculty in the liberal arts and natural science colleges as our study population. The departments in these colleges include: anthropology, art, biochemistry, biology, chemistry, computer sciences, economics, English, foreign languages, history, journalism and technical communication, mathematics, music, philosophy, political sciences, physics, psychology, speech, sociology, and statistics. Faculties in these departments post about 700 courses on WebCT annually. These posted courses are not fully online courses, but use WebCT as a tool to support on-campus classes. They represent 43 percent of the faculty on campus and generate 54 percent of the courses taught on campus.

4.2 Instrument and administration procedure

Using the university campus mail system in the spring of 2003, we surveyed the liberal arts and sciences faculty following Dillman's (2000) Tailored Design Methodology. The questionnaire was an eight page, 7 by 8.5 inch stapled booklet (printed on 8.5 by 14 inch paper and then folded to create the booklet) with the front cover containing a title, art graphic, organizational address and control number. Half of the back page was blank, should the respondents desire to provide additional comments. The six pages of questions were set in 11 point Times Roman font. The university Office of Human Resources provided a master list (n=657) of tenured, tenure-track, and adjunct faculty members. Adjunct faculty members were either part-time or full-time instructors hired to teach one or more courses during any one academic year. No graduate teaching assistants were included in the study. We then pulled a systematic random sample of 328 faculty names. From the original names sampled, 22 surveys were returned incomplete for a variety of reasons, such as the faculty members were no longer teaching, had left the university, were on sabbatical, had not taught in the previous year, and so forth. This reduced our sample size to n=306.

Three weeks into the spring term, we sent participants a letter notifying them that they would be receiving a survey through campus mail in about a week. A week later they received the initial mailing packet consisting of the cover letter, booklet questionnaire, and addressed envelope so that they could return the survey through campus mail. About two weeks later, we sent participants a reminder postcard asking them to return the survey, if they had not done so. We had planned a third mailing two weeks after spring break, but delayed the third mailing (which included a new cover letter, questionnaire, and return envelope) for another week because a major snowstorm closed the university the week following spring break. We waited for four weeks after the last mailing, then entered the data in SPSS for Windows Release 11.5, verified the data, and ran frequencies, descriptive, and inferential statistics.

5. Results

5.1 WebCT usage (research questions one and two)

Fifty-nine percent (n=172) of the faculty surveyed (n=306) returned completed questionnaires. Of the respondents, 37% (n=57) reported using WebCT for their classes. Using a 1 to 5 scale whereby 1 = “never” and 5 = “frequently,” the leading usage of WebCT tools, i.e. tools rated above the 2.50 median, included the content and syllabus tools, grade book, e-mail, and publishing Power Point presentations/PDF files (see Table 1).
Table 1: Usage of WebCT Functions among Faculty Members Adopting WebCT

<table>
<thead>
<tr>
<th>Item</th>
<th>Percentage</th>
<th>Never</th>
<th>Frequently</th>
<th>Mean +/- SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content and related tools (syllabus)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade book</td>
<td></td>
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<tr>
<td>E-mail</td>
<td></td>
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<td></td>
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<tr>
<td>“Publish” PowerPoint presentations or PDF files</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Threaded discussion</td>
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<tr>
<td>Assessment quiz</td>
<td></td>
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<tr>
<td>Chat/Private discussions</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Group presentations/student home pages</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Other</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Note: Because of rounding, percentage may be greater than 100%</td>
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</tbody>
</table>

While respondents reported using WebCT overall, their use of some WebCT tools was low, with two-fifths or more of the participants not publishing Power Point and PDF files to WebCT, using threaded discussion, using chat/private discussions, and using group presentations (see Table 1).

5.2 Impact of technology (Research question three)

Next, we explored the differences between WebCT adopters and non-adopters on the impact of technology on their teaching. In comparing WebCT adopters with non-adopters, significantly more WebCT adopters reported that technology saved them time on their daily tasks and enabled them to improve their teaching (see Table 2). However no significant differences between WebCT adopters and non-adopters emerged on the nine other variables of teaching activity.

Table 2: Perceived impact of technology on teaching*

<table>
<thead>
<tr>
<th>Item</th>
<th>Adopters</th>
<th>Non-adopters</th>
<th>t-Values</th>
<th>P values</th>
</tr>
</thead>
<tbody>
<tr>
<td>I save time on daily tasks.</td>
<td>M 2.92</td>
<td>2.40</td>
<td>t = -2.24</td>
<td>.026</td>
</tr>
<tr>
<td></td>
<td>SD 1.29</td>
<td>1.27</td>
<td>(1,167)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N 56</td>
<td>113</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I spend more time with students.</td>
<td>M 2.50</td>
<td>2.57</td>
<td>t = -.32</td>
<td>.747</td>
</tr>
<tr>
<td></td>
<td>SD 1.05</td>
<td>1.23</td>
<td>(1,165)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N 55</td>
<td>112</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I spend less time lecturing.</td>
<td>M 2.06</td>
<td>2.16</td>
<td>t = -.612</td>
<td>.542</td>
</tr>
<tr>
<td></td>
<td>SD 0.94</td>
<td>1.09</td>
<td>(1,163)</td>
<td></td>
</tr>
<tr>
<td>I am more comfortable with small group activities.</td>
<td>M 2.28</td>
<td>2.26</td>
<td>t = .123</td>
<td>.902</td>
</tr>
<tr>
<td></td>
<td>SD 1.01</td>
<td>1.21</td>
<td>(1,159)</td>
<td></td>
</tr>
<tr>
<td>I am more comfortable with students working</td>
<td>M 2.61</td>
<td>2.61</td>
<td>t = .030 (1,160)</td>
<td>.976</td>
</tr>
<tr>
<td>independently.</td>
<td>SD 1.22</td>
<td>1.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am better able to differentiate instruction for</td>
<td>M 2.67</td>
<td>2.52</td>
<td>t = .779 (1,159)</td>
<td>.437</td>
</tr>
<tr>
<td>students.</td>
<td>SD 1.24</td>
<td>1.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am better able to present complex information.</td>
<td>M 3.31</td>
<td>3.08</td>
<td>t = .993</td>
<td>.322</td>
</tr>
<tr>
<td></td>
<td>SD 1.35</td>
<td>1.41</td>
<td>(1,164)</td>
<td></td>
</tr>
<tr>
<td>I am better able to assess students’ work.</td>
<td>M 2.67</td>
<td>2.44</td>
<td>t = 1.162</td>
<td>.247</td>
</tr>
<tr>
<td></td>
<td>SD 1.28</td>
<td>1.17</td>
<td>(1,162)</td>
<td></td>
</tr>
<tr>
<td>I am better able to create a collaborative</td>
<td>M 2.76</td>
<td>1.59</td>
<td>t = .803</td>
<td>.423</td>
</tr>
<tr>
<td>learning environment.</td>
<td>SD 1.22</td>
<td>1.32</td>
<td>(1,161)</td>
<td></td>
</tr>
<tr>
<td>I am able to improve my teaching.</td>
<td>M 3.67</td>
<td>3.23</td>
<td>t = 2.07</td>
<td>.040</td>
</tr>
<tr>
<td></td>
<td>SD 1.24</td>
<td>1.28</td>
<td>(1,166)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N 56</td>
<td>112</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
I am able to improve student learning.

<table>
<thead>
<tr>
<th>Item</th>
<th>Adopters</th>
<th>Non-adopters</th>
<th>t-Values</th>
<th>P values</th>
</tr>
</thead>
<tbody>
<tr>
<td>M 3.55</td>
<td>3.17</td>
<td>t = 1.85</td>
<td>.067</td>
<td></td>
</tr>
<tr>
<td>SD 1.59</td>
<td>1.31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N 56</td>
<td>111</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Scale: 1 = Strongly Disagree to 5 = Strongly Agree

5.3 Demographic differences (research question four)

We then explored demographic factors that might have explained differences between WebCT adopters and non-adopters. No significant differences emerged in the percentage of male and female respondents using WebCT; about the same percentage used WebCT (Females = 30% vs Males = 35%, Chi Square = .392, df = 1, 169; p = .531). Nor were there significant differences between WebCT adopters and non-adopters in the percentage of time spent teaching [57.9% vs 60.0% (t = -.603, df = 1, 150)], time spent on research [25.8% vs 24.5% (t = .398, df = 1,144)], or time spent on service activities [15.8% vs 17.72% (t = .909, df = 1,144)]. Likewise we found no significant difference between tenure and tenure-track respondents and their adopting WebCT (41% vs 27.6%, Chi Square =1.533, df= 1, p = .213). Nor did we find a significance difference in the adoption between tenure and tenure-track faculty and adjunct faculty (37% vs 29.9%, Chi square .912, df=1, p =.340).

5.4 Effects of information technology on faculty evaluation and rewards (research question five)

Expectancy factors, i.e. norms and reward structures, can influence technology adoption. Faculty evaluations for annual merit raises, tenure, and promotion may reflect the importance of using technology and course management software. While significantly more WebCT adopters than non-adopters reported that using information technology for teaching influenced their annual merit evaluations, its importance was not high (see Table 3). No significant differences emerged between WebCT adopters and non-adopters on their perception of the importance of using information technology, and they rated its importance low for promotion, tenure, and post-tenure.

Table 3: Comparison of importance of using technology toward faculty evaluations and promotions among WebCT adopters and non-adopters*

<table>
<thead>
<tr>
<th>Item</th>
<th>Adopters</th>
<th>Non-adopters</th>
<th>t-Values</th>
<th>P values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual merit</td>
<td>M 1.97</td>
<td>1.66</td>
<td>t = 2.03</td>
<td>.045</td>
</tr>
<tr>
<td>evaluations</td>
<td>SD .989</td>
<td>.79</td>
<td>(1,130)</td>
<td></td>
</tr>
<tr>
<td>Promotion</td>
<td>M 1.83</td>
<td>1.74</td>
<td>t = .521</td>
<td>.603</td>
</tr>
<tr>
<td>M 1.72</td>
<td>1.81</td>
<td>t = -.557</td>
<td>.578</td>
<td></td>
</tr>
<tr>
<td>Tenure</td>
<td>M 1.72</td>
<td>1.78</td>
<td>t = -.161</td>
<td>.872</td>
</tr>
<tr>
<td>Post tenure</td>
<td>M 1.75</td>
<td>1.78</td>
<td>(1,119)</td>
<td></td>
</tr>
<tr>
<td>review</td>
<td>SD 1.01</td>
<td>.926</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N 44</td>
<td>77</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Scale: 1 = Not at all to 5 = Very Important

The availability of technology training and support can influence the adoption of technologies (Adams 2003). Respondents were asked to respond to how frequently they took advantage of activities related to technology training and support, using a 1 to 5 scale where 1 = “not at all” to 5 = “very frequently.” WebCT adopters versus non-adopters reported significantly higher frequencies of attending seminars on information technology, talking with other faculty members about information technology, and trying new software programs, but not observing other faculty members (see Table 4).
Table 4: Opportunities to learn about technologies

<table>
<thead>
<tr>
<th>Item</th>
<th>Adopters M</th>
<th>Non-adopters M</th>
<th>t-Values</th>
<th>P Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attend seminars or demonstrations</td>
<td>2.56</td>
<td>2.14</td>
<td>t = -2.45 (1, 164)</td>
<td>.015</td>
</tr>
<tr>
<td>Talk with other faculty</td>
<td>3.40</td>
<td>3.04</td>
<td>t = -1.98 (1,165)</td>
<td>.050</td>
</tr>
<tr>
<td>Observe other faculty</td>
<td>2.53</td>
<td>2.55</td>
<td>t = -1.36 (1,165)</td>
<td>.892</td>
</tr>
<tr>
<td>Try new software or programs</td>
<td>1.18</td>
<td>1.17</td>
<td>t = 3.53 (1,165)</td>
<td>.001</td>
</tr>
</tbody>
</table>

5.5 Respondents’ additional comments

The back of the questionnaire provided space for comments. Four respondents provided reported usability problems with WebCT. Two others reported technical problems using WebCT during the previous term. One respondent reported her (or his) time was better spent working on articles for progress toward tenure, another pointed out that she (he) had no incentive financial or otherwise to use WebCT, and a third reported WebCT was not worth the effort required.

6. Discussion

Even though the university has made a concerted effort to encourage faculty to adopt course management software for their classes, less than two-fifths of the faculty in the arts and sciences departments reported using WebCT, and they used only a limited number of the available tools. A closer look at what WebCT tools are used reveals that WebCT’s website publishing tools (such as content page, syllabus, and presentation distribution tools) are the most used, while the interactive tools (such as chat, group presentations, and threaded discussion) were seldom used. As course management software, WebCT seems to be used more to increase faculty members’ productivity versus to increase students’ opportunity for higher order learning or more active student-centered teaching strategies. According to Sandholtz, Ringstaff, and Dwyer (1994), the real benefit of technology use as an instructional tool is as a “medium for thinking, collaborating, composing, and communicating” (p. 1). Garrison (1997) agrees that threaded discussion in particular allows for reflective discussion and as a means of communication, is consistent with higher-order thinking and cognitive development. Faculty choices regarding WebCT have not been to develop collaborative learning environments, but to support information exchange.

The faculty members' limited use of WebCT may also explain the limited difference between WebCT adopters and non-adopters in terms of the perceived impact of technology on teaching. WebCT adopters reported that using it saved them time on their daily tasks and helped them improve their teaching--impacts that are related to productivity issues, not changes in teaching and learning environments.

Adams (2003) reported that faculty members who integrate technology into their teaching are more likely younger, female and have less teaching experience. However, Schifter (2002) found no statistically significant differences for faculty gender, age range, rank or tenure status in distance education participation at higher education institutions. Our data also reflects this pattern with no significant differences between WebCT adopters and non-adopters on teaching/research/service time distribution, by gender, nor by their status or rank as being tenure, tenure-track, or adjunct instructors.

The value of technology-related projects in tenure and promotion decisions was not found to be significant. Although WebCT adopters thought technology innovation had a slight importance in their annual merit evaluations, the means for all faculty evaluation and promotion questions were low (between 1.00 and 2.00 on a scale of 1 to 5, where 1 was “not at all important”). Our findings appear to align with Young (2002) who reported that technology-based projects often are not recognized as part of the traditional three categories used in promotion: teaching, research, and service. In a study of four Carnegie Class One Research institutions regarding reward systems for distance education, distance education is not identified.

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as an area of professional practice, i.e. it doesn’t serve as a measure of faculty productivity (Wolcott, 1997). However, distance education work by faculty is acknowledged at the department level and during annual performance reviews, which is consistent with our results. According to Gruber (2000), promotion and tenure committees are reluctant to acknowledge or reward a candidate’s technology integration into coursework. These arguments about whether technology in teaching should be counted in tenure and promotion decisions are expressed more at research universities than at institutions with a more teaching focus (Young 2002).

7. Recommendations

Although the university has offered more than 60 short courses and seminars on WebCT for faculty, and many more courses on technology innovations, the limited use of the different WebCT functions suggests that faculty members are not using WebCT as a tool for changing their instructional methods. In reviewing the WebCT and technology session topics offered by our university, most training sessions are how to use the technology tool versus how to integrate the technology tool to enhance the learning process. We suggest that WebCT training includes pedagogy and student engagement solutions so that faculty members understand how to effectively use WebCT and other technology tools.

According to Allen and Seaman (2003), 11 percent of all United States higher education students took at least one online course in Fall 2002 and that the number of students taking at least one online course is projected to increase by 19.8 percent over a one year period. Because of the increasing need for online methods of instruction, we suggest that universities develop a protocol to reward and acknowledge online creative works as part of the tenure and promotion process. Criteria that could be used are (1) contribution of the project to the field, (2) national and local recognition of the project, and (3) strong research based for the project (Seminoff and Wepner 1997). The consortium entitled Multimedia Educational Resource for Learning and Online Teaching (MERLOT) was formed to look at this issue, and is attempting to establish a peer-review process for electronic teaching materials as is used for journal articles (Young 2002).

8. Further research recommendations

Continued research is needed in faculty and student adoption of course management software as well as its overall impact on teaching and learning. Research into the factors associated with faculty adoption of course management software includes six areas.

First, research is needed to explore the factors that might explain the differences between those who adopt and do not adopt course management software. Additional social and psychological factors need to be investigated, using both quantitative and qualitative methods, to ascertain the differences in adoption and non-adoption.

Second, research is needed to investigate the usability of WebCT and course management software in general. Such research needs to ascertain the usability and the learning curve required to develop proficiency when using course management software. Usability testing, based conceptually on protocol analysis from cognitive psychology (Ericsson and Simon 1993), has emerged as a major methodology for evaluating software and Web sites (Druin 1999; Nielsen 1993, 2000; Shneiderman 1998; Zimmerman and Akerelrea (forthcoming). Usability testing quickly identifies the major problems in design and structure of software that create difficulties for users.

Third, research is needed to determine the extent of abandonment of course management software and the factors contributing to its abandonment. The authors currently subscribe to a university course management listserv that provides technical support. Over the three weeks prior to beginning the Fall 2003 term, we noted a series of e-mails from senders asking to be removed from the mailing list, explaining that they were no longer using the course management software.

Fourth, research is needed to ascertain faculty’s perceptions of what kinds of classes for which course management software is most appropriate. Respondents from some departments reported that WebCT was not an appropriate teaching tool for their respective classes, but they did not elaborate on their reasoning.

Fifth, research is needed to investigate how faculty use course management software in
institutions where it is required compared to those institutions where its use is optional.

Sixth, research is needed to explore the differences in adoption rates of different course management software across different educational institutions and different academic areas. Comparing the rate of adoption by faculty in research institutions and teaching institutions and the factors influencing the rate of adoption may provide insights into how to encourage the adoption of course management software. Understanding the different factors involved in adoption among various academic areas could also highlight unique factors that influence adoption by content area. Conducting this research across educational institutions and academic departments will add to the generalizability of this research.

Research into students’ perception of course management software needs to focus on three areas. First, research is needed on students’ perception of course management software’s impact on course delivery and its impact on their learning. Second, research is needed to ascertain if using course management software enhances students’ learning where course management software is used as an adjunct to on-campus instruction. Third, research is needed on the usability of the software by students and to identify what kinds of problems they encounter when using course management software.

9. Conclusion

Clearly, higher education institutions are investing hundreds of thousands of dollars in course management software, building faculty training programs, and maintaining the infrastructure to support course management software. To maximize those investments, higher education institutions needed to invest in empirical research to determine the factors associated with adoption, non-adoption and abandonment of course management software. Identifying such factors will enable the refinement of the course management software functions, potentially make it easier to use, and help guide faculty training programs. Such investments would enable institutions to maximize the return on their investments in online course management software.

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