Journal of Educational Technology & Society

Aims and Scope

Educational Technology & Society is a quarterly journal (January, April, July and October), but the articles will be published as soon as they are ready for publication (benefit of the electronic medium!), so that the issue will be built up and at any moment, one issue of the journal would be available to accept the articles.

Educational Technology & Society seeks academic articles on the issues affecting the developers of educational systems and educators who implement and manage such systems. The articles should discuss the perspectives of both communities and their relation to each other:

- Educators aim to use technology to enhance individual learning as well as to achieve widespread education and expect the technology to blend with their individual approach to instruction. However, most educators are not fully aware of the benefits that may be obtained by proactively harnessing the available technologies and how they might be able to influence further developments through systematic feedback and suggestions.
- Educational system developers and artificial intelligence (AI) researchers are sometimes unaware of the needs and requirements of typical teachers, with a possible exception of those in the computer science domain. In transferring the notion of a 'user' from the human-computer interaction studies and assigning it to the 'student', the educator's role as the 'implementer/manager/user' of the technology has been forgotten.

The aim of the journal is to help them better understand each other's role in the overall process of education and how they may support each other. The articles should be original, unpublished, and not in consideration for publication elsewhere at the time of submission to Educational Technology & Society and three months thereafter.

The scope of the journal is very broad as can be seen from the following list of topics considered to be within the scope of the journal:

- Architectures for Educational Technology Systems
- Computer-Mediated Communication
- Cooperative/ Collaborative Learning and Environments
- Cultural Issues in Educational System development
- Didactic/ Pedagogical Issues and Teaching/Learning Strategies
- Distance Education/Learning, Distance Learning Systems
- Distributed Learning Environments
- Educational Multimedia
- Evaluation, Human-Computer Interface (HCI) Issues
- Hypermedia Systems/ Applications
- Intelligent Learning/ Tutoring Environments
- Interactive Learning Environments
- Learning by Doing
- Methodologies for Development of Educational Technology Systems
- Multimedia Systems/ Applications
- Network-Based Learning Environments
- Online Education
- Simulations for Learning
- Web Based Instruction/ Training

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Guidelines for authors

Submissions are invited in the following categories:

- Peer reviewed publications
  - Full length articles (between 4000 and 7000 words)
  - Short articles, Critiques and Case studies (up to 3000 words)
- Book reviews
- Software reviews
- Website reviews

All peer review publications will be refereed by at least two international reviewers with expertise in the relevant subject area. Book, Software and Website Reviews will not be reviewed, but the editors reserve the right to refuse or edit copy.

Each peer review submission should have at least the following items:
- title (up to 10 words)
- complete communication details of all authors
- an informative abstract (75-200 words) presenting the main points of the paper and the author's conclusions
- four - five descriptive keywords
- main body of paper
- conclusion
- references

Submissions should be single spaced.

Footnotes and endnotes are not accepted, all such information should be included in main text.

The paragraphs should not be indented. There should be one line space between consecutive paragraphs.

There should be single space between full stop of previous sentence and first word of next sentence in a paragraph.

The keywords (just after the abstract) should be separated by comma, and each keyword phrase should have initial caps (for example, Internet based system, Distance learning).

Do not use 'underline' to highlight text. Use 'italic' instead.

Heads

Articles should be subdivided into unnumbered sections, using short, meaningful sub-headings. Please use only two level headings as far as possible. Use 'Heading 1' and 'Heading 2' styles of your word processor's template to indicate them. If that is not possible, use 12 point bold for first level headings and 10 point bold for second level heading. If you must use third level headings, use 10 point italic for this purpose.

There should be one blank line after each heading and two blank lines before each heading (except when two headings are consecutive, there should be one blank like between them).

Tables

Tables should be included in the text at appropriate places and centered horizontally. Captions (maximum 6 to 8 words each) must be provided for every table (below the table) and must be referenced in the text.

Figures

Figures should be included in the text at appropriate places and centered horizontally. Captions (maximum 6 to 8 words each) must be provided for every figure (below the figure) and must be referenced in the text. The figures must NOT be larger than 500 pixels in width.

Please also provide all figures separately (besides embedding them in the text).

References

- All references should be listed in alphabetical order at the end of the article under the heading 'References'.
- All references must be cited in the article using "authors (year)" style e.g. Merrill & Twitchell (1994) or ("authors1, year1; authors2, year2") style e.g. (Merrill, 1999; Kommers et al., 1997).
- Do not use numbering style to cite the reference in the text e.g. "this was done in this way and was found successful [23]."
- It is important to provide complete information in references. Please follow the patterns below:

Journal article


Newspaper article


Or

**Book (authored or edited)**

**Chapter in book/proceedings**

**Internet reference**

**Submission procedure**
Authors, submitting articles for a particular special issue, should send their submissions to appropriate Guest Editor rather than to the address below. Guest Editors will advise the authors when to submit final version to following address.

Due to the nature of the journal, all submissions should be in electronic form. The editors will acknowledge the receipt of submission as soon as possible.

The preferred formats for submission are Word document and RTF, but editors will try their best for other formats too.

For figures, GIF and JPEG (JPG) are the preferred formats. **Authors must supply separate figures** in one of these formats besides embedding in text.

Please provide following details with each submission:
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- Full contact details of ALL authors including email address, postal address, telephone and fax numbers

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- kinshuk@inspire.net.nz or kinshuk@massey.ac.nz (only if previous email does not work for any reason)
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Volume 6 Number 4 2003

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Adaptive Patterns in Authoring of Educational Adaptive Hypermedia

Moderator & Summarizer:
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Discussion Schedule:
Discussion: 14-23 July 2003
Summing-up: 24-25 July 2003

Pre-Discussion Paper

Problem issues

One of the main problems with e-learning environments is their lack of personalization (or adaptivity). They cannot offer customisation for the student; they can only offer identical contents to all the consumers.

Educational Adaptive Hypermedia (EAH) environments should be the answer to this problem. Adaptive Hypermedia is a relatively new field (starting around the early 1990s), but it already has reached some maturity and already features some good applications.

Imagine, for instance, that, instead of showing all students an example of a painting by Rembrandt and then show them the description of the chiaroscuro technique, one could write a rule:

IF student.chiaroscuroTechnique.motivation='non-existent' THEN show.paintingRembrandt;
Show.chiaroscuroTechnique;

So, show the painting only to students without motivation in studying the chiaroscuro technique (with the hope that seeing such a great painting will motivate them), and skip this step if the motivation is already there (give direct information for motivated students). This very simple rule already offers some customisation, dependent on a student model variable called ‘motivation’.

At the Eindhoven University of Technology, for instance, a few courses are given already for a couple of years on-line, in adaptive hypermedia environments (featuring student models and automatic adaptation to student’s computed ‘knowledge level’: e.g., http://wwwis.win.tue.nl/2L690/).

However, such EAH environments are not yet as spread as we would have expected, and not many educators even know about the opportunities offered by such automatic personalization, let alone make use of it.

Our opinion about those issues

The major drawback that we have found is that, at present, there are no good authoring tools for educational adaptive hypermedia, and creating EAHs from scratch without such tools becomes actually a programmer’s job – and not that of an author (e.g., teacher).

Therefore, we embarked on the quest of designing appropriate authoring tools for EAHs.

Please note that such authoring tools as we envision do not try to compete with commercial tools such as Blackboard, WebCT, etc. What we want is to complement these tools with what they lack: the possibility of expressing the automatic personalization elements for the student.

Please also note that such authoring is normally more difficult than authoring of a sequential course: alternatives have to be designed, linked and annotated (i.e., the static descriptions). The rules of when and how to take the alternative routes have to be specified (i.e., the dynamics description).
In order to make authoring efficient, such an authoring system should propose to the author a lot of methods of reuse, both of contents (static description) as well as of contents dynamics.

The static contents description reuse has been discussed and researched more thoroughly, and it can be based on the learning object model (LOM), on the emerging SCORM standard, as well as on work on hypermedia patterns as developed by the team of Franca Garzotto (http://www.elet.polimi.it/upload/baresi/pub/papers/SCI02.pdf) and on our own work on course domain structuring (http://wwwis.win.tue.nl/cheetah/~acristea/HTML/Minerva/papers/WWW03-cristea-mooij.doc) [4].

Therefore, our main focus is to research and work on the re-usage of the dynamics, i.e., on the re-usage of adaptation features. Please note that the IMS ADL simple sequencing protocol, although a step in the right direction, cannot provide all the features of adaptation that adaptive hypermedia can offer.

Suggested solutions

We are running a European Community project, ADAPT, whose main goal is to extract adaptive patterns of educational adaptive hypermedia, and to use these in authoring:
http://wwwis.win.tue.nl/cheetah/~acristea/HTML/Minerva/

Our purpose is to find these more general patterns of adaptive behaviour, and then make them reusable via an authoring environment that offers these patterns, or even groups of patterns (adaptation strategies), as we shall see. To go back to the adaptation example above, the IF-THEN rule described there cannot be reused: it is too specific, binding two specific instances, paintingRembrandt and chiaroscuroTechnique. Moreover, if we would want to make a similar connection between Picasso and the collage technique, we would have to actually write a new rule:

IF student. collageTechnique.motivation='non-existent' THEN show.paintingPicasso;
Show.chiaroscuroTechnique;

Obviously, the two rules have much in common, and it is natural to expect that an author would want to use a similar structure for the Picasso case, which s/he can reapply instead of writing a new rule. To make this rule reusable, we should be allowed to write higher (schema) level constructs such as:

IF student. Technique.motivation='non-existent' THEN show.painting;
Show. Technique;

The advantage of the rule above is not only that it summarizes the rules for Picasso’s and Rembrandt’s paintings, but that it can connect any other painter and the technique s/he invented. This is just a very simple example how generalization of the content structure can lead to reusable components, even for adaptation rules. However, we can go even further than that, and notice that the two higher level constructs, technique and painting, can be seen as representing some theory and its corresponding example, and that they could be both belonging to a concept that binds the theoretical part with its practical part. As we can then define a relation that connects this theoretical part of the concept with its practical part, by marking the example as a specialization of the theory (and, vice versa, the theory as a generalization of the example), we can replace the previous rule with a higher-level language rule, as follows:

IF student. Concept.motivation='non-existent' THEN specialize;
genralize;

From these kinds of considerations the first constructs of an adaptation language emerged, as described more systematically in [1]:
http://wwwis.win.tue.nl/~acristea/HTML/Minerva/papers/UM03-cristea-calvi-accepted.doc

The idea behind it was, as mentioned above, to let the author of adaptive educational hypermedia work on a higher semantic level, instead of struggling with the ‘assembly language of adaptation’. Furthermore, these patterns should represent the first level of reusable elements of adaptation, as shown in the examples above.

However, reusability can go further than that. Even this adaptation language, we are aware, might still be difficult to handle for some authors (teachers). So, as mentioned in the paper above ([1]), reuse should be strived at even at the level of adaptation strategies (that correspond to cognitive/learning strategies). In this paper we show how the four cognitive styles identified by Kolb (converger, diverge, assimilator, accomodator) can be
written in adaptation language (as well as in adaptation assembly language) and transformed into adaptation strategies, ready to be reused. Below (table 1) is an extract example from the paper with the implementation for the cognitive style converger, using the specialize and generalize adaptation language constructs, as described previously, but also some other special construct, such as enough. The latter is a more relaxed way to specify preconditions, without precisely defining them. In this case, enough (result) means, e.g., having a passing average for at least two of the tests, but other definitions are also possible.

Table 1. Adaptation strategy for cognitive style: converger (abstract, active)

<table>
<thead>
<tr>
<th>medium_increase()</th>
<th>generate adaptive presentation with (obviously) increasing difficulty</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Explanation: Convergers are abstract and active; they like to feel in control; start with course for intermediates at medium adaptivity level, repeat for a number of times:</td>
<td></td>
</tr>
<tr>
<td>- evaluate state of learner and start increasing difficulty &amp; decreasing adaptivity level if result=good</td>
<td></td>
</tr>
<tr>
<td>- evaluate state of learner and start decreasing level if result=bad</td>
<td></td>
</tr>
<tr>
<td>2. Translation at medium level: (ENOUGH shows here that the result is above an average result)</td>
<td></td>
</tr>
<tr>
<td>AdaptLevel= 5; N=AskUser(); # this is to let user feel and be in control; levels: (1=min to 10=max)</td>
<td></td>
</tr>
<tr>
<td>FOR &lt;i=1..N&gt; DO</td>
<td></td>
</tr>
<tr>
<td>{ SPECIALIZE (ENOUGH(Result)); IF (AdaptLevel&gt;1) AdaptLevel--;</td>
<td></td>
</tr>
<tr>
<td>GENERALIZE (NOT(ENOUGH(Result))); IF (AdaptLevel&lt;5) AdaptLevel++;</td>
<td></td>
</tr>
<tr>
<td>} # Note that adaptation level is not allowed to increase too much</td>
<td></td>
</tr>
<tr>
<td>3. Translation at low level: (the average can be implemented but takes more space)</td>
<td></td>
</tr>
<tr>
<td>DiffLevel = 3; AdaptLevel= 5; # note that there is no predefined number of repetitions</td>
<td></td>
</tr>
<tr>
<td>IF &lt;ACTION&gt; THEN # Note that above we don’t need the action of the user for triggering;</td>
<td></td>
</tr>
<tr>
<td>{ IF (Result1 +Result2)/2&gt;5 AND DiffLevel&lt;10 THEN # Note that ‘enough’ and specialize</td>
<td></td>
</tr>
<tr>
<td>{ DiffLevel++; IF (AdaptLevel&gt;1) AdaptLevel--; } # must be redefined each time</td>
<td></td>
</tr>
<tr>
<td>IF  (Result1 +Result2)/2&lt;5 AND DiffLevel&gt;1 THEN {DiffLevel--; IF (AdaptLevel&lt;5) AdaptLevel++;}</td>
<td></td>
</tr>
<tr>
<td>}</td>
<td></td>
</tr>
</tbody>
</table>

In discussions resulting at the User Modelling conference, other cognitive styles that should be implemented were suggested, such as field dependence versus field independence.

Questions for the members to respond to

1. What other cognitive/learning strategies would be appropriate to experiment with for e-learning in particular? (i.e., to transform them into adaptation strategies) The main target we are envisioning are university students, but extensions towards other categories of pupils are also important, especially in the context of life-long learning.

2. Are the patterns described so far enough for describing the cognitive/learning strategy you would like to implement?

3. What other patterns would be necessary, and for what cognitive/learning strategies?

4. Would you opt for reusing directly adaptation strategies, or would you prefer to write your own?

5. If you would write your own adaptation strategies, what would you need in the adaptation language?

6. What criteria/constraints should the adaptation language fulfil?

Papers produced by this research


Post-discussion Summary

This is a summary of what has been discussed within the IFETS discussion group on the topic of adaptive patterns in authoring of educational adaptive hypermedia (EAH).

Initial goal

The INITIAL GOAL of the discussion was to find out what can be reused from the dynamics of the EAHs (so what are the ADAPTIVE PATTERNS), in order to complement the research on what can be reused from the static EAH data. A 3-layer structure of adaptation was proposed, with at the lowest level IF-THEN rules traditionally used in EAH, but which cannot be reused. The next layer contains ADAPTATION LANGUAGE constructs, such as Generalize, Specialize, Repeat, While, Break. This layer already represents a higher semantic level as compared to the traditional first one. The last layer is made of ADAPTATION STRATEGIES, such as the ones proposed based on the Kolb model of cognitive style characterization.

Main questions

The main questions were grouped around finding out the appropriateness of this division from an educator's (and author's) perspective on one hand, and finding suitable suggestions for populating the 2nd and 3rd layer with respective new adaptation language constructs or new adaptation strategies, which would correspond to a specific teaching style/ theory.

Reactions

Reactions to the above proposal and questions were as follows:

Robert Valian suggested that the Annehurst Curriculum Classification System (ACCS) developed by Jack Frymier at the Ohio State University in the '70 for student classification might be a good source to look at; unfortunately, this is out of print - and might be outdated (?). It is surely a good starting point, but we have to look at more up-to-date opportunities.

José M Parente de Oliveira noted that adaptation strategies might be grouped around instructional/ learning theory in conjunction with cognitive styles and learner preferences; this could be a good direction to develop adaptive strategies on; here, the question is what would be the typical instructional strategies that should be translated into adaptation strategies, and if it seems feasible with the few adaptation language constructs that we have proposed (Generalize, Specialize, Repeat, While, Break + low level If-Then-Else) or if more would be needed?
Clark Quinn and others pointed with their comments to the fact that adaptation strategies could be directly inferred from a specific domain structure (such as in automatically smoothing the transition from one topic to another by inserting introductory/explanatory information, if this exists and is appropriately tagged in the domain description); the same idea has been brought up by José M Parente de Oliveira and also mentioned by Simos Retalis in the form of using generic relationships between resources to generate adaptive patterns (for learning or assessment of learning); this is another proof of the inter-relatedness of the static representation and the adaptation dynamics (same as re-iterated below).

Clark Quinn also stressed the fact that for a good adaptation model in general a rich and specific tagging system is necessary; although this represents the static part of the EAH, it is a necessary precondition for a good development of the dynamics; the adaptation language and adaptation strategies should have as base a rich model of the domain or learning content, of learner characteristics (knowledge + others: compendium of potential standards: Jonassen & Grabowski, eds., 1992? + emotional data - D.A. Norman, A. Ortony), context or presentation platform characteristics (PDA, mobile phones, web, etc.), pedagogical constraints and goal model (Jeroen J.G. Van Merrienboer). These different aspects of the elements of learning can be decomposed, as proposed in a 5-layer model in: http://wwwis.win.tue.nl/~acristea/HTML/Minerva/papers/WWW03-cristea-mooij.doc. The question than remains: given a representation, what are the adaptive patterns that can be applied?

Can these patterns be used to author new adaptive strategies?

Eric Flescher had an interesting proposal regarding adaptation strategies: adaptation strategies should be able to be written that allow for meta-cognition and incubation, for slow, methodical work; this issue also raises the question of what specific patterns of adaptation language would be appropriate to represent such adaptation strategies?

Conclusions

The main conclusion of the discussion on adaptive strategies and adaptive patterns for educational adaptive hypermedia is that, although the discussion is closed, there are many questions that remain open.

In this way we have just made the research - as well as the educational practitioner community attentive to the possibilities that can be opened by our line of research.

Hopefully, we will be able to reiterate this discussion at some other time, with new results, as the topic is by no means exhausted.

Clear from the discussion is that adaptive patterns for adaptive educational hypermedia should rely heavily on patterns of the static description of the elements involved, such as the domain model, user model, etc. Adaptation can only describe ‘intelligent’ dynamics if the basic tagging and meta-data is present in the model on which it is applied. Therefore, any attempt to describe adaptive patterns for educational adaptive hypermedia has to also be paired with the respective description of the static elements. This leads, obviously, to a multi-dimensional view. The exact number of dimensions is still a matter of discussion and research, but some are clearly needed, such as the domain -, user – and adaptation model.

Moreover, the discussion pointed out that the focus should not be only on the cognitive strategies, but also embrace learning theories. The question than remains: how these can be translated into adaptive strategies.

Important open questions that remain are the different granulation levels that are needed for creating appropriate adaptive patterns for educational adaptive hypermedia, as well as the proper adaptive language that has to be used. It is important to keep in mind that this language has to be used by authors and designers of on-line courseware, so by teachers, so it has to be at a level that is comprehensible for them.

As already mentioned in the introductory paper, we are now running a project that has as one of the main goals finding an answer to these open questions: "ADAPT: Adaptivity and adaptability in ODL based on ICT": http://wwwis.win.tue.nl/~alex/HTML/Minerva/index.html.
Digital Contents for Education

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Digital Contents for Education was the label the editors chose in order to cover a variety of research projects and initiatives aimed at improving the way ICT helps educators and students in a teaching and learning scenario. Recent technological developments have led to the availability of powerful environments for the production of a range of electronic material for education. A number of products and prototypes for assisting teaching and learning have been produced and educational material has been extensively published electronically but it is still unclear to what extent all of this is of use to students and lecturers/tutors when it comes to real teaching and learning. Definitions, models and theories to define what electronic learning objects are, standards and guidelines for the production of “good” digital content are still to be found and adopted successfully and usability issues are still to be explored in their complexity and importance in evaluating how these objects are having an impact on education. For this reason we hope that the papers presented in this special issue can be of great interest and utility to a number of people in education involved in design, production, delivery and use of electronic material and tools.

This special issue of the Educational Technology and Society Journal evolved from the track titled "Digital Contents for Education" of the SAC 2003 conference held in Melbourne, Florida, in March 2003.

One of the objectives of the track was to raise awareness of the various initiatives on-going under the wide label of applied computing targeted to educators and students. Researchers are aware of how crucial this area is but it is difficult to find relevant contributions collected under one label, good papers tend to be dispersed under various related areas, ranging from the wide Web Applications and Human Computer Interaction contexts to the smaller Electronic Publishing and Information Retrieval tracks. Our track was meant to attract the attention of a mixed and still undefined polyedric community of designers, publishers and users of electronic material for education, where very often researchers play more than one role at time (classically by being authors, designers and then delivering the same material).

Authors that presented in Melbourne were than asked for a contribution to this special issue and with few carefully selected additions we have produced a selection of high quality papers each of them covering a different aspect of the wide area covered by the label of Digital Objects for Education from an original perspective. Electronic books and in particular portable devices for consulting them are the subject of the paper by R. Wilson, “Ebook Readers in Higher Education”. A case study that explores usability issues of current hardware and provides useful guidelines for the design of future devices. The need for a more user-centred approach is discussed in “XML-based Adaptation Framework for Psychological-driven E-learning Systems” by H. Rumetshofer and W. Woß. The main focus is on cognitive and learning styles and on how an intelligent learning environment should accommodate for them. On a similar position are the authors of “InterMediActor: an Environment for Instructional Content Design Based on Competences” by F. Valverde-Albacete et al. Here a novel method for designing educational applications is discussed with particular attention to the core concept of competences. “A framework for the management of digital educational contents conjugating instructional and technical issues” by F. Buendia and P. Diaz merges brilliantly theoretical issues with usability by showing how digital content for education can be produced and managed effectively with the user still being the focus of the
On a similar note is “Dynamic Learning Modeller” by Y. Atif et al. another topical paper on how theory and good practice could enhance the quality of Digital Content in education. From teaching to training, “Designing Training in Manufacturing Organizations Using the Genre-based Method” by A. Honkaranta and P. Tyrväinen discusses the analysis and design of training material in manufacturing organizations. The authors discuss how attention to genre issue can impact on delivery and communication during training. They also consider content reuse and its potential by applying XML transformation techniques.

With “A Personalisable Electronic Book for Video-based Sign Language Education” by J. Ohene-Djan, et al. the attention is very much on the user and in particular on special need users. Electronic books have for a while been expected to fulfill a gap in the market by delivering personalised material for education, but they have not yet done so mainly because of the complexity of the task and the lack of financial support, this paper describes a good example of how this could be achieved. And looking into the needs of educators, “Dynamic Composition of Math Lessons” by M. Kellar et al. provides a good example of a system for the production of web-based material for teaching and learning where teachers of mathematics in high school are the target users.

Finally, “A Usability Study for Promoting eContent in Higher Education” by N. Shiratuddin et al. looks into how improving usability, a common theme in this issue and studying new marketing models for e-Content in education could promote its use. With this selection of papers the editors believe to have achieved their main goal: to provide the reader with a broad picture of research in this area, while proving how articulated this area is. There are still a number of open challenges such as the holy grail of setting recognised and workable standards and the definition of those ineffable criteria for measuring how successful e-learning objects are in achieving their objectives. This is what makes research in this area such a challenge.
Ebook Readers in Higher Education

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Abstract

Ebook readers have received a mixed press, with some hailing them as the future of reading and others believing that they will never be popular. The study outlined here aims to understand the attitudes of, and issues of importance to, lecturers in UK academia, with a view to improving the design of ebook readers for education in the future. An evaluation of five portable devices is presented, in which lecturers were given the opportunity to read an ebook and provide feedback via a questionnaire. Results are compared with concerns arising from other experiments in the same field, and recommendations are made for successful ebook design.

Keywords
Electronic books, Electronic textbooks, Evaluation, Usability

Introduction

Electronic book readers have been defined by Lemken (1999) as “mobile, physical devices to display electronic (i.e. digital) documents”. In today’s market, they can be one of three things (Wilson, 2001):

1. Dedicated ebook readers. Built solely for the purpose of book reading, these are small, lightweight devices (usually with larger screens than PDAs and Pocket PCs) with backlit screens and embedded dictionaries. Often they enable searching, bookmarking and annotating, and can either be connected to a PC or contain internal modems so that content can be downloaded from the Internet. The Rocket eBook and the SoftBook are the parents of the dedicated ebook reader, and have a steadily growing family, including the goReader and AlphaBook.

2. PDAs and Pocket PCs. These are usually smaller than dedicated ebook readers and primarily function as personal organisers. Often they also offer Internet access and word processing, spreadsheet and MP3 playing capabilities. Increasingly, as content and ebook reader software for these devices becomes available, they are now being used additionally to read books.

3. Hybrid devices. Several devices have emerged which cross these previously distinct boundaries between hardware designed especially for reading books, and hardware designed to perform personal organiser tasks, with ebook reading an added functionality. These “hybrid devices” look similar to dedicated readers, with larger screens intended for reading long streams of text, buttons placed for easy turning of pages, and with the usual ebook capabilities such as bookmarking and annotating, but may also contain address books and to do lists, and be used to perform the types of task normally associated with PDAs, such as email reading, Internet browsing and MP3 playing. Examples include the eBookMan, which supports audio files and contains an address book and a to do list, and MyFriend.

Ebook readers have received a very mixed press, with some authors believing they represent the future of reading (Midgley, 2002), and others claiming that reading long texts from a screen is an inherently unpleasant experience and, therefore, will never be popular (Weeks, 2002). In a 2001/2002 survey of lecturers at three UK universities (Wilson, 2003), of those who used electronic teaching resources only 9% delivered electronic books as course material, and 21% recommended them to students. Ebooks were not used at all in Computer and Information Sciences, Engineering, Mathematics and Statistics or Medicine.
The Electronic Book Group at the University of Strathclyde, UK, believes that the design of devices plays a crucial role in their acceptance (Wilson, 2002), and set about investigating this issue in a small-scale experiment focusing on the opinions and experiences of university staff. The group’s EBONI (Electronic Books ON-screen Interface) Project (2002) studied the importance of design in an evaluation of five ebook readers. The aim was to investigate issues surrounding ebook reader design in general (such as ease of use, navigation, reactions to size, weight, display, and so on), as well as to discover, in more detail, opinions on the use of ebook readers in an academic setting. Details and results of the experiment are outlined below.

Methodology

The experiment employed EBONI’s Ebook Evaluation methodology (Wilson and Landoni, 2001), which has been applied to other evaluations in the ebook arena and aims to produce results that are comparable across experiments. The methodology provides a flexible framework for selecting material and participants, defining criteria and measures, and implementing evaluation techniques such as “low cognitive skill” tasks set by lecturers to measure user understanding of concepts in the texts, and questionnaires designed to measure user satisfaction. By adopting these different techniques, the model aims to measure usability, relevance and satisfaction comprehensively and at a variety of levels, incorporating traditional Information Retrieval concepts as well as lecturers’ objectives. Four general phases are involved:

1. Selection of material. Ebooks can be selected for evaluation according to three parameters: format/appearance, content and medium.
2. Selection of actors. Four possible actors in an experiment can be distinguished: the participants, the evaluators, the task developers and the task assessors.
3. Selection of tasks. The following task-types are proposed for gathering quantitative feedback from participants about the material:
   a. Scavenger hunts, which involve participants in hunting through the material selected for evaluation in search of specific facts.
   b. Exams, which involve the participant reading a chapter or a chunk of text for a short period of time, learning as much as possible in preparation for a short exam.
4. Selection of evaluation techniques, such as:
   a. Subjective satisfaction questionnaires.
   b. Think-aloud sessions.
   c. Interviews.

Details of the application of these four phases to the design of this evaluation of ebook readers are provided below.

Material

Five ebook readers were compared in this experiment: a SoftBook, a Rocket eBook, a Jornada 548, an eBookMan 900 and a Palm Vx.

The SoftBook, by SoftBook Press of Menlo Park, California, has a leather cover which, when opened, automatically starts up the book. It holds around 250 books, has a backlit, 8x6 inch grayscale screen, weighs nearly three pounds and, when available, cost around $600. Its battery provides up to five hours of viewing, and it offers a fast recharge of an hour. The SoftBook uses an HTML-based proprietary format for displaying books. Functions such as choosing a title, page turning, bookmarking and annotating are performed using touch-screen technology.

The Rocket eBook, by Nuvomedia, Inc. in Palo Alto, California, holds ten books (4,000 pages of text), weighs one pound and, when available, cost around $270. It has a 4.5x3 inch, high-resolution black-and-white screen, a number of font sizes can be selected, and it can be customised for left- or right-handed use. The battery lasts for about 20 hours when backlit, and 45 hours without being backlit. Like the SoftBook, the Rocket uses a proprietary ebook reader format.

The Jornada 548 by Hewlett-Packard is a Pocket PC with 32 MB RAM and a 134 MHz 32-bit processor, and cost, at the time of the evaluation, around $500. It has a 2.9x2.1 inch high-resolution, backlit colour screen and weighs 9 oz. The battery life is around 8 hours. In this experiment, titles were displayed using Microsoft Reader
software. The layout of a text in Microsoft Reader is very clean and simple: only the text of the book is displayed, and no icons are visible on screen; functions like highlighting and annotating only become visible when the reader interacts with the book by clicking on the screen.

The Franklin eBookMan 900 cost around $130 at the time of the evaluation, has a 240x240 pixel grayscale LCD screen, without backlighting, and weighs 7 oz. The device takes 2 AAA batteries. Content is downloaded to a PC running the eBookMan Desktop Manager, and sent to the eBookMan via a serial or USB connection. In this experiment, Franklin Reader software was used for reading books.

The Palm Vx weighs 4 oz and has 8MB RAM and a 2.5 inch grayscale, 160x160 resolution, backlit LCD screen. The rechargeable lithium ion battery lasts for 25 hours at a time. It cost, at the time of the experiment, around $210 to $230. Palm Reader (formerly Peanut Reader), an ebook reader for Palm and Windows CE devices, was used. This offers bookmarking, annotating and search facilities.

Table 1 provides a summary of the characteristics of the five ebook readers.

<table>
<thead>
<tr>
<th>Device</th>
<th>Type</th>
<th>Weight (ounces)</th>
<th>Screen size (inches)</th>
<th>Colour/grayscale</th>
<th>Resolution</th>
<th>Backlight</th>
<th>Battery life (hours)</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>SoftBook</td>
<td>dedicated</td>
<td>45</td>
<td>8x6</td>
<td>grayscale</td>
<td>640x480</td>
<td>yes</td>
<td>5</td>
<td>$600</td>
</tr>
<tr>
<td>Rocket</td>
<td>dedicated</td>
<td>16</td>
<td>4.5x3</td>
<td>grayscale</td>
<td>480x320</td>
<td>yes</td>
<td>20</td>
<td>$270</td>
</tr>
<tr>
<td>Jornada</td>
<td>pocket PC</td>
<td>9</td>
<td>2.9x2.1</td>
<td>colour</td>
<td>320x240</td>
<td>yes</td>
<td>8</td>
<td>$500</td>
</tr>
<tr>
<td>eBookMan</td>
<td>hybrid</td>
<td>7</td>
<td>3.5x2.75</td>
<td>grayscale</td>
<td>240x200</td>
<td>no</td>
<td>15</td>
<td>$130</td>
</tr>
<tr>
<td>Palm</td>
<td>PDA</td>
<td>4</td>
<td>2.5x2.5</td>
<td>grayscale</td>
<td>160x160</td>
<td>yes</td>
<td>25</td>
<td>$220</td>
</tr>
</tbody>
</table>

* 45 hours when not backlit

Actors

18 participants took part in this experiment, comprising staff (primarily lecturers and researchers) in Strathclyde University's Centre for Digital Library Research (CDLR) and the Department of Computer and Information Sciences (CIS). A between-subjects design was adopted so that each participant was randomly assigned to just one condition.

Over a period of three months, each participant was lent one device with a book of his or her choice downloaded to it, for approximately seven to 14 days. Participants were provided with verbal instructions on how to perform basic functions with the ebook hardware, such as switching it on, turning pages and recharging the battery. One evaluator distributed the devices, provided operating instructions, and gathered feedback.

Four participants used the SoftBook, four used the Rocket eBook, three read a book on the Jornada, three used the Franklin eBookMan, and four the Palm.

Selection of Tasks

The only “task” assigned to participants was to attempt to read the selected book on the given device. Scavenger hunts and exams were inappropriate for this type of material (mainly fiction), and allowing participants to approach their books in a natural way, according to their own preferences, was felt to be important in gauging their responses to the medium; therefore, they were free to read the book at times and locations of their choice.

Evaluation Technique and Measures

At the end of their allotted timeframe, participants returned the ebook hardware to the evaluator, and were asked to complete an online questionnaire. Of the criteria outlined in EBONI’s methodology, it was decided that simply measuring user satisfaction via a questionnaire would require minimum time and effort from busy
lecturers and researchers who had already committed energy to the experiment, and enable the collection of structured and unstructured data. Satisfaction was measured via the four properties of the questionnaire (quality, ease of use, likeability and user affect), and indicated participants’ sense of engagement. (Sense of engagement is “the level of interest the system induces in the user” and is related to the level of interaction available and the novelty of the system (Landoni et. al., 2000).)

Since ebook readers were a relatively new area of research for EBONI, several open questions were included in the questionnaire, intended to provide fuller responses and highlight recurring themes.

Results and Discussion

Participants

The majority of participants were aged 21-50 and male; only three were female. All participants were university staff; most were lecturers or researchers. A combination of lecturers and researchers used each device.

Eight users had read an electronic book prior to this study, of whom three had used Microsoft Reader, two had used Palm/Peanut Reader, two had read Web-based books, and one had used early Hypercard products on a Mac.

The Electronic Reading Experience

Ten participants read a whole book using the device they were lent; eight did not. Users of the Jornada and the Rocket eBook who did not read a whole book gave reasons unrelated to the fact that it was presented in electronic format (such as “I didn’t like all of the poems” or “I only read those short stories that grabbed my attention”). One Palm reader failed to complete the book because reading from the small screen was “painful”, and one SoftBook user gave the reason that he found the electronic format, in general, unappealing. One user of the eBookMan did not read the whole book because the device crashed and the text was lost; another found it inconvenient to use.

After the verbal instructions provided by the evaluator, all participants learned to use the devices very quickly, quickly or quite quickly, compared to what they expected. All four SoftBook users learned to use it very quickly (see Figure 1).

As shown in Figure 2, most participants found the text very easy, easy, or quite easy to read using their ebook reader. One Palm user and one eBookMan user found the text not very easy to read; these devices have lower resolution than the others.
Most participants found the books easy to navigate (see Figure 3). Two SoftBook users and one Rocket user found them very easy to navigate; two Palm users, one eBookMan user and one Rocket user found navigation not very easy.

**Preferred E-Reading Material**

Participants said they would read a variety of material on an ebook (see Figure 4). In addition to the suggestions provided in the questionnaire (novels, textbooks and reference books), non-fiction, maps, journal articles, magazines, user-generated material, minutes and reports were suggested by users as material they would like to read in digital form.
Build of the Physical Object

Size and weight provoked the greatest number of comments from participants, with users preferring small, slim, lightweight devices such as the eBookMan, the Jornada and especially the Palm. The SoftBook received the largest number of negative remarks in this area, particularly with regard to weight, and Rocket users also found their device too heavy.

It follows that these larger devices were also uncomfortable to hold, while the smaller, lighter devices, especially the Jornada, received positive feedback in this area. However, while users disliked the design of the Rocket, the SoftBook, with its leather cover, was considered visually appealing. Participants also liked the design of the Palm.

All the devices, except for the eBookMan which has rubber edges and a plastic flip cover, were criticised for being too fragile and thereby restricting usage. Generally, users disliked using stylis to control the ebooks, finding them awkward to handle, and worrying about losing them. The Jornada’s “wheel” for turning pages was liked by all its users (although the equivalent control on the eBookMan was felt to turn pages too slowly), with several commenting that they felt they could read faster using this method of page turning: “In turning a paper page you lose momentum, albeit for a second or two. I didn’t find this at all with the ebook.”

The SoftBook’s and the Rocket’s simple “page forward”, “page back” buttons were felt to be intuitive, but the Palm’s buttons were described as “too small and fiddly”.

Overall, the Jornada received the most positive feedback in this category, closely followed by the Palm and the eBookMan. The largest and heaviest of the devices, the SoftBook, received the most negative feedback, while the Rocket was also felt to be too cumbersome: “The device itself was quite bulky and heavy. Some effort had obviously been put into the ergonomics of the device, but it just didn’t feel right. I found myself constantly shifting it from hand to hand”.

Display Technology

The Palm, while praised for its size and weight, was heavily criticised for the size of its screen and the fact that this restricted the amount of text displayed in any one “page”, meaning that users had to turn pages very frequently (“Pages are too small - always turning the damn page!”). The larger devices, the SoftBook and the Rocket, received positive remarks about their screen size, while the Jornada and the eBookMan’s screen size (larger than the Palm, smaller than the Softbook and Rocket) was not commented on.

The only device to receive positive feedback about the quality of its display was the Jornada. This has a high resolution colour screen and exploits ClearType technology which claims to triple the resolution of text by

Figure 4. Type of material participants would read on ebooks
smoothing the spaces between the pixels on a computer screen. The SoftBook was criticised most for its screen quality, one user complaining that “it was slightly hard on the eyes after an hour of reading”, closely followed by the eBookMan and the Palm. Backlighting was felt to be an important feature; the eBookMan 900 was the only device used in the experiment which did not have this capability, although other eBookMan models do.

Overall, the Jornada was felt to have the best quality display, with the Rocket and the SoftBook successful in terms of the size of their displays. The Palm received the greatest number of negative remarks in this category.

Functionalities

Functionalities of the reader software such as searching, bookmarking and annotating were generally appreciated by participants, although it was frequently commented that these features were awkward, difficult or time-consuming to use. As one eBookMan user noted, “The search facility was useful for flicking back through the story, although it took a couple of attempts before I understood how to use it”. The ability to search across all texts held on one device was suggested as a useful feature. Use of hypertext to link from the contents page to individual chapters, and from one chapter to another, was felt to be essential in an era where people are familiar with using the Web. The integration of dictionaries and thesauri was also felt to be important, particularly in situations where devices are being used for studying.

Overall, the Rocket, the SoftBook and the eBookMan were felt to have the best and easiest to use functions.

Presentation of Book Content

The Jornada (using Microsoft Reader software) and the SoftBook presented book content in the most satisfactory way, according to the participants, both using typographically sophisticated pages and navigation systems that are simple and intuitive. The Palm Vx (using Palm Reader software) and the Rocket were criticised most heavily for their unsophisticated typography, awkward navigation, and lack of “sense of place”; the eBookMan (using Franklin Reader software) was also criticised for the latter, as well as for its use of unintelligible icons.

Ebooks in an Academic Environment

Half the participants said they would use an electronic book for work; half said they would not. Those who said they would cited reasons such as portability, and advantages of the electronic medium such as hypertext and searchability. Those who said they would not use an electronic book for work gave reasons such as price, poor battery life (eBookMan) and weight (SoftBook); several users felt that portable electronic books offer no advantages over print or reading from a PC; some enjoyed reading fiction on their ebook device but said they would not enjoy reading textbooks or papers in this manner; and several said they would use ebooks for work if they had greater functionality.

The lecturers who participated in the study were divided in their opinion on whether students would find an ebook device useful. Those who believed students would use ebooks gave the following reasons:

- Portability – students could access large amounts of material “anytime, anywhere”.
- Additional functions offered by some devices (diaries, notebooks) would help students become more organised.

Those who believed students would not find ebooks useful gave the following reasons:

- Devices are too difficult to use, especially for cross-referencing purposes.
- Devices are prone to damage, loss, or dead batteries.
- Ebook hardware is too expensive.

Comparison with Other Studies

The findings of EBO NI’s evaluation are corroborated by other studies of electronic books in academic settings. In the Electronic Books in Libraries (2002) project, the libraries of New York’s University of Rochester and
Rochester Institute of Technology circulated SoftBooks and Rocket eBooks to their patrons. All participants were asked to complete a satisfaction questionnaire, and focus groups of patrons, librarians and educators provided supplemental feedback.

In another initiative (Peters, 2000), two Illinois colleges integrated the Franklin eBookMan 911 and the REB 1100 (which superseded the Rocket eBook) into their libraries and English classrooms, in Autumn 2001. Over an eight-week period, 35 students read novels on the two devices. A Yahoo! group discussion ran throughout the eight weeks, each participant submitted a two-page essay, and students were interviewed.

Marshall and Ruotolo (2002) describe a third study in which two University of Virginia classes were conducted using materials available in ebook format on Pocket PCs. The aim was to investigate whether students can and will read digital library materials on handhelds, and feedback was collected via observation and interviews.

And, in the UK in May 2000, students and staff at Loughborough University evaluated the Rocket eBook and the GlassBook (Dearnley and McKnight, 2001). 20 participants read Stephen King’s *Riding the Bullet* for 30 minutes then completed a questionnaire.

The following findings complement the results of EBONI’s experiment:

- The weight of the devices was commented on in three of the studies. In the Rochester study, the SoftBook in particular was felt to be too heavy, and users complained about the weight of the REB 1100 and the Rocket eBook in the Illinois and Loughborough experiments respectively.
- The second most common suggestion in the Rochester study for improving the devices was longer battery life. In the Illinois study, several students were irritated by having to pay attention to the state of the battery.
- In the Illinois and Virginia studies, the ability to locate the correct place within an e-text quickly, particularly in collaborative situations, was felt to be crucial to the success of ebook readers in an academic environment.
- Highlighting and underlining functions were considered useful in the University of Virginia study.
- Loughborough staff and students felt that glare and screen quality were a problem when reading ebooks. Backlighting was cited as a major advantage in the Rochester and Illinois studies.

In the Illinois study, many of the participating students noted that the speed with which they read seemed to increase with ebooks. Similarly, in the Rochester study, one reader noted about the Rocket, “It makes me read faster!” Participants in EBONI’s evaluations made the same observation.

Further, the Illinois study drew some initial observations about the effectiveness of ebook readers in teaching students. It was found that use of ebook devices did not impede learning in these Higher Education courses, and may even offer improvements in terms of motivation, retention, and reading persistence. The achievement of pedagogical objectives did not appear to be impaired.

**Recommendations**

Overall, in EBONI’s study, the Jornada with Microsoft Reader was found to be most satisfactory device by its three users, offering the most satisfying combination of weight, size, screen quality and presentation of content.

The feedback gathered from the evaluation points towards several elements as worthy of attention when designing ebook readers:

- Display technology should be high resolution, with high contrast, minimal glare and backlighting.

- Finding the optimum size of ebook hardware is a question of balancing weight, portability and ergonomics against legibility and quantity of text on screen.
- Ebook hardware should be designed for comfort, and the ability to hold a device easily in one hand is considered an advantage.
- The number and diversity of situations in which ebooks can be read can be constrained when devices are delicate, fragile or costly.
- Certain aspects of the paper book metaphor should be adhered to:
Each book should have a “cover”. This reinforces the user's perception that he or she is reading a unique set of pages which form a cohesive unit, and provides a point of recognition on return visits to the book.

“Opening” an electronic book at the correct page should be as quick and easy as opening a paper book.

The paper book metaphor should be considered in relation to the size of pages (the quantity of text visible on the screen at any one time).

Cross-referencing between pages in a book, and from one book to another, is considered important and should be made possible.

Indications of a reader’s progress through the book should be accurate and visible.

Use of graphics, typography and layout should be as sophisticated as that of the paper book.

Bookmarking and annotating should be simple to achieve.

Incorporation of hypertext (to move from the Table of Contents to individual chapters, for example) can improve navigation.

Careful design of buttons or dials for turning pages can improve this aspect of the paper book metaphor, leading to a smoother, faster transition from one page to the next.

Devices should contain thesauri and dictionaries.

Font sizes should be manipulable to suit individual preferences.

Icons should be explicit.

Search facilities are appreciated.

Electronic Textbook Design Guidelines

These recommendations, together with those emerging from EBONI’s other ebook evaluations, form a complete set of Electronic Textbook Design Guidelines (Landoni, et. al., 2002). Other evaluations focused on on-screen design issues and included:

- An evaluation of three textbooks in psychology, all of which have been published on the Internet by their authors and differ markedly in their appearance (Wilson, et. al., 2003).
- A comparison of a title in geography which is available in three commercial formats: MobiPocket Reader, Adobe Acrobat Ebook Reader and Microsoft Reader.

In addition to the above recommendations, guidelines emerged with respect to the use of structural elements inherited from the paper medium, such as tables of contents and indexes, the provision of content summaries to enable scanning, the use of colour and images to break the flow of text, and implementing multimedia and interactive elements to engage users.

Conclusion

Just like the coverage that they have received in the press, this paper reveals a mixed set of views on ebook readers. A set of issues related to reading books on portable devices was uncovered, and recommendations for responding to these issues through good design were derived.

However, some concerns are difficult to resolve adequately with current technology. Users of electronic books would like screens that are large enough to read from comfortably, but do not want the associated bulk and weight. They want to read from screens as effortlessly as they do from paper, making notes and marks anywhere they like, and flicking through the pages naturally, browsing and glancing. In the words of Birgit Lemken, “Though we can look back at more than 35 years of computer supported document processing, paper is still the preferred media for reading. This is not only due to insufficient hardware but also to unsatisfactory interfaces and presentation principles” (Lemken, 1999).

Electronic paper, now being developed by several major companies, has the potential to combine the advantages of the electronic medium (instant updating of material, user of hypermedia, etc.) with those of the printed page (lightness, flexibility, legibility, typographical quality, and familiarity to the user). Possessing so many of the qualities of the print medium, perhaps it will bridge the divide between print and screen and make electronic books an appealing, realistic option for more people.
The study presented here was small-scale, involving 18 participants from homogeneous backgrounds. Future research will replicate this work on a larger scale, with a greater number of participants, including students, from heterogeneous backgrounds.

References


*EBONI (Electronic Books ON-screen Interface) Project* (2002), http://www.ebooks.strath.ac.uk/eboni/


XML-based Adaptation Framework for Psychological-driven E-learning Systems

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Abstract
E-learning systems grew to popular knowledge delivery systems until now. Several applications have already been implemented and many project initiatives have been started. Although such systems come with interesting advantages, there are still many unsolved problems. Enriching common learning content by applying multimedia did not meet the general expectation to decrease drop out rates of e-learners using such systems. Additionally, most e-learners complain about a "one-size-fits-all" philosophy, a resulting cognitive overload and consequently the lack of personalization of existing applications.

In this paper a user-centric approach is presented in order to improve the usability and acceptance, thus, making e-learning systems more successful. For this purpose psychological factors are integrated in an adaptable learning system which is based on meta data enriched learning objects specified and described in XML documents. General learning objects are transformed into personalized learning objects depending on the user profile and adaptation rules. Beside learning objects also layout and navigation through the content are adapted and personalized. An adaptation framework is introduced to show the interaction of the discussed concepts to fulfill the request for individualized learning systems.

Keywords
Digital learning environment, Intelligent learning environment, Personalized learning objects, Metadata for education, Learning technologies, Cognitive styles, XML, XSLT.

Introduction
E-learning is one of the most interesting trends in computer science and psychology. As it is meant as any form of learning that utilizes a network for delivery, interaction or facilitation, anytime and anywhere it allows people and organizations to keep up with rapid changes that define the Web and the global business. It is regarded as "a key strategy for maximizing human capital in the knowledge economy" (Hambrecht, 2001).

Despite these promises and although enormous amounts of financial investments have been spent for developing multimedia-rich e-learning courses, current e-learning systems lack in accompanying, guiding and motivating individuals. The question why people are frustrated, de-motivated and finally drop out has already been frequently posed (CHI, 2001). Finally, experts identified the necessity to make learning systems more user-centric. However, a successful answer how to reach this approach has not or only rudimentarily been delivered. The approach introduces individualized learning objects based on psychological factors such as cognitive styles, learning strategies or skills, adapted according to individual user profiles. Personalized learning objects are dynamically generated by applying the possibilities of XML (eXtensible Markup Language) (W3C, 2001) and XSLT (eXtensible stylesheet language transformation) (W3C, 1999) which are used to describe user profiles, general learning objects, adaptation rules and personalized learning objects. In addition, with XML and XSLT beside learning objects also layout and navigation through the content are adapted and personalized.

The paper is organized as follows: chapter 2 illustrates related work in the cognitive field, chapter 3 describes several psychological aspects relevant for learning systems in more detail. Section 4 presents implementation aspects such as how to perform adaptation, how to integrate learning knowledge and finally, introduces an XML-
based framework for improving e-learning systems. Section 5 concludes the paper and describes further research activities.

Related Work

Interactive multimedia provides the stimulation for students to be actively involved in their learning. They can be encouraged to think for themselves to gain a better understanding of the content material. Despite the promises, if such sophisticated systems are not well designed they can create problems in terms of the cognitive demands they place upon the learner and by inadequately supporting changes in individual and group working practices (Preece et al., 1992).

To improve the efficiency of learning, learning systems can be designed in a way to cope with different learning styles and goals of students. Learning systems can offer several features to compensate the differences in learning outcome causes by various learning styles. The differences between good learners and bad learners, or between experts and novices, usually lie in their use of learning strategies.

In the 1960s, Witkin introduced the term “cognitive style” (learning style) to describe the concept that individuals consistently exhibit stylistic preferences for the ways in which they organize stimuli and construct meanings for themselves out of their experiences (Ayersman et al., 1995; W3C, 2001). Cognitive styles include variables within a single dichotomy such as global-holistic versus focus-detailed, field-dependent versus field-independent or right-brained versus left-brained. Learning style is a biologically and developmentally imposed set of personal characteristics that make the same teaching/learning strategy effective for some and ineffective for others. Learning styles refer to an individual’s characteristic mode of gaining, processing, and storing information (Kogan, 1971).

In the design of interactive multimedia material, a more enriched learning experience occurs when learners are presented with different styles of learning in both content and teaching style. If learners are able to determine their own pathway in selecting the information available to them, in the manner that best suits to their own learning style, then the whole learning process may be more efficient. Research in instructional design needs to investigate questions about learners and their characteristics in order to determine what type of delivery instruction is best for which type of learner in what type of environment (Orr et al., 1992).

Although considerable research has been conducted on learning strategies and cognitive styles separately, few studies have considered both cognitive styles and learning strategies together. Individual differences of learners may play an important role in the use of learning strategies. It is necessary to consider the impact of cognitive styles on the use of learning strategies (Jonassen, 1988; Liu et al., 1994).

Several existing systems aim to link specific learning strategies with cognitive processes. For this, learning strategies are embedded in some instructional activities, and these instructional activities correspond with learners' cognitive processes. For example, drill and practice is designed to provide a practice environment for learning declarative knowledge. Tutorials are designed to provide guidance and intervention for procedural knowledge.

Research indicated that embedding learning strategies in a computer program was effective (Barba, 1993; Thornburg et al., 1991). Learners in a group which had learning strategies embedded inside the program not only performed better than those without learning strategies embedded, but also retained these strategies after two months (Thornburg et al., 1991). Additionally, e-learning benefits will be heightened when e-learning is dynamically personalized to both groups and individuals. In this case the same courses will be presented with different content variations to different virtual groups. As learners move through the content, the course content and flow will alter. Much of this can be done now by a few systems, but it can be expected that over the next two years, these features will become more robust and will move into the mainstream. All of this personalization will integrate LMS (learning management system) and LCMS (learning content management system) more deeply so that RLOs (reusable learning objects) can be tracked and managed more effectively. An RLO is a discrete reusable collection of content used to present and support a single learning objective (Jacobsen, 2001).

The intelligence of a system also includes the knowledge on the course space translated into learning objectives and on the organization of the didactic resources. The knowledge of these three dimensions (cognitive style, knowledge space and didactic resources) allows the system to provide adapted content fitting to the needs of each individual student (Souto et al., 2002).
The instructional content adaptation to the student’s individual characteristics implies that a learning system has to: (i) recognize the cognitive patterns of each student’s learning and its pedagogical implications, (ii) know the training knowledge space being proposed, (iii) know the instructional material organization, and (iv) be able to dynamically generate the best suited selection and sequence for each student in a particular course stage. These four requirements shape an educational model. The approach presented in this paper refers to these requirements and provides an adaptable learning system based on meta data enriched learning objects.

Psychological Aspects

To keep a common understanding of what is meant here by the terms “psychological aspects” or “psychological factors” the following paragraphs introduce appropriate concepts that affect people’s individual thinking and behaviors. The presented aspects are cognitive styles, learning strategies, skills, learning modalities and sequencing of instructions.

Cognitive Styles

According to Kearsley, cognitive (or learning) styles describe a person’s typical mode of thinking, remembering or problem solving. Research began in the early 1950’s and literature shows that more than nineteen cognitive styles such as holistic/analytical, verbal/imagery or field dependence versus field independence have been identified since then. According to Witkin, field dependence-independence is value-neutral and is characterized as the ability to distinguish key elements from a distracting or confusing background (Witkin et al., 1977). Cognitive styles are considered as bipolar dimensions whereby having a certain cognitive style determines a tendency to behave in a certain manner. It influences attitudes, values, degree of social interaction or shortly the preferred way a person processes information. The following table describes a set of cognitive styles and their impacts on learning as presented in (Dufresne et al., 1997; Hsiao, 1997; Kearsley, 2002).

<table>
<thead>
<tr>
<th>Cognitive Style</th>
<th>Description</th>
<th>Impact on learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holistic</td>
<td>tend to see a situation as a whole;</td>
<td>prefer to learn in a hierarchical fashion;</td>
</tr>
<tr>
<td>Analytical</td>
<td>tend to view a situation as a collection of parts and often stress only one or two aspects at a time;</td>
<td>prefer to learn in a sequential manner;</td>
</tr>
<tr>
<td>Verbal (sensory preferences)</td>
<td>tend to be external and stimulating;</td>
<td></td>
</tr>
<tr>
<td>Imagery</td>
<td>tend to be internal and passive;</td>
<td></td>
</tr>
<tr>
<td>Field Independent</td>
<td>tend to approach things analytically; are likely to either analyze a field when it is organized or impose a structure on a field when it lacks organization of its own; are prone to be impersonal; tend to have self-defined goals and reinforcement;</td>
<td>tend to learn more under conditions of intrinsic motivation (self-study); may themselves provide the mediating structural rules as analyzing and structuring;</td>
</tr>
<tr>
<td>Field Dependent</td>
<td>tend to approach things in a global way; are interested in interacting with other people; prefer to be guided and to rely on external referents;</td>
<td>tend to be better at learning and remembering social material and learning it in a social way; tend to adopt a passive approach in learning and problem solving;</td>
</tr>
</tbody>
</table>

The presented set of cognitive styles gives an impression of how different people are in absorbing, processing and retaining information. These cognitive differences affect additionally the use of learning strategies as introduced in the chapter Related Work.
Learning Strategies

Learning strategies describe techniques as illustrated in (Kearsley, 2002) that students use to learn, either methods to improve memory for better learning or test-taking strategies. They subsume two aspects: first, cognitive strategies and second, metacognitive strategies (Hsiao, 1997).

Cognitive strategies refer to plans that are used by students to acquire, retain and retrieve different kinds of knowledge. These activities range from acquiring, selecting and organizing information to rehearsing learning material or relating new material to information in memory. Adjunct questions, reflective questions, summarization, note taking, keyword method, pegword method, method of loci, advance organizer or concept mapping have been identified as effective strategies to improve learning.

Methods for “learning to learn” are described as metacognitive strategies. All activities such as checking, planning, encoding, reviewing and evaluating with the aim to monitor the learning process. A set of cognitive strategies i.e. consisting of concept mapping, advance organizer and any method relevant for monitoring activities can be considered useful for meta cognition on learning. The ability to cope with learning processes enables students on the one hand to improve their learning and on the other hand to become more independent learners.

Skills, Learning Modalities

Improving to learn also assumes that individual learning skills have to be identified. Skills can range from skills such as speaking foreign languages to skills like reading, writing or adapting gained information to knowledge. Beside cognitive styles, which describe the way people process information, individual differences in abilities – also considered as modalities – describe students’ peak or high performance in learning. Abilities are unipolar, they range from zero to a maximum value. Consequently, students might prefer one kind of ability that may be beneficial but also have other intelligences to a certain extend. Most well-known is probably Howard Gardner’s theory of Multiple Intelligences. He has identified seven different intelligences illustrated in (Conner et al., 1996) that should be considered for each individual student to improve their learning: verbal-linguistic (sensitive to the meaning and order of words), musical (sensitive to pitch, melody, rhythm, tone), logical-mathematical (able to handle chains of reasoning and recognize patterns and order), spatial (perceive the world accurately and try to re-create or transform aspects of that world), bodily-kinesthetic (able to use the body skillfully and handle objects adroitly), interpersonal (understand people and relationships), intrapersonal (possess access to one’s emotional life as a means to understand oneself and others).

Sequencing

There are a number of theories that describe the order and organization of learning activities or sequencing of instruction. As sequencing of instruction influences the way information is processed and retained as mentioned in (Kearsley, 2002) the kind of building up sequences may be strongly affected by an individual cognitive style. The theories suggest simple-to-complex sequences, goal-directed sequences, linear sequences, letting students form their own learning sequences or adapting instructions to the experience or interest of learners.

Implementation Aspects

The previous chapters described research and theory behind psychological aspects. This chapter will present the impacts of combining cognitive styles, learning strategies, skills and sequencing on developing learning systems. To provide successfully psychological aspects in learning systems their common modules should be firstly identified. Parts in a learning system are the knowledge base providing necessary content such as learning lessons and courses, student administration for accompanying and monitoring success or failure, authoring tools for managing new content provided by teachers or trainers and the pedagogical module that currently can be primarily regarded as a way for instructors to build up learning sequences or courses.

As most available systems are not able to give a strategic answer to the current call for more user-centric systems, it seems appropriate to identify a possible way to overcome this barrier. The next three chapters introduce a methodology that bases on the integration of psychological factors and learning objects to propose new implementation aspects for an adaptation framework.
Adaptation – What and How?

Adaptation in learning systems is two-fold: on the one hand, there is the question of what can be adapted in such environments and on the other hand, there should be given an answer to the question of how the presented psychological factors influence the proposed adaptation. According to Brusilovsky, there are three kinds of adaptation in hypermedia systems: first, content, second, layout and third, navigation (Brusilovsky, 2001). In case of learning system, a specialization of hypermedia systems, the proposed adaptation mechanisms request further investigations. Figure 1 shows considerable psychological aspects and impacts on an adaptable learning system.

Additionally to hypermedia systems, content adaptation in learning systems not only depends on a student’s preferences, what he would like, but also on his personal skills what he can achieve. Lessons and courses, particularly the severity of learning material needs to be adapted according to the student’s abilities and current learning progress. Individual skill gaps should be identified by the system and content delivery has to be adapted to overcome these gaps step by step without losing the student. Lessons able to teach writing and reading skills should for instance be firstly presented to students who are weak in these cultural skills before they are confronted with a mass of complicated and difficult courses.

The decision for layout has primarily been the task of computer scientists implementing information systems or in the Web era the success of Web designers producing creative applications. Unfortunately, this cognitive overload interrupts people having different intelligences, abilities and ways to process information. It seems obvious to provide students who are visually strong with images, graphs and tables additionally to common text. The visualization and animation of content, combination of text, sound, video and images is heavily influenced by the kind of students’ learning modalities.

Figure 1. Impacts of psychological factors in a learning system

Navigation adaptation in learning systems is strongly effected by learning sequences, which describe the order and organization of learning activities. As sequencing of instruction affects the way information is processed and retained, cognitive styles seem to be responsible for determining an individual’s request for the kind of sequence. Analytical people for instance prefer to learn in a sequential manner and may be supported by a linear sequence of instruction. In contrast to holistic persons who prefer to learn in a top-down manner to keep a global picture which could be encouraged through a simple-to-complex sequence. Furthermore, field independent individuals who are more self-motivated and less interested in a structure to the subject might be supported from time to time through content-different lessons to keep their attraction and motivation.

Field dependent or holistic people favor to learn in a global way, field independent persons however tend to learn more analytically being interested in single factors at one time. The support of detailed chunk of information without connection to a learning domain, chapter or lesson will probably unsettle field dependent or holistic persons. Therefore, the surrounding of an adaptable learning system should at least provide a possibility to gain access to context data either through hyperlinks or more sophisticated through illustrating students’ current position, learning progress and available actions that may be taken.

As field dependent persons prefer social contacts and tend to learn in social ways services such as mailing lists, chat rooms or forums seem to be desirable for those learners. These services may in contrast be disturbing for field independent people who are prone to be impersonal. Learning systems should therefore be competent.
enough to enable or disable access to these services according to individual requirements. Further services to support individual learning strategies may also be adapted with respect to student’s cognitive styles.

Respecting individuals’ cognitive styles are without any doubt capable of improving their learning performance and making them happier in passing learning lessons. However, there remains the desire to go beyond one’s individual learning horizon, to strengthen one’s weaknesses and to broaden one’s cognitive styles. This will be achieved by conflicting students from time to time with lessons, surroundings or navigation abilities, which are not meeting their individual styles. Nevertheless, one could argue about the necessity of psychological aspects in learning systems, why considering individual differences at all? The answer to this objection is easily offset because the identification of individual cognitive differences enables at all to distinguish between matching styles for better learning as well as communication and putting place for conflict for challenging or unsettling experiences (Bostock, 1998).

Learning Objects

Learning objects describe any chunk of learning information, digital or non-digital, such as an image, text, video, educational game or sound files. The aim of those entities is to provide a tremendous set of learning knowledge that once developed can be exchanged among organizations, and be used to build up several individual lessons and courses (McGreal et al., 2001). The key factor for this flexibility is not performed by the physical learning object itself but by its standardized description or more precise its metadata specification. As cited in IEEE (IEEE, 2002) Learning Object Metadata (LOM) specification:

A metadata instance for a learning object describes relevant characteristics of the learning object to which it applies. Such characteristics can be regrouped in general, life cycle, meta-metadata, educational, technical, rights, relation, annotation, and classification categories.

During the development of a learning system, especially because single organizations call for individual approaches without losing access to available knowledge resources, this standard simplifies the integration of learning objects. The simplification is supported because each learning system can emphasize this metadata information that seems to be most important in certain circumstances, e.g. the diversity of cultural and lingual contexts, and however may make extensive use of all available learning objects.

![Learning Object Metadata extended with psychological aspects](image)

**Figure 2. Proposed extension of the Learning Object Metadata specification**

The current version of the learning object metadata specification supports educational description such as if an object requires active (pass a question, enter some text) or passive (read a text) student interaction. Nevertheless, it lacks in providing psychological factors as described here although its extensibility would give enough room for such an integration. The advantage of specifying these aspects in the LOM standard enables to select suitable objects for any individual student for any kind of learning system being built on the metadata specification. Figure 2 illustrates the current LOM version and its proposed extension.

After ensured that single learning objects are aware of their psychological strengths a convenient framework being capable of processing this kind of information for cognitive adaptation will be introduced in the following chapter.
Adaptation Framework

The approach presented in this paper primarily focuses on the methodology of adapting learning material and the learning environment with respect to cognitive individualities of single students. The system has therefore to provide two different kinds of data: first, the learning knowledge in form of learning objects equipped with psychological information (as presented in chapter 4.2) and second, a set of adaptation rules to determine the mapping between a student’s individualities and the impacts on the kind of response delivered to this person (as introduced in chapter 4.1). To meet this challenge, Figure 3 illustrates an overall picture of the proposed workflow and adaptation mechanisms.

![Figure 3. Framework for adapted learning systems](image)

Adaptation Methodology

In an initial phase (1.1 initial assessment), the student is asked for passing an assessment center to identify his individual psychological factors such as cognitive style, learning modalities or skills, shortly defined as student profile. The complexity of this center can range from simply questioning to more sophisticated cognitive tests. In the context of this paper however, we assume that the identification of students’ profiles is in any form existent. The system keeps the profile in the local memory (1.1.1) and additionally, stores it in the profile database (1.1.1.1) for further interactions.

After the identification of a student’s cognitive profile, any requirements requested by the student will be channeled directly (1.2 common request) to the system. More precisely, the invoked component is named Adaptation Engine. The engine requests the current student profile necessary for performing adaptation from the system’s local memory (1.2.1). The awareness of the current profile enables to select on the one hand, an appropriate set of adaptation rules from the database (1.2.2 rules) and on the other hand, a matching set of learning objects from the knowledge database (1.2.3 data). Both databases retrieve the results to the adaptation engine (1.2.2.1 adaptation rules, 1.2.3.1 learning objects) in a convenient format such as XML. The adaptation rules may specify the type of the selected learning objects and how the learning system has to be adapted, illustrated in the following example:

It is assumed that the current student’s profile defines a field dependent person who prefers visual learning modality. The delivered adaptation rules, for instance, determine that proposed learning objects have to support either field dependent style or visual representation capabilities (LO1, LO2). The rule (RO1) may therefore have an influence on the selection of learning objects, which have to be proper enough to support in this case these two psychological aspects. An additional rule (RO2) may define that field dependent persons have to be supported with access to a chat room tool, mailing lists and to be provided with a convenient context description.
There might be another rule (RO3) that specifies the visual representation of the interface to the learning system explicitly adapted to field dependent, visual persons.

The combination of learning objects and adaptation rules can then be handled by the engine through techniques such as common programming logic or XSLT (1.2.4 transformation). XSLT is an effective way to produce adapted output in form of HTML (hypertext markup language), WML (wireless markup language) or XML, which can be directly responded to the student asking for a specific learning lesson, which is finally embedded in a learning system optimized for individual cognitive requirements (1.2.5 response).

**XSLT Adaptation Process - from a user profile to individualized output**

The power of XSLT enables to solve similar problems by following one kind of XSLT employment. During the last years common best-practices according to the implementation of XSLT have been developed and design patterns came into existence. Design patterns are a powerful reuse mechanism to provide a standard solution, and a common language about a recurrent problem. One of those patterns in XSLT are rule-based stylesheets. Rule-based stylesheets consist primarily of rules describing how different features of the source document should be processed. They form the essence of the XSLT language and therefore build an optimal basis for the introduced adaptation mechanism. As specified in (Kay, 2001) they are "at their most useful when processing source documents whose structure is flexible or unpredictable and are very useful when the same repertoire of elements can appear in many different document structures".

```xml
<userprofile>
  <username>donald</username>
  <cognitivestyle>
    <theory><expert>Witkin</expert><title>Field Dependence/Independence</title></theory>
    <characteristics>
      <name>field-independent</name><occurrence><fact>false</fact></occurrence>
      <name>field-dependent</name><occurrence><fact>true</fact></occurrence>
    </characteristics>
  </cognitivestyle>
  <learningmodality>
    <theory><expert>Howard Gardner</expert><title>Multiple Intelligences</title></theory>
    <characteristics>
      <name>spatial</name><occurrence><percentage>80</percentage></occurrence>
    </characteristics>
  </learningmodality>
</userprofile>
```

**Figure 4. User profile in XML**

In this context, single XSLT documents represent the desired result for a certain part of the requested Web page. The outcome is therefore governed through XML documents hosting user profiles, adaptation rules, learning objects, and adaptation possibilities such as access to services or description of the learning context. Figure 4 introduces exemplarily a user profile as XML document.

Adaptation rules are selected according to a single user profile. As illustrated in Figure 1 proposed single psychological factors influence the outcome of the learning system in different ways. Consequently, the selection of those adaptation rules, learning objects or learning environment necessities has to be based on the implementation of filter strategies or dependence rules.

Dependence rules can either follow more simple approaches such as rule-based techniques or more intelligent solutions like case-based reasoning. Additionally, to keep high flexibility in extending adaptation possibilities each psychological aspect and its impacts are clustered and encapsulated in single components.

Following our previous example, selected adaptation rules are filtered from the existing pool with respect to user profile data such as cognitivestyle/fielddependent/true, learningmodality/spatial/80% or learningmodality/linguistic/20% (means that the user “donald” strengthens his visual intelligence, and favours
linguistic abilities only to a certain extend). A single rule determines thereby one single instruction. Remembering and employing Brusilovsky’s thesis, a rule may influence: (i) content, (ii) layout and (iii) navigation. Figure 5 shows some rules influencing layout and navigation in XML (no. 1 and no. 2) and introduces learning objects represented according to LOM specification (no. 3 and no. 4). All rules are interpreted by the XSLT adaptation mechanism. Figure 6 introduces XSLT exemplarily for available XML input. According to the rule-based approach there may be a single XSLT for any available XML element. This fragmentary pool allows to define the outcome for a specific element without explicit knowledge of how to pull them together to form different output and vice versa.

Figure 5. Adaptation rules, learning objects in XML
All filtered rules and learning objects are then interpreted through XSLT stylesheets following the rule-based design pattern approach. As result of the transformation each single user will gain his individual, personalized learning environment dependent on his cognitive style, learning modalities, skills or learning strategies, according to his current user. Figure 7 presents the specific outcome for the proposed example. Limitations of common learning systems currently present in the Web namely, offering learning modules in standard fits-for-all-interfaces can be avoided with the introduced approach. Additionally, users will benefit because at any moment the system is capable of treating single persons as individuals having a specific way of information processing and certain abilities.

Conclusion and further research

In this paper an approach for adapting e-learning systems to psychological factors has been presented, whereby the primary aim was to enable more user-centric opportunities. The method is based on research in the field of cognitive science, the learning object metadata specification provided as IEEE standard and the introduction of adaptation rules combining cognitive aspects with services available in e-learning systems. Personalized learning objects are dynamically generated by applying the possibilities of XML and XSLT which are used first, to describe user profiles, general learning objects, adaptation rules, and personalized learning objects and second, to adapted and personalize layout and navigation through the content. Finally, an adaptation framework has been introduced to show how all the illustrated concepts might work together to fulfill the request for individualized e-learning systems.

Further research in this field will be investigated to detail the semi-structure of adaptation rules, to extend the LOM standard with psychological aspects and to integrate assessment center methodologies for identifying individual student profiles.
Figure 7. A single transformation result in HTML

<table>
<thead>
<tr>
<th>Learning Objects</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is XSLT?</td>
<td>Mailing Lists</td>
</tr>
<tr>
<td>A transformation</td>
<td>XSLT group</td>
</tr>
<tr>
<td>A template</td>
<td>XML Community</td>
</tr>
<tr>
<td>Any comments should be entered here.</td>
<td>Notetaking</td>
</tr>
</tbody>
</table>

References


InterMediActor: an Environment for Instructional Content Design Based on Competences


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Abstract
This paper describes the basic architecture and functional principles of a new instructional design system called InterMediActor (IMA) and reports about its implementation state. IMA provides an environment for instructional content design, production and reuse and for student evaluation that is based on the decomposition of the learning objectives in a hierarchical structure of competences. The process of content production and learning in competence-based systems is described and the main advantages and differences in relation to other proposals, like SCORM and EML, are discussed.

Keywords
E-learning environment, Learning Management Systems, Educational content development, Competences, Learning objectives

Introduction
With the advent of the Web, distance learning has become a main concern for most academics who are well aware of the advantages it offers to improve the learning process. Nevertheless, developing a new electronic course is a complex and time consuming task.

There are some authoring tools and course management systems developed with a view to providing assistance to course developers, including WebCT (WebCT Inc., 2003) or Blackboard (Blackboard Inc., 2003), but they are based on templates which are often too rigid to meet the teachers’ needs.

Another relevant area of research in education is the deployment of standards for learning objects (LO) as independent units of content whose main features are accessibility, reusability and interoperability. In this area, there is still an open discussion on the meaning and implications of a LO which in most cases are too general to be useful. For instance the SCORM, Sharable Content Object Reference Model (Advanced Distributed Learning initiative, 2003) proposes the sharable content object (SCO), which “represents the lowest level of granularity of learning resources” that “could be reused in different learning experiences to fulfill different learning objectives”; reusing content at this level of granularity can be as costly as directly using raw material. Also, the Learning Technology Standardization Committee (LTSC) of the IEEE proposal defines a “Learning Object Metadata” (LOM) as “any entity, digital or non-digital, that can be used, re-used or referenced during technology-supported learning” (Learning Technology Standardization Committee - IEEE, 2000), a definition that is rewritten by Wiley into more concrete terms as “any digital resource that can be reused to support learning” (Wiley, 2001).

But the main obstacle for learning objects (whatever their definition) to be really useful is the extensive assistance needed by educational content developers to match the concept of a LO to their teaching goals and needs. Developers of educational applications, particularly those lacking a background on instructional design models (Dick and Carey, 1990; Merrill, 1996), need more than software tools to compose multimedia courses or standards to define reusable LOs. Rather, they need a well-defined framework to develop their content taking
into account the learning needs and goals they are devoted to satisfying as proposed, for instance, by the Educational Modelling Language (Koper, 2001).

Most methods used in distance-education experiences are based on a concept-based presentation of the subject to be taught. The subject is usually hierarchically structured into a number of concepts or topics described by means of multimedia contents. In such organization, sequential reading among topics is the main access mechanism supported (Brusilovsky and Rizzo, 2002).

But, in our opinion, learning is not only concerned with acquiring factual knowledge but also with developing competences such as inference, deduction, discrimination, problem-solving or learning strategies. Indeed, when educational content developers face the specification of new curricula they rarely think about specific contents but, rather, on general goals expressed in terms of the competences students ought to acquire. Also, the learning experience requires a non-sequential access mode in which stale competences incident in the learning context may be refreshed or alternative learning paths undertaken.

We also believe that the evaluation of the learning process should be consubstantial with the learning experience and this demands a tight integration between the access mode and formative and summative assessment.

In this paper we propose the use of a method for designing and using educational content based on the concept of a competence (Bousoño et al., 1999) and its implementation in the InterMediActor (IMA) environment (IMA, 2000). We will also discuss how to incorporate competences as the basic building blocks to be reused across different educational materials. In this sense, our proposal for the content unit is one instance of how to fill the placeholder “learning object” in the LOM and similar ontologies. We will put forward techniques for incrementally deriving relationships between competences leading to a graph-like organization of possible learning paths and techniques for embedding assessment within each learning unit so that the learning process can be followed and acted upon when detecting gross deviation from expected learning outcomes.

This paper is structured as follows: the next section describes the fundamentals of the competence-based instructional model used in InterMediActor; in the following section some rationale for using competences is demonstrated by means of the tools allowing it. Then a discussion concerning the main advantages of this approach is presented, where the relation with similar works, particularly SCORM learning objects and EMLs, is analysed. Finally, some conclusions are stated and further work anticipated.

**A Methodology For Instructional Content Design**

The method that we propound uses an analysis-synthesis process to develop educational content (Bousoño et al., 1999); it tries to adapt to electronic content the process described in (Melton, 1997) having two main phases: a top-down analysis of learning objectives and a bottom-up synthesis of competences. This process will be carried out by a (knowledge-)domain expert, i.e. the person in charge of making explicit the knowledge brought to bear in a particular learning project.

To this learning objective-based methodology we add a course-assembly step in which curricular requirements get fleshed out into courses.

**Learning content description and creation**

In this subsection we explain how to refine learning objectives and how to transform them into competences.

*An analysis of grounded learning objectives*

Learning objectives are always stated in positive, finalistic language such as the following example:

Ex. 1: “To be able to recognize, understand the structure of and code XML documents”

They often start with “to be able to”, “achieving the capability of”, stating explicitly the learning outcome that we’d expect to be able to test for in any content implementing such objective. Finality-motivated expression of objectives helps focus both the content and the learning experience on the expected learning outcomes.
Such generic, complex learning objectives demand their breaking up into several new ones; we refer to the process of expanding a learning objective into a number of sub-objectives as its refinement. Whether an objective should be refined or not is a matter entirely left at the discretion of the domain expert (in fact a complex function of the target audience, the level of complexity required of the learning experience, etc.)

Eventually, some objectives will not be refined, possibly because their complexity is judged amenable to grasping in a single learning interaction (i.e. reading a paragraph, glancing at an image, running an animation, etc.) We will refer to such objectives as atomic.

The decision to refine or to mark as atomic an objective generates a finite tree of objectives like the one shown in Figure 1.

Subobjectives of a common parent objective may also take part in particular relationships distinguishing them as:
- **Parallel subobjectives** whose fulfillment may be undertaken without references among themselves; in any case, all of them should be navigated sooner or later or, in other words, the competences they lead to, somehow fulfilled.
- **Sequential subobjectives** whose fulfillment must proceed in a definite order prearranged or suggested by the domain expert.

A structure accommodating both kinds of objectives is a directed graph of subobjectives (of the original objective) in which:
- Nodes represent the sub-objectives;
- links outgoing from the same sub-objective represent parallel alternative paths;
- Paths of links describe sequences of sub-objectives.
The analysis of objectives into parallel or sequential ones generates finite graphs of local dependences like the ones shown within squares in Figure 2.

**Top-down analysis of learning objectives**

The purpose of the process of analyzing learning objectives is to obtain a graph showing not only the refinement relation, but also the parallel or sequential nature of some of the relationships between objectives as well as the atomicity of some of them.

Top-down analysis of learning objectives proceeds from an over-arching, all-encompassing root learning objective stating the desired learning outcome, through adequate refinement into more detailed and concrete objectives. Eventually all objectives will be either refined or declared atomic.

For instance, example 1 is too generic to be considered an atomic instance and is easily refined into the following:

Ex. 2: “To be able to recognize XML documents”
Ex. 3: “To be able to understand the structure of XML documents”
Ex. 4: “To be able to code XML documents”

The process ends when atomic objectives are identified, that is, when the educational designer decides one objective is simple and relevant enough to be considered as an atomic study unit.

The whole process is depicted conceptually in Figure 3. The result of this analysis is thus a heterogeneous graph of dependences between learning objectives with two types of dependence relationships between objectives:

- The refinement relationship between one objective and its subobjectives, describable as a tree-like hierarchy;
- The depends-on relationships between objectives that are parts-of the same (more general) objective, describable as a finite (di) graph.

This graph is instrumental for synthesising competences, which will be the actual learning objects in our methodology.

![Figure 3. Top-down analysis for a hierarchy of objectives](image)

**A model of grounded competences**

Competences are the atoms of the learning experience. The emphasis on grounding highlights the fact that they are tied to the particular learning situation in which their spawning objectives were captured: unless this situation is reproduced (as regards targeted audience, level of complexity, etc.) the learning experience will be in a less than optimal situation.
Consistently with the two types of learning objectives obtained in the analysis process, there are two types of grounded competences: atomic and aggregated.

Because they are more directly related to universal learning experience, the concept of an atomic competence is easier to grasp as well as label than aggregated experiences. An atomic competence consists of:

- The learning objective it implements.
- An advance organizer introducing the matter to be learned, so as to set in context the learning experience about to happen (grounding it).
- Some pre-requisites to be grasped before trying to understand this particular competence, some of which encode the depends-on relationships with atomic competences of the same granularity. Other, external dependences may also be required for each competence referring to learning outcomes of previous learning experiences. For example, basic math competences would be incidental to most engineering competences.
- The content to be learned itself, which can be a complex multimedia object, but is designed as a single psychological 'totum', a screenful of self-contained text, a complete picture, or a single concept and illustration.
- A summary, to state what the learning outcome should be, in order to convey a feeling of achievement, for instance:

  Ex. 5:  “In this unit you have learnt to recognize XML documents”.

- Some self-assessment and final-assessment tests based on the content introduced, capable of fulfilling formative and summative evaluations of the learning outcome (if only for the atomic competence).

This is a straightforward extension of Melton’s scheme (Melton, 1999) to emphasize both assessment and a multimedia content management context.

Although each of these constituents was initially targeted at highly verbalized content, i.e. text, nothing prevents their being generic multimedia records fulfilling the same function in an interaction carried out in a different modality. For instance, children may find it advantageous to be presented advance organizers as pictures or cartoon animations rather than text, possibly tagged in the nouns of the objects or characters in the competence being introduced, so as to focus the context of the learning experience being undertaken and close the universe of discourse. For adult technical learners, problem-based methodologies may emphasize the stating of the problems to be solved with a mixture of text, formulae and diagrams.

![Organization of a Competence](image)

**Figure 4.** Transforming an atomic objective into an atomic competence

**Bottom-up synthesis of competences**

Whenever an objective is declared atomic, the corresponding atomic competence may be synthesized. Figure 4 depicts the transformation of an atomic objective into an atomic competence:
We clearly see that building a competence requires much more content than can be captured in a bare objective. To complete it is the responsibility of the domain expert. The different skills called for the development of competences demand that the domain expert be good not only at knowledge elicitation (i.e. to state content and dependences) but also about knowledge testing (i.e. to write assessment tests) and learning motivation (i.e. to write advance organizers and summaries.)

After atomic competences are completed, more complex competences can be synthesized following a bottom-up approach along the refinement in the hierarchy in the inverse order they are stated:

- Atomic competences may be aggregated as the content of a higher-level competence including the parent of their learning objectives.
- An aggregate advance organizer and summary related to those of the joined competences need further be provided.
- It is also worth noting that formative and summative assessment may come from those of the aggregated competences or be used to assess new, emerging features of the aggregate itself.

Notice that such an aggregated, second-order competence can then be used to synthesize less-refined ones as directed by the analysis graph.

This process ends when each learning objective in the analysis coalesces into a competence and the resulting content has the shape of a competence graph which closely resembles the learning objective graph, the difference being all the content aggregated in each synthesizing step. Figure 5 depicts the appearance of such a final coalesced graph.

![Figure 5. Fully-synthesized competence resulting from a competence-aggregation process](image)

*From curricular requirements to courses*

Content creation is seldom a spontaneous activity whereby the domain expert elicits her own knowledge. Rather, it involves some previous motivation, most often curricular requirements: the need to provide content for a certain subject in a curriculum which students should undergo with a certifiable standard of success. Course editors may aggregate basic competences as well, but by far their most important role is to “close” a particular aggregation of competences into a course, which is an instance of aggregated, formatted content with specific learning objectives and expected learning outcomes placed in the context of a particular curriculum.

This introduces the notion that course assembly is really a question of fleshing a curricular requirement top-down, and we propose to make use of existing competences to do so. This is depicted in Figure 6 where the ideal process of obtaining certified professionals from the society’s needs is outlined: society (i.e. committees, professional bodies) first generates curricular requirements later imposed on educational bodies as directives or laws. These are grounded in each educational institution into learning objectives which can be then subject to a content production process (competence synthesis). Adequate clothing of content (competences) may turn them into courses which allow to certificate professionals according to society’s needs.
Curricular requirements resemble grounded learning objectives in that they define the learning experience by its learning outcomes. However, the emphasis is to add a social ingredient of adequacy (of the learning outcome) and require a notion of certification: no curricular requirement is considered achieved without attesting to it.

Also, courses embody curricular requirements in the same sense that competences embody learning objectives, with a shift in the nature from learning outcomes to summative evaluation, as a means to certify learning success. Courses fulfill curricular requirements by certifying a degree of excellence in the learning outcomes assessed for particular competences, thus permitting certification.

Curricular requirement analysis

The objective of curricular requirement analysis is to obtain a description of these in terms of grounded learning objectives. In this sense, it is a question of trying to fit curricular requirements into pre-existent, synthesized learning objectives.

The knowledge processing skills here involve learning objective identification and matching to curricular requirements, which call for another actor in the model, the course editor, and for an emphasis on reuse rather than creation.

Course edition & assembly

If competences embody the atoms, courses embody the molecules of the learning experience: they are functional units intended for specific learning outcomes with certifiable degrees of achievement.

Aggregated competences are perfect candidates for courses in the particular subjects their learning objectives tried to capture:
- They can be navigated through the competence/sub-competence and the depends-on relationships inherited from learning objectives.
- They embody the learning objectives as stated by the content developer (expert, teacher).

In a course, there is a head competence, often aiming at complex or generic learning outcomes. For a competence to become the head of a course its objective has to match the course’s curricular requirements and little else. The idea that courses are assembled whereas competences are synthesized, brings the notion of using preexisting competences and information retrieval techniques for assembling new courses.

The learning experience with courses built out of competences

With courses built on top of competence graphs, the learning experience may be reduced to navigating such graphs, starting from head competences.
The dependence relationship may be further used to guide/allow to navigate in certain directions: summative competence assessment success may be used to license a competence and its successors, opening a new part of the graph for browsing. At any instant after some time of graph traversal, for whatever competence within the graph, its positive summative assessment increases the user’s choice of successors depending on:

- The graph of dependences, more refined competences or competences at the same level or refinement may now be navigated.
- The state of the graph traversal: if the recently licensed competence was key prerequisite for another one, the latter becomes available.

As an added bonus, refreshing skills may be simply attained by the act of re-traversing the competence graph. However, when revisiting or refreshing competences, summative evaluation should be disallowed and only formative evaluation permitted.

**Figure 7.** Conceptual content producing and consuming flows in the basic design

This will also cater for pre-assessment of the level of achievement in one competence for discontinuous learning: to pre-assess the level of achievement of a competence, we may simply navigate its formative assessment.

Finally, assessment for the whole course may be cast into the form of an assessment for the head competence.

**Discussion**

Because of the difficulty of defining what atomic content is, many decisions about the criteria for some content to become atomic have to be taken into consideration, including terminal capabilities and user sensory capabilities. This may break the “at a glance” nature of atomic content.

Apart from deciding which objective is atomic and which is not, the question of different depth of treatment of subjects is not catered for in this methodology at present. We cannot speak about levels of difficulty for each learner – starter, advanced, proficient - which may be necessary when trying to cater for the learning needs of a heterogeneous population of learners.

It is also feasible to come across learning objectives which have not been synthesized into competences as yet, particularly in the period of migration from traditional to computer-based content development. Thus selection of a learning objective by a course editor may trigger costly competence synthesis processes. Eventually, however, a course editor need not submit a learning objective to a domain expert to synthesize it in order to build her course.

To conclude this partial discussion we need to remark that for some conceptions of learning objectives the inclusion of a minimum level of excellence in them, which is then translated into a level of excellence in the
competences that embody them to license their learning outcomes, is a requisite. The difference between curricular requirements and learning objectives (respectively, courses and competences) would then be blurred and some other pragmatic considerations must differentiate them. For one reason, curricular requirements would never be stated in the level of detail that we demand of learning objectives here. Also, as seen from traditional courses they sometimes show a structure of blocks and the units within these blocks (such being rather loose conceptual separations which would roughly correspond to our alternative sub-objectives but deprived of an encompassing objective other that the disjunction of them all.)

An Environment for Managing Educational Content: InterMediActor

In this section we describe the InterMediActor architecture (IMA for short) for electronic content development, deployment and use. It is therefore an instance of what has come to be known in the literature as a Learning Management System, LMS. We first describe the general design and later report in the actual development state for the first release of the architecture. We also make a brief description of the intended mode of work with it.

The InterMediActor Architecture

Functional architecture and user roles

Figure 7 depicts the functional architecture designed for IMA, that of producer-consumer stateful clients which understand the different stages of content as it is developed, decoupled by stateless servers from a pool of repositories which store content of different kinds and degrees of completion.

This architecture can be exploited in several ways by users in different roles:

- **Domain experts**, elicit their implicit knowledge of the domain to provide some explicit knowledge.
- **Layout providers**, provide formats for maximizing content conveyance.
- **Course editors**, bundle content according to some criterion of what is a separate learning unit.
- **Learners**, profit by the effort of everybody else.

The main working flows entwine to allow incremental analysis of learning objectives, incremental synthesis of competences, course assembly and navigation.

Figure 8, on the other hand, depicts the architecture as of version 1.0. Although content provision is rather well developed, we point out that layout provision and serving is not catered for in the actual implementation and that course edition facilities are restricted to a minimum. In fact, the competence server automatically promotes all root competences to courses (by making them head competences).

Also worth noticing is the explicit allowance for a local state in the clients, implemented as local databases, that allow to introduce the notion of a possibly discontinuous session in content elicitation and navigation. This is paramount for big aggregated competences, difficult to synthesize in one session, or to browse in a single learning interaction.

As a final deviation from the initial design it can be seen that some servers which are coupled in the present state of development were initially separate, most notably the multimedia record and competence servers. This must always be seen as a temporal decision until the decoupling becomes necessary when adding new functionalities, for example installing information retrieval capabilities on the records but not the competences, etc.

Client and server technology in IMA version 1.0

All information structures in IMA have been captured into DTDs to use XML validity concept to implement input and communication validation.
We use two types of building blocks for clients, both in java, possibly merged together to offer a unified view to users:

- A graph editor, parameterized in the type of the basic nodes and links it may represent.
- A syntax-oriented XML editor, parameterized in the type of input it accepts, by means of an instantiating DTD, which generates well-formed XML (and indeed, in most of the cases valid XML.) It is an in-house development.

Clients are stateful and keep track of what is the filling state for the particular instance of the DTD being processed. Communication between clients and servers is straightforwardly implemented as POST and GET operations into which XML documents encoding information structures are embedded.

The graph editor is a shareware piece of code: the OpenJGraph library resource for manipulating graphs in JAVA (Salvo, 2003) which generates instances of XGMML, the eXtensible Graph Markup and Modeling Language (Punin, 2003), an XML scheme describing graphs which remain underspecified in their nodes, links and a number of other data items.

On the other hand, servers have been implemented as:

- A front-end endowed with CGIs mechanisms to manage communications, and validate-parse XML,
- A middle-tier to handle data conversions but envisioned for more complicate information processing tasks and
- A back-end attacking the appropriate tables in a database server.

They were also parameterized in some DTDs: on receiving communication from a client or in transitory instances of communication between servers all XML is validated against such DTDs.

All servers were written in Ocaml, a functional language in the ML family (Leroy et al., 2002) with a dedicated community and a number of facilities for processing XML, in particular the Polymorphic XML Parser, PXP (Stolpmann, 2001) used extensively for validating and extracting information from the XML sent by clients and the OCamlODBC interface (Guesdon, 2003) to a Postgres DB backend. A CGI library was also used.
Using InterMediActor in a learning environment

Table 1. DTDs used in version 1.0

<table>
<thead>
<tr>
<th>Name</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>LearningObjectives</td>
<td>Describe all types of learning objectives</td>
</tr>
<tr>
<td>Competences</td>
<td>Describe and validate all types of learning competences</td>
</tr>
<tr>
<td>UnderspecifiedCompetence</td>
<td>Support translation of objectives into competences for later filling with editor</td>
</tr>
<tr>
<td>LearningObjectives and Competences</td>
<td>Support incremental development of mixed structures with learning objectives and competences</td>
</tr>
<tr>
<td>Courses</td>
<td>Describe courses</td>
</tr>
</tbody>
</table>

In the following, we describe the intended use and flow of content in the InterMediActor platform. The process proceeds from the incremental analysis of learning objectives to the incremental synthesis of competences, thence to course assembly and deployment and finally to navigation of the synthesized materials.

The results of this process can be effectively captured by means of two XML DTDs:
- A learning objective DTD, which is essentially a way to specify a graph of learning objectives with the part-of and depends-on links explicitly marked;
- A competence DTD, a way to describe a graph of competences.

For the purpose of developing aggregated competences incrementally, it is also necessary to have a DTD that fuses both previous DTDs so that an educational content developer can incrementally write a competence while having part of the learning objective graph still under-specified. Table 1 lists all DTDs used in IMA v1.0.

Support for incremental analysis of learning objectives and synthesis of competences

The process of content creation starts with domain experts creating from scratch or uploading a partially developed learning objective graph. The refinement graph for learning-objects and the competences fleshing them is what learners will later use in a learning experience as content.

![Figure 9. Input tool for an atomic objective showing instances of elements being introduced](image)

A learning objective editor is available for the purpose of creating this graph (basically a syntax-oriented editor with an extra built-in graph editor) working on the head objective supplied initially. Both editors are parameterized in the learning objective DTD as described in the previous section.

On the one hand, an objective may be tagged atomic with a right-click and this invokes the atomic competence editor. Thanks to the strict DTD describing an atomic competence, the syntax-guided editor can be used to help
input and upload of content to and from the record and competence server. Figure 9 shows the input screen for the atomic competence editor where the abstract syntax tree of the competence being built is shown in arboreal form, one XML element to each line.

On the other hand, declaring an objective as non-atomic invokes the graph editor to provide its sub-objectives. A partially-specified objective may also be loaded into the editor. Shown in Figure 10 is the sub-objective graph of an intermediate objective.

When a new learning sub-objective is introduced it becomes a node in the graph, from which arrows may point to other nodes, declaring dependence. Double left-clicking in any non-finished node opens a new editor into which data may be entered.

![Figure 10. Sub-objective graph creation tool](image)

The tool also has support for locally storing or sending the competence graph being built to the competence and record server. However, there is no support yet in either editor to retrace the decision of tagging an objective atomic or non-atomic.

The server checks the graph against the objective DTD again to prevent a faulty implementation of the editor from introducing invalid XML into the databases.

**Support for incremental synthesis of competences**

Once, the learning objective graph is obtained, giving an overall view of the whole content to be described, the process of fleshing out objectives so that they become competences may start. This is shown in Figure 11 for an aggregate competence.

![Figure 11. Input tool for an aggregate competence showing its graph](image)
For this process we have also provided a syntax-oriented competence editor and a competence graph editor, this time parameterized in the DTD for competences. Although the syntax-oriented editor is bound to be used extensively (due to the relative lack of content of objectives as compared to competences) the same will not happen with the graph editor or rather graph viewer, given that the process of transforming an objective into a competence does not affect the relationships between nodes.

Atomic objectives will not show any graph content. The client is thus simpler and may appear in a single window, as Figure 12 shows.

The learning objective graph must afterwards be transformed into a competence graph. We use for this purpose an XSLT script which operates on the learning objective DTD documents to obtain underspecified competence DTD documents (see Table 1), whose elements are not as strictly required as for the final ones. This transforms every objective into a competence with place-holders which the domain expert must fill, as illustrated by Figure 13.
Once transformed, competences must be filled appropriately with the help of the competence editor, and then sent to the server. It then checks against a more stringent competence DTD than that used to generate the underspecified competence and reports any lacking element to the client, whose responsibility is to supply the missing information.

After validating it, the competence and record server extracts all elements of the competence graph document into records which are stored in the record database and the remaining skeleton of the competence into a competence database. Although recomposing the original competence from the pieces is very costly in time, this procedure allows a very fine-grained retrieval of the documents, which we envisage for future versions of the environment.

Notwithstanding the description done in this and the previous sections in which sequential development of objectives and then competences is proposed, competences may also be introduced during the process of writing learning objectives. This is to better allow domain experts to judge the complexity of their content and to see parts of it finished so as to guide the finishing of other objectives. In future versions of IMA, this will also allow us to support refurbishing competences from obsolete ones or collaboratively compose them.

**Support for course creation in IMA v1.0**

Courses are high-quality content given their assembly method: their content could be synthesized by downloading competences and layouts from their respective servers, and uploading them to the course server after validation. This validation would be carried out by running the course in the final form it would adopt for students.

For the time being, though, course assembly is automatic: out of each aggregated competence provided by domain experts, the competence server adopts the role of a course editor, creates a course and places the competence as the head for the course. This gets later sent to the course server which analyses it against the course DTD reporting problems when they exist or storing the course in the course database otherwise (see Figure 8 for this path between servers). However, because the course DTD is available and strict, we may still visualize this course with the help of the embryo of the future course editor, as depicted in Figure 14.

![Course visualizer for IMA 1.0](image)

**Figure 14. Course visualizer for IMA 1.0**

We could have devised a very simple client doing the retrieval of the course and then its submission to the course server, but in this way we are trying yet another technique to help domain experts build courses as easily as possible and test their materials.

**Support for course navigation in IMA v1.0**

Courses in the server are immediately deployed by a navigation server as URLs in an HTML page which can be consulted by prospective learners.
User validation is carried out with the help of the LDAP proper to our department, but may be easily hooked onto our institution’s computer-based learning facilities, *Aula Global* (Universidad Carlos III de Madrid, 2003).

**General Discussion and Further Work**

**A Comparison of Other Content Description Methodologies and IMA’s**

This subsection is intended to shed some light into the relation between the methodology for content provision as implemented in IMA v1.0 and that proposed by other approaches.

*A comparison between LO and competences as basic units for educative content*

We can point out a number of differences between competences and the learning objects defined for SCORM by the Advanced Distributed Learning Initiative (2003).

First, the components envisioned by the SCORM Content Aggregation Model are either *assets*, learning content in its most basic form (i.e. images, web pages, text, etc.), or *Sharable Content Objects* (SCOs), representing a collection of one or more assets or *blocks*, hierarchical representation of SCOs and/or other blocks. Combining adequately these components we may build higher level units of instruction. These can be likened to IMA’s multimedia records, although these are not given any status as learning content in our methodology.

Furthermore, SCORM defines a Content Structure Format (CSF), which is used by a Learning Management System (LMS) to aggregate learning content into cohesive units of instruction. However, a CSF definition is insufficient by itself. We need to pack content to allow for the migration of learning objects from one environment to another, and to describe this learning content with meta-data. In this way, content can be searched, found and retrieved once and again. Nevertheless, the real content (physical content) is written in HTML and JavaScript. This fact forces such content to communicate data between the runtime environment and the SCOs using an API. Finally, when building a unit of instruction by SCORM, we need to write an html document and a Course/Content/Raw-Media metadata XML Document, and both documents must be linked.

The use of competences provides two advantages: first, to build units of instruction in IMA we only need one element, i.e. competences. Since a competence embodies a grounded learning objective, we compose higher level units joining atomic competences to build other aggregated competences, and if it is necessary joining aggregated competences too, until we have the unit level of instruction that we wish. This can immediately be transformed into a course.

Second, a competence is an XML file composed by two sort of elements: the first one allows to describe the content of the competence to make possible its search, discovery and use, whereas the second stores its content. To display it we make use of XSLT style sheets that generate visual content in XHTML. In this way, on one hand we separate data from presentation, an urgent need as the range of interoperable devices grows, and on the other hand transmitting data between applications is made easier (only XML gets sent). Moreover, making use of XSLT style sheets we can display the competence's content in several styles and forms, thus catering for particular users' needs, by means, for instance of personalization procedures: style sheets reside in clients and XHTML is generated on the fly.

Further, the Advanced Distributed Learning (ADL) initiative does not define a method to assess learning content objects, and, in any case, the assessment of such objects is optional. This fact has brought about a variety of conflicting approaches to assessment. In IMA all competences must encapsulate predetermined assessment of their content so that learning outcomes are assessed and validated before proceeding further into training.

*A comparison between EML and IMA methodologies for educational content*

It is also worth mentioning several differences between the Educational Modelling Language, EML (Koper, 2001) and IMA, although the coincidences here are more extensive.

EML is a semantic information model and XML binding, describing the contents of units of learning from a pedagogical perspective and must therefore accommodate all possible pedagogical strategies for educative content delivery. For such reason it is considered a *meta-model* for e-learning. IMA is rather an instantiation of...
one such model based on grounded objectives (Bousoño et al., 1999; Melton, 1997) with the content-development architecture associated to it.

Moreover, important content-production questions such as how the content is incrementally developed are not considered in EML, whereas IMA gives a model for them in the form of top-down analysis of objectives and bottom-up synthesis of competences and the DTDs encoding such processes. Another important aspect of our environment is that it forces content developers to make a domain analysis in order to ground learning objectives and their relationships in the educational domain at hand whereas EML is oblivious to these needs or underspecified.

Furthermore, the IMA environment is aware of the problem of re-using educational materials already available in many organizations, and proposes a method to do so (Pedraza-Jiménez et al. 2002).

Functional architecture and roles

Support for peer-to-peer educative processes

To cast it in previously described roles, some educational methodologies propound that learners become course editors in their turn to share their learning experience with coexisting peers or future ones, for example, Edutella (Wolfgang, 2001). It would also be interesting if course providers provided basic competences to better glue courses when detecting insufficient content on linking a course. A better functional architecture for these purposes would be a peer-to-peer network.

Although such a general mechanism of feedback between consumers and producers in an educational setting is interesting, we have decided to disallow this educational framework for the time being: it resembles the peer model of agency which is under close scrutiny at present due to its particular security features (Oram, 2001). Also, it is by no means clear that the free-riding behavior pervasive in peer-to-peer networks would encourage collaborative production of content. In any case, supporting such peer networking in an educative environment is left for future research.

Including new roles

Although we could have devised an administrative role to adopt the guise of curricula enforcers or constrainers (which would have needed yet another server for subjects in the curricula, and so forth) we decided to entrust course providers with the deployment of courses so that learners could navigate whatever course they had at their disposal in the course server (although they may not seem at first related to their own curriculum).

Layout providers are essentially communication artists, more concerned with the ergonomics and sensorial appeal of content and its easy apprehension than its information content. They use several types of content (textual, graphical, formulae, animations, etc.) built into competences to test their layouts upon them. Layout providers will also have a tool to help them upload layouts to a layout server, but for the time being very simple layouts are provided to test built competences with.

Assessment and guided navigation

Learners should navigate content and acquire the competences embedded in it to some degree. By means of the validation tests within each competence, we assess the learning outcomes of the educational experience. Also, learning outcomes (as measured by basic and aggregated competence validation tests) are stored in the curricula servers, there to testify to a learner’s progress. This is a crucial feature of any LMS that must be included in future versions of the environment.

Assessment, though, may also be used to guide navigation or enforce the repetition of the learning process, as detailed in (Pedraza-Jiménez et al., 2002). We are doing preliminary work on using fuzzy decision to guide the recommendation of particular exploration strategies (Kavcic, 2003) or predicting the outcome of the assessment of particular courses based upon the performance of previous ones (Pedraza-Jiménez et al., 2002), as a basis to include these features in later version of our LMS.
XML-related techniques

Pollution of name-spaces, as with all large projects with global namespaces seems to be getting a problem in IMA. For future versions it is envisioned that we will switch to XML NameSpaces for solving such problems, and this probably suggests turning to XML Schemes rather than to DTD for describing documents. We will wait beforehand, though, for both techniques to stabilize.

Validation

Although most of the architecture is implemented we have not as yet decided on the best method to validate it. In spite of all competences (as units of educative content) being endowed with assessment tests on the learning outcomes, it is difficult to ascertain what would the influence be of this particular educative content developing methodology in such outcomes.

Catering for special content and teaching needs

Also, the development of programming and mathematical skills being heavy subjects in the curricula of engineers, we would like to see how tools like Matlab would lend themselves to be integrated into such an open architecture. As part of our personal researching history, our interests in mayeutics (dialectical educative methodology historically propounded by Plato) makes us also wonder whether if the competence-lecturing approach we have devised as first approximation could be improved using more interactive techniques.

Conclusions

We have introduced a methodology and Learning Management System for educative content development, production, deployment and use rotating around the concept of a competence, the educational equivalent of a grounded learning objective aiming at some learning outcome.

We have detailed its state of completion in release version 1.0 and explained further avenues of development regarding the initial conceptual design.

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A Framework for the Management of Digital Educational Contents Conjugating Instructional and Technical Issues

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Abstract
Nowadays, the e-learning industry is focused on producing and managing digital learning contents. There are several examples of learning objects, content packages or metadata proposed by different organizations such as IMS, IEEE or ADL. However, little attention has been paid to the specification and management of instructional processes, teaching strategies and learning activities. These issues are addressed by instructional design approaches but there are few formal computer-based notations and methods to specify and implement them. This paper describes a framework for managing digital contents and the processes that use them in an instructional way both from an instructional point of view as well as from a software design perspective. Such framework is based on an instructional application model which provides entities such as the User Profile that stores relevant information concerning the learning and teaching processes; the Learning Scenario as the set of terms, conditions and activities that characterize the user learning in a specific context and the Didactic Structure that is addressed to organize educational contents in a didactic way. The proposed framework supports the translation of these instructional entities to hypermedia entities in order to support the software design of e-learning products. Thus, this design method eases the development of Web-based instructional applications that can be adapted to different learning contexts.

Keywords
Instructional Design, Learning Contents, Educational Modeling Languages, Hypermedia Model

Introduction
Nowadays, the e-learning industry is chiefly focused on producing and managing digital learning contents that can be reused in different educational settings, for which several representational notations have been proposed. For instance, according to the IEEE LSTC examples of learning objects include “multimedia content, instructional content, learning objectives, instructional software and software tools, and persons, organizations, or events referenced during technology supported learning” in the Learning Object Metadata (IEEE LSTC, 2003) and metadata are defined as “the attributes required to fully/adequately describe a Learning Object”. IMS Global Learning Consortium (IMS, 2002) is developing and promoting open specifications for managing learning objects, providing content package structures, metadata or sequencing schemas, as well as XML bindings. Other institutions and organizations such as Ariadne (Ariadne, 2003), DublinCore (DC, 2003) or Advanced Distributed Learning (ADL, 2003) are also providing specifications, guidelines and run-time environments for learning objects.

However, little attention has been paid to the specification and the management of instructional processes as the cornerstone that facilitates successful learning experiences, going beyond the boundaries of deploying learning objects and putting more emphasis on instructional design as a discipline to build systems that take account learning needs and goals in an effective way. There are several instructional approaches in the literature that provide guidelines to apply learning theories and models, ranging from more traditional views (including objectivist and cognitivist) such as the Dick & Carey work model (1996), Gagne conditions (1977) or the Merrill’s Component Display Theory (1983), to constructivist proposals such as the Jonassen’s Constructivist
Learning Environment (Jonnasen & Rohrer-Murphy, 1999). A review of these approaches and a study of their application to the design of Web-based courses can be found in Moallem (2001). But still these instructional models do not provide a computer-based formal model for specifying and managing instructional entities such as user needs, objectives, task or activity definitions, or media and content specifications and therefore, the gap between technical and instructional issues is not covered.

Recently, EML’s (Educational Modeling Languages) have arisen to model the learning process and not just learning contents. The survey of existing EMLs reported in CEN/ISSS Learning Technology Workshop (CEN/ISS, 2003) led to select EML-OU (Koper, 2002) as the basis for the Learning Design specification (IMS LD, 2003) that combines EML with other IMS specifications, particularly, those concerning content packaging, metadata and simple sequencing. The main goal of Learning Design is to offer a framework of elements that can be used to describe any teaching or learning experience in a formal way characterized by its completeness, pedagogical flexibility, personalization, reproducibility, interoperability, compatibility and reusability.

All these approaches provide instructional designers with means to develop formal instructional specifications. However, they are addressed to develop final products that are used in very specific environments and, consequently, they are usually focused on translating such specifications, generally written in XML, to a very specific displaying and publishing format, such as HTML or PDF. A step further would be to map instructional products into technical specifications that are independent from implementation platforms, which is a main concern in this work. In this way, not only interoperability is supported, making possible to use the same instructional application in different hardware and software platforms, but also software design entities, representing the instructional application from a technical point view, can be automatically generated.

The framework here proposed is addressed to conjugate instructional and technical issues by processing instructional specifications from a software design perspective. The basic assumption of this proposal is that educational software development is a two-faced process: on the one hand, instructional design has to be considered as efficient learning and teaching is pursued; on the other hand, technical design has to be supported as a complex and quality software tool is being built. The framework is then based on an instructional application model, called Xedu (Buendía et al., 2002), that provides entities representing the main instructional components such as learning scenarios, contents and user information, and that will drive the instructional design process. These instructional entities are automatically translated into the entities of a hypermedia reference model, called Labyrinth (Díaz et al., 1997a; Díaz et al., 2001a), that will drive the technical design of e-learning products. The closeness between the learning material, traditionally based on document formats, and the hyperdocuments managed by hypermedia models, supports this proposal. Moreover, hypermedia models provide independence from implementation technology improving interoperability.

The remainder of the paper is organized as follows. Second section describes the Xedu model entities, focusing on Didactic Structures that organize contents from an instructional point of view. Third section describes the Labyrinth model and its support to model structural and navigation issues. Fourth section explains the design method that links both models. An application example is described in the fifth section. Finally, section 6 presents some remarking conclusions.

**The Xedu Model for Instructional Design**

The Xedu model is oriented towards offering instructional designers a framework for the specification of any instructional application from two different perspectives:

- the semantic view, where the instructional aspects are specified using an information model representing the composition of learning activities, contents and user information as well as their relationships; and,
- the operational view, where the application use and behavior are defined.

An Instructional Application in Xedu is composed by three main entities:

- **User Profile**: that stores relevant information concerning the learning and teaching processes.
- **Learning Scenario**: that is defined as the set of terms, conditions and activities that characterize the user learning in a specific context.
- **Didactic Structure**: that is addressed to organize educational contents in a didactic way.

Since this paper focuses on the management of contents from an instructional point of view and Didactic Structures are specially devised for this purpose, the remaining of this section will concentrate on this element. Detailed information on other Xedu elements can be found in (Buendía et al., 2002). To enhance readability,
descriptions are illustrated by means of an example shown in Figure 1 where a Didactic Structure oriented towards learning about magnetic disks in a Computer Architecture course is shown.

A Didactic Structure is composed by a KnowledgeStructureSet, that is an aggregation of one or more Knowledge Structures, and an InstructionalTaskSet that also aggregates one or more Instructional Tasks. Knowledge Structures are based on the concept of Knowledge Structure proposed by Merrill & ID2 (1996) and they are used to organize the contents of Didactic Structures whose atomic units are called Knowledge Objects. There are several types of Knowledge Structures, each of which proposes a way to structure Knowledge Objects, such as “List”, “Part Taxonomy” or “Dependency”, described in Merrill & ID2 (1996). Knowledge Objects are characterized by attributes such as the identifier or the type (“Entity”, “Process” or “Action” as defined in Merrill & ID2 (1996)), and elements such as Portrayal or Properties. In the example, two KS types are considered:

- a “Part-Taxonomy” that is aimed at describing the components of a magnetic disk, and
- a “Dependency” that will establish a sequence of knowledge items that help to understand how a file is physically stored on a disk.

In the example only the “Part-Taxonomy” Knowledge Structure is presented, and not completely for readability purposes, to illustrate the Xedu components. The “Part-Taxonomy” Knowledge Structure is a hierarchy rooted at the element called “KSDiskPartTax” whose child concerning the disk device is decomposed into “Mechanical System” and “Information System”.

All these Knowledge Objects include information about the concepts they deal with, but it is still required to specify how these items can be used to support learning in an efficient way. Knowledge Structures are devoted to gathering the structure of learning contents, but learning material can be used in different ways depending on the learning goals and needs. To cope with this requirement, the model introduces Instructional Tasks that, extending the concept of “transaction shell” (Merrill & ID2, 1996), are devoted to supporting the access to the contents of a Didactic Structure in a pedagogical way. With this purpose, they use Instructional Objects and Instructional Parameters. Instructional objects are used to deal with Knowledge Objects from an educational point of view while Instructional Parameters values represent the conditions in which these Knowledge Objects are accessed, such as the abstraction level or the portrayal configuration. The didactic knowledge taxonomy proposed by Leidig (2001) is used to represent Instructional Objects (including types like “Definition”,...
Compared to other EMLs, Xedu offers several features that are useful for instructional purposes:

- "Visit": aimed at accessing descriptive data about the Knowledge Structure components using different Instructional Objects and Instructional Parameters. In Figure 1, the "Example" Instructional Object is used as a learning activity where images of the "Disk Arm" component are shown (see the value of the Instructional Parameter "Portrayal") with a low level of depth (see the value of the Instructional Parameter "Depth")
- "Explain": is a more complex Instructional Task that involves Instructional Objects of type "Explanation" aimed at providing a deeper knowledge on a particular topic. This kind of Instructional Objects are usually attached to other types of Instructional Objects such as "Activity" or "Question" that allow the user to interact with Knowledge Objects to assess if the content was understood. The values returned by this Instructional Task can be used to determine how to navigate through the Knowledge Structure taking into account the student’s progress.

As it can be seen, Xedu provides instructional designers with elements to specify advanced educational issues. These elements can be easily and automatically translated into XML, so that educational software can be produced. However, a Xedu specification has no use for software engineers and programmers. If the product under development is a complex software system, an engineering perspective is also required to improve reusability, maintainability and quality. For that purpose, a technical model is required. In our case, Labyrinth a hypermedia reference model was chosen, since it could also contribute with the benefits of hypermedia as a learning tool.

The Labyrinth Model for Hypermedia Specification

The Labyrinth model (Diaz et al., 1997a; Diaz et al., 2001a) provides formal elements to describe the static structure and dynamic behaviour of this kind of non-linear, multimedia and interactive applications. This is a technical model which provides software engineers and programmers with a complete and consistent specification of the components, structures, behaviors and features of the system to be developed. Since most instructional applications are being deployed as web applications, which can be considered as a special case of hypermedia, the use of this kind of model to specify technical entities seems quite appropriate. Moreover, hypermedia has been proved as a useful learning tool in many experiences and, therefore, a hypermedia model could contribute with its associative structure.

Labyrinth represents a hypermedia application or hyperdocument by means of a Basic Hyperdocument which includes the elements that can be accessed by users. The access to this hyperdocument is controlled by means of a security mechanism aimed at safeguarding the information confidentiality by means of negative access control lists, where users or groups who cannot access a specific item are included. Moreover information integrity is preserved by means of context-dependent user abilities (Diaz et al., 2000). For example, a teacher can be allowed to modify her courses but just to browse the courses of her colleagues. In addition, each user or group of users can define and manage their Personalised Hyperdocuments in which the components of the Basic Hyperdocument are modified, deleted or created to fulfill the user needs and preferences. For example, an educational hyperdocument can be adapted to the student's knowledge in order to support an individualised learning process. This personalization can also be defined at the group level to cope with students sharing a same learning style. In fact, the security mechanism underlying the Labyrinth model has been used to personalize hypermedia learning systems (Aedo et al., 2002).
A Labyrinth hyperdocument (see Figure 2) is composed by the following elements: users, nodes, contents, anchors, links, attributes and events. The user set includes the potential users of the system. Composition mechanism for users is provided where users can be aggregated in teams (e.g. courses, students profiles) or generalized into roles (e.g. the learner, the teacher, the tutor).

A node is an information container which structures the set of resources and a content represents a piece of information. Contents can be placed in the nodes using a Location Function which specifies when and where the content has to be displayed, but they are maintained as separated entities. This separation between structure and content makes possible to share contents among nodes teaching different subjects as well as having nodes related to the same subject but which differ in the number or the depth of their contents. Labyrinth also provides composition mechanisms to model complex structures. For example, aggregation allows different elements to be referred to by means of a single composite element and generalization defines a composite element whose components inherit all its properties.

Other key concepts in a hypermedia are anchors and links. An anchor in Labyrinth determines a reference locus into a node or a content. For example, a hotword in a textual content or an area of a node can be anchors and, therefore, act as the source or the target of a link. In turn, a link is a uni or bi-directional labeled connection between two sets of anchors, sources and targets. Four types of links are defined in Labyrinth: referential, aggregation, generalisation and version. The referential type is used to represent associiative connections between elements (nodes or contents) while the other ones are used to create composite objects from the primitive nodes or contents (e.g. to aggregate related nodes such as those that describe the problems of a certain topic or to group the temporal versions of a program content). Version links can be very useful in educational applications, particularly to support co-operative work.

Labyrinth attributes are properties that are associated to users, nodes, contents and links in order to increase their semantics. There are no restrictions in the number of attributes for each element of the model, although some of them have mandatory attributes. For example, useful attributes in an educational hyperdocument can be the topic a node deals with or its educational goal, and the level of difficulty of a question. Educational metadata, such those proposed by the Dublin Core initiative (DC, 2003) or LOM (IEEE LSTC, 2003) are treated as Labyrinth attributes.

Figure 2. UML representation of the Labyrinth Hyperdocument
Finally, any Labyrinth element can be associated with a given action which is performed when such element is accessed and a certain condition is fulfilled. This dynamic behavior is modeled by means of events which can be used to define interaction mechanisms as in Diaz et al. (2001a) where a crossword exercise in the Now-Graduado educational application was implemented using events. Moreover, events set the basis for the definition of virtual objects created at runtime. For example, adaptive links which are presented only when the student has acquired a certain level of knowledge, as in Interbook or Elm-art (Brusilovsky, 1998), can be modeled by means of an event tied to the node where the link has to be embedded.

The Labyrinth model was selected to design Xedu applications from a software point of view, for several reasons. Firstly, this model, that has been successfully applied in some educational examples (Díaz et al., 1997b; López-Rey et al., 1999) makes a clear distinction between structure and content that does not appear in some reference hypermedia models; a separation which is quite useful in learning environments to reuse contents as well as structures. For example, the same structure can be accessed with different contents to deal with students with different backgrounds. On the other hand, there are several features of this model which can help to create useful educational environments, including:

1. The use of personal views to support individual and cooperative work spaces.
2. The separation between contents and links, which makes the hyperdocument easier to maintain (Mendes and Hall, 1999).
3. The possibility of creating links anchored in any kind of content.
4. The inclusion of mechanisms to create multimedia presentations in which elements can be organised and harmonised in the bi-dimensional space (the screen) as well as in the time.
5. The possibility of including properties to categorise the different elements.
6. The use of events to define interactive behaviours and virtual objects.
7. The ability to establish an access policy where the rules to access the hyperdocument are defined, whether for security purposes or to support adaptive environments.

Even though this model has been used to implement some educational hypermedia applications, it does not offer any kind of instructional support. Consequently, to be really useful in e-learning developments it should be coated with an instructional design layer.

A Framework Reconciling Technical and Instructional Design

An e-learning environment has an instructional goal, for which instructional design methods are required, but it is also a computer-based system, for which software engineering methods are needed. The main goal of the framework proposed in this paper is to guide the design of e-learning products that manage digital contents conjugating these two perspectives. Thus, the framework will made possible to have instructional design and software design for a same product but maintaining them as two different and complementary views that are useful for different kinds of developers such as instructional developers and software engineers. Educational digital content management is performed at three different levels that are shown in Figure 3:

- The Xedu level represents the higher abstraction level and it is based on Xedu entities such as Didactic Structures. Figure 3 shows some examples of Didactic Structures such as an “Electronic Book” or a “Tutorial” (see boxes with the dashed line) which identify specific ways to organize educational contents. These entities are close to the user point of view and their implementation allows instructors and learners to interact with them.
- The Labyrinth level specifies the hypermedia entities that model the Didactic Structures, using the Labyrinth notation. It addresses a software design perspective, independent from any specific computer-based technology, but useful for developing the implementation of the e-learning products that manage the Didactic Structures.
- The Data level represents the physical resources storing the educational contents such as text items, images, animations or simulation tools.
Users interact with educational contents by means of Xedu entities. Instructors have different rights to access to the contents organized in the Didactic Structures that will determine whether they can browse, edit or personalize these contents. Learners access these Didactic Structures through Learning Scenarios that enable and assess the use of Didactic Structures. The only way for a learner to access to these entities is using Instructional Task operations that are called from the Learning Scenario. This feature provides a strict instruction control that makes possible to check the learning effectiveness.

Working with Instructional Tasks involves several entities such as Instructional Objects, Knowledge Structures and Knowledge Objects that are described in the Xedu model section. These entities are close to the instructor point of view but they are distant from a software designer perspective. For that reason the translation of Xedu entities to Labyrinth notations is proposed.

Labyrinth nodes are used to represent Didactic Structures. They are containers that store information about the Didactic Structure components and which corresponding implementation units are visualisation areas (i.e. windows or frames). Additionally, information such as the component type or location can be represented using Labyrinth attributes. The structural relationships between these components are based on aggregation and generalization links. Other kinds of relationships such as the connection between Instructional Tasks and Knowledge Structures, or between Instructional Objects and Knowledge Objects, are specified by means of referential links. These Labyrinth entities can be used to build a navigation representation, as the one shown in Figure 4. This diagram shows the steps required to access to the list of Instructional Tasks for a given Didactic Structure called “Magnetic Disk”, and to select and execute one of them. The selected Instructional Task belongs to a “Visit” type and it has a reference value (“VisitDisk”) that locates its implementation in the Didactic Structure context. The “VisitDisk” Instructional Task has semantic relationships with an “Example” Instructional Object, a “Portrayal” Instructional Parameter that selects the media resource used to display the “Example” information, and a “PartTaxonomy” Knowledge Structure that specifies the Knowledge Object to be “visited”. The “Example” Instructional Object is also related with the Knowledge Objects whose type is
“Entity”, in order to select the physical resources that are stored on the Data level and meet the “Portrayal” features. This graphical representation of instructional issues that is based on hypermedia components can help instructors to assess their specifications.

Translation of these instructional entities to hypermedia components of a reference model has two main advantages. On the one hand, a more technical specification can be provided to software engineers to assist them during the development process. On the other hand, since the hypermedia model is platform-independent it can be transformed into different implementation platforms including mark-up languages (e.g. HTML, XML or Smil) as well as authoring tools.

Figure 4. Navigation through the “Magnetic Disk” Didactic Structure

Application Example

This section describes an example of instructional application whose development is based on the proposed design framework. This application is called Tutorial Tool and it is addressed to display the contents organized in a Didactic Structure. Figure 5 shows a screenshot of the teacher’s view of an animation about the component assembly of a magnetic fixed disk. The Tutorial Tool runs on a Web environment and it divides the application window into several frames:

- The Main Area is located at the upper frame and it displays a form that shows the components of the InstructionalTaskSet node (grouped by means of aggregation links) and the Knowledge Structure types (grouped by means of generalization links). The user can select one of these components and types by means of the “Selection” button or obtain their description using the “Help” button. The event assigned to the “Selection” button enables the action represented by the “Select” referential link that targets the chosen Instructional Task node (see Figure 4).
- The Control Area is located at the left frame and it is addressed to controlling the components of the selected Instructional Task node. There is a form to select of Instructional Object and its configuration parameters. It also includes a list of the Knowledge Structure nodes that belongs to the Knowledge Structure category chosen in the Main Area. The “Display” button enables the action represented by the “Select” referential link that targets the selected Knowledge Structure node (see Figure 4).
The **Display Area** is located at the right frame and it displays the results of linking an **Instructional Task** and a **Knowledge Structure**. Figure 5 shows a form identified as “Event control” that permits the selection of a **Knowledge Structure** component. Below, part of the animation content is displayed, including a form that controls its display through two buttons, “Next” and “Previous” that control the access to the image sequence.

![Image of Tutorial Tool Web application](image)

**Figure 5.** Example of Tutorial Tool Web application

That is an example of application that shows the advantages of the Xedu model to manage learning contents, a management that is not bounded to display these contents. Adaptive features, such as the employment of user information (e.g. objectives or preferences), can be introduced to filter the content information. For example, the **Instructional Task** parameter called “Context” in Figure 5 allows the learner to choose the access method to the **Knowledge Structure** components (e.g. direct or sequential access). As it can be seen, this tool provides the instructor an easy and visual access to instructional specifications, so that it can be helpful with checking purposes (e.g. to verify how many types of **Instructional Tasks** are defined or which **Knowledge Objects** can be accessed from a specific **Instructional Operation**).

The **Tutorial Tool** application is based on XML documents that specify the Xedu entities and they are processed by means of XSL scripts that interpret the Labyrinth conversion. For example, the node components or attributes can be represented using selection buttons in an HTML form. A Javascript function can be invoked to implement the selection of a referential link. These systematic procedures help to develop the instructional application in a hypermedia environment like the Web.

These elements can be transformed into hypermedia components providing a software engineering specification. As an example, Figure 6 shows a Structural Diagram where the nodes making up the application and their relationships are represented, and Figure 7 shows the Navigation Diagram where the browsing paths are depicted. Both diagrams are products proposed by the Ariadne Development Method (ADM) (Díaz et al., 2001b) which taking as core components the elements of Labyrinth offers a number of activities, steps and products to develop hypermedia in a systematic way.
As it can be seen in Figures 6 and 7 this representation is a quite useful one for programmers, who are not concerned with learning issues but with technical ones. For example, while Figure 4 shows a navigation structure representing relationships among instructional entities that is useful for instructional designers, Figure 7 uses technical entities to describe how to browse the software application which is useful for software developers.

**Conclusions**

This paper has introduced a framework for managing digital contents and the processes that use them, from an instructional as well as a software design perspective. Such framework is based on an instructional application model, called Xedu that provides entities representing the main instructional components such as learning scenarios, contents and user information. The Xedu model supports the specification of instructional issues in a formal and systematic way. The main model contributions related to the content management are: (1) the possibility of establishing dynamic links between Learning Scenarios and Didactic Structures so that the best
Didactic Structure can be chosen at runtime according to some adaptation rules (e.g. user preferences, learning style or features of the environment); (2) the representation of multiple Knowledge Structures that organize contents beyond the traditional hierarchical structures, the learner to obtain several perspectives about a topic, easing his learning; (3) the use of Instructional Objects that add didactic information to the Knowledge Objects, so that the same contents can be presented using different approaches, e.g. changing the abstraction or depth level at runtime.

Xedu entities have been specified using XML documents that enable their automatic processing. However, an Xedu specification has no use for software engineers and programmers. If the product under development is a complex software system, an engineering perspective is also required to improve reusability, maintainability and quality. Such software engineering perspective has been based on the hypermedia model called Labyrinth. This model provides some features that are interesting for designing Xedu applications from a software point of view: (1) the separation between structures and contents that allows for the representation of entities such as Learning Scenarios, Didactic Structures or Knowledge Structures to organise educational information in multiple ways; (2) the possibility of creating links anchored in any kind of content or node that can be created at runtime, enabling the dynamic connection between entities such as Learning Scenarios and Didactic Structures or Instructional and Knowledge Objects; (3) the inclusion of mechanisms to create multimedia presentations in which elements can be organised and harmonised in the bi-dimensional space as well as in the time, so that it supports the display and navigation of Knowledge Object information using different media formats and timing requirements.

The proposed framework supports the translation of the Xedu instructional entities to Labyrinth hypermedia entities that drives the software design of e-learning products. An application example has been implemented to demonstrate the framework possibilities. It is called Tutorial Tool and is addressed to display the contents organized by a Didactic Structure. This application is not bounded to display these contents in a fixed way and it supports adaptive features, such as the employment of user information (e.g. objectives or preferences) to filter or adjust the content information.

Further works include the development of tools and methodologies to support the full design process of this kind of instructional applications. This endeavour will imply to provide guides about how to use the Xedu components to design useful instructional applications. A less ambitious project will consist on building a visual tool to generate Xedu specifications and link it with the software tool actually supporting the Ariadne method (called AriadneTool), in such a way that the framework here proposed would be fully automated.

References


Abstract
Constructive approach to learning focuses on the learner’s behavior, enabling a self-adapted exposure to knowledge that is precisely tailored to the learner’s needs and background. The building blocks for such adaptive knowledge construction are the evolving learning objects (LOs) which are self-contained entities that encapsulate a segment of knowledge as well as some metadata attributes and procedures. In addition to complementing the standard specification of learning objects to incorporate self-adaptive learning features within the LO construct, the paper also proposes a learner-modeling technique which learns from the learners about the learners. In this dynamic learner modeling approach, past learning experiences are reused to stereotype future learners. The proposed adaptive learning architecture in this paper supports both navigation and presentation learning adaptivity.

Keywords
Adaptive learning, E-learning, multimedia material for education, Learning objects, Learner modeling, Hypermedia courseware.

1. Introduction
Web-based education and training is currently a hot research and development area (Khan 1997). Most of the progress made in this field has been influenced by the evolving technological infrastructure, the need for competitive workforce, the availability of learning material in cyberspace, and the progress made towards standards for learning architectures to ensure knowledge reuse and interoperability of learning management systems (Koidl 2002). One of the most important features which has not been fully explored in this area is the ability of the learning system to adapt to the learner’s profile.

Unlike conventional learning practices, adaptive e-learning should address both the curriculum requirements and strategies for knowledge delivery to suit individual learners. The objective of adaptive e-learning is to offer personalized learning, taking into account the learner’s goals, background, learning styles, presentation preferences and performance requirements. In addition, adaptive e-learning systems should be able to identify skill gaps and prescribe the necessary learning material. They should also allow individuals to monitor their own progress and guide them completing the remaining learning tasks in an efficient way. Many research efforts were made to achieve these goals. As a result, a number of e-learning systems have been developed (Karagiannidis et al., 2001; Castro et al., 2001; Dufresne 2000; Brusilovsky 1998 & 1999). These are mainly based on technologies in the area of adaptive hypermedia. Most of these systems are platform development rather content development.
The shift to content development based systems is recent, nevertheless, significant work has been undertaken to develop e-learning standards and specifications by such groups as the Instructional Management Systems (IMS Global Consortium 2003), the IEEE Learning Technology Standards Committee (IEEE-LTSC 2003), and the Advanced Distributed Learning (ADL Co-Labs 2001). The aim is to develop standards and specifications capable to support open, widely distributed, reusable, content sharable, interchangeable, and intensely interactive learning infrastructures. In this context many concepts such as Learning Objects (LO), Meta-Data, Document Object Model (DOM), Computer Managed Instruction (CMI), and Data Interchange Protocol (DIP) have emerged to address important issues such as those related to: i) interoperability of content from multiple sources; ii) interchangeability of content for transfer between sources; iii) reusability of content within the same source; and iv) accessibility of content to search object repositories (Theorix 2003). However, there has been limited emphasis on the need for introducing adaptive learning features within the learning object. Under the current version of these standards, the LO is treated as an opaque entity that cannot yet be adapted to learners’ profiles (Rodriguez et al. 2002).

In previous work (Atif et al. 2003), we addressed the lack of adaptability in the learning object by expanding semantically the learning object metadata to accommodate individual learner’s needs, and to enable dynamic generation of personalized learning routes. In this work, two other fundamental aspects of adaptive e-learning systems were investigated. These are the problems related to difficulties encountered while profiling learners and courseware design issues respectively. As far as the learner profiling process is concerned, we believe that many learners do not properly contribute in the pre-assessment given to them in order to build their profile. In fact, many learners do not seriously fill in the required questionnaires nor answer properly test questions, which usually results in an unreliable and incomplete learner model. As for the courseware design, not all authors have the required pedagogical skills and knowledge to properly plan different versions of a course to suit all kind of learners. Based on these assumptions, the proposed system is designed so that both the learner and the courseware author are relieved from these tedious tasks.

The remaining sections of this paper are organized as follows. Section 2 presents the background and related work. Section 3 describes learning resources construction framework. In Section 4, we present the adaptive learning architecture. Finally, the proposed work in this paper is summarized and further research work is suggested.

2. Background and Related Work

A major current focus in designing modern e-learning systems is the actual concentration on efficient production of instructional components or objects which are interoperable and reusable (Najjar, 1996; Redeker, 2002). With no doubt the concept of reusability has become a key issue for new e-learning initiatives. The reusability of learning objects provides a framework that builds on past experience and creates new mechanisms for producing and exchanging knowledge. There is an actual need to discover new techniques for the exchange and integration of various sources of knowledge from different institutions. The shift from platform-development to content-development of e-learning systems will have a significant impact on developing such techniques (Koidl 2002). An important implication of this shift is to allow learners to take control of their own learning process in an active mode rather than in a massive, receiving way (Fung and Yeung 2000). Unfortunately, these goals are not yet achieved and most available e-learning systems are still tutor or author centered and not learner centered.

Learner centered systems should adapt to the learner’s goals, background, skills, presentation preferences and learning styles. Developing a system that can deal with all of these learning aspects is one of the most challenging tasks facing the research community today. This is mainly due to the fact that we do not really know how the human really learns (Koidl 2002). Moreover, the process of adapting content to different learners, based on their profile and behavior, is not a straightforward task. So far, the majority of existing adaptive web-based learning systems are based on hypermedia (Brusilovsky 1998). Adaptive hypermedia systems build a model of the individual learner. This model is used throughout the interaction to adapt the hypermedia document to the learner needs (De Bra et al. 1999). The learner’s model is usually initiated from a questionnaire at the beginning of the course. Typical questionnaires are based on stereotype like beginner, intermediate, and advanced (Brusilovsky 1998). Tests during a learning session can also be used for further adaptation. These assessment tools are used to check the learner’s knowledge and to predict their learning modalities and the learning style that suits them most. Consequently, most of the focus for these systems is on the learner’s model that is a kind of repository about the learner and forms the heart of the learner centric system.
Adaptive learning in hypermedia systems was dealt with from different perspectives (Brusilovsky 1998 & 1999). A good review of the different adaptive techniques can be found in (Brusilovsky 1998). The main approaches have been adaptive curriculum sequencing, adaptive presentation, and adaptive navigation support (Brusilovsky 1998). In adaptive curriculum sequencing, the learner is provided with the most suitable individually planned sequence of learning objects to learn from, and a sequence of learning tasks to work with. This is done by showing and hiding of content based on information extracted from the learner’s model ((Brusilovsky et al., 1997; Specht et al., 1997). Adaptive presentation techniques, on the other hand, adapt the content of a learning object accessed by the learner to the current knowledge level, goals, and other characteristics of the learner. Thus, different learners might get different content for the same learning object (Calvi and De Bra, 1997; Eliot et al., 1997). Finally, adaptive navigation support can be considered as an extension of adaptive curriculum sequencing into a hypermedia context. However, it is less directive than traditional sequencing in the sense that it guides learners implicitly and leaves the choice of the next learning item to the learners. This is based on the idea that if the learner navigates from one item to the other, the system can for example hide, sort and annotate the links to provide best guidance to the learner ((Brusilovsky and Schwarz 1997).

The feature shared by most of the above mentioned adaptive learning techniques, is that they all heavily rely on the pre-assessment based learner model. The proposed system does not require such a model. Also, the courseware author is not requested to design different versions of the same course to suit all kind of learners. The author rather focuses on the learning object metadata (LOM) which empowers the learning objects’ dynamic. The proposed system combines adaptive navigation support and adaptive presentation technique in an orthogonal way. The system follows the adaptive navigation support model whereby new learners are matched with previous learning-path profiles in order to either: i) adhere to a known learning model; ii) to confirm and consolidate an existing learning experience which might be added to the learning models repository; or iii) to enrich the system with a new learning experience not mature enough to be included in the learning models repository but which must be kept in a database of candidate learning models. Before applying the adaptive presentation technique, the system dynamically classifies the learner based on categories such as beginner, intermediate and advanced. The classification process depends mainly on the number of visited prerequisite learning objects during a learning session. Unlike most existing systems, this classification is not permanent, but contextual, and may even change many times during a learning session. This is mainly due to the fact that a learner might possess the skills in dealing with some concepts and lacks knowledge when dealing with others. Consequently, this classification reflects the knowledge level of a particular learner dealing with a specific concept. This fine grain adaptation is dealt with using adaptive presentation technique. This is carried out by the LO adaptor which dynamically adapts the content of the learning object accessed by the learner based on the category allocated to that learner.

3. Learning Construction Framework

In this paper, we propose a hierarchical, incremental framework for packaging learning content into learning objects and a web connectivity of learning objects through which a personalized learning route is identified. The learning object design forces a certain e-pedagogy discipline in order for instruction designers to operate under a well defined framework that prevent the design of lengthy and discursive material which may not benefit learners.

As shown in Figure 1, the learning objects are self-contained instructional units which content accommodates heterogeneous learning sources (text, presentation, audio or video) or a combination of any of these media. Moreover, learning objects are inter-linked to form a network of learning resources through which learners navigate to build a personalized learning path. They can also be reused a number of times in different contexts and can be delivered over the Internet in an open system framework free from any vendor-specific container. Hence, learning objects appear as modular building blocks, which can be easily integrated to manage e-learning content according to a specific learning strategy. The e-learning system presented in this paper promotes such generic object-based learning which has the ability to capture any learning source.

The proposed framework consists of three conceptual layers (see Figure1): authoring layer, LO production layer and LO deployment layer. The authoring layer allows courseware authors to build LO content. The system uses industry standards for learning resource authoring and management. This ensures LO interoperability and thus allows LO export/import from/to other learning systems. The LO production layer is crucial to adapt LO content to the targeted learners. This is done by the LO adaptor which adjusts the LO content based on the LO metadata and the learner’s category provided by the learner modeler. Finally, the LO deployment layer deals with the process of constructing personalized learning paths. At this layer, a courseware structure is represented as a web
of learning objects for a particular course, representing the various concepts interdependencies among learning objects. However, a learning path is a subset of the courseware web represented by a sequence of instance-LOs to which a particular learner get exposed during a learning session.

![Figure 1. Learning Construction Framework](image)

3.1. Learning Objects

To allow the deployment of LOs in an adaptive way, extensions to the existing IEEE/IMS LOM (IEEE-LTSC LOM 2003) specification were introduced to dynamically allow LO integration, LO correlation, media selection and learner-LO interaction. Thus, the proposed metadata structure describes a multimedia rich interactive LO. The LO structure used in this paper is based on the LOM specification which includes elements such as general, rights, lifecycle, classification and annotation to describe the static features of the learning object. However, additional features extend standard elements such as educational, technical and relation to dynamically adapt the LO to learners’ profiles. The proposed structure of learning object attributes is depicted in Figure 2.

![Figure 2. Learning Object Attributes](image)

Learning object resources construct is rather media-centric which captures both tangible and intangible formats of learning. Learning resources such as text script, video, animations and images represent the static attributes of the learning object. These are the attributes which cannot be modified when reused. On the other hand, relation, technical and educational related features (IEEE-LTSC LOM 2003) represent the dynamic attributes which can modify some aspects of the LO when reused. Below, we summarize the educational, technical, and relation

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attributes. However, we provide a detailed description of the metadata attribute due to its dominant role in the LO adaptation. The remaining attributes are similar to the LOM specification.

- The educational element is enhanced with features related to media selection, analogy, assessment and customization. Below we provide a description of each if these features:
  - Media selection allows a learner to customize the object to zoom on a particular media in case the learning object is a combination of multiple media.
  - Analogy facilitates learning by analogy and offers learners alternatives to comprehend further the subject imbedded in the LO.
  - Assessment enables problem-based learning and corresponds to a particular assessment strategy by which the learner can assess his understanding of the material embedded in the learning object.
  - Customization provides learners with the opportunity to augment learning content during instruction by taking their own personal notes. The customization assumes an authentication process for learners who may then take notes through the system at playback time to reflect their own understanding of the presented material. These notes are attached to the profile of the learner for the currently being played object.

- The technical attributes represent the synchronization and layout features describing respectively the level of synchronization involved in combining multiple media, and the actual time and space distribution of the learning media.

- Relation corresponds to the "correlation" feature which reflects the self-adaptability nature of the LO. As a response to a learner state, the learner modeler suggests a learning sequence of LOs, and individual LOs are adapted and connected accordingly. Thus, this attribute contributes in self-adjusting the proposed learning material based on the behavior of the learners as dictated by the constructivist approach (Duffy and Jonassen 1991). Different learners follow different learning routes suitable to their background level and understanding pace.

- Metadata attribute enables further intra-LO adaptation by providing five LO functionalities. These are LO sequencing, LO structure, LO presentation, LO navigation support and LO interactivity. These are briefly described below.

a) **LOs Sequence:** Different techniques can be used to track learners’ behaviour in order to invoke the appropriate LO sequence that provides personalized learning content. As learners interact with the e-learning content, results are communicated to the interaction manager which adapts the LO sequence accordingly. For example, learners might be sent to different places in the content based on user-initiated request for clarification of prerequisite knowledge, or user requests for supportive knowledge expressed in terms of examples, case studies or procedural information. In the proposed system, each learning object has semantic connections with other objects. Different users navigate across the learning web composing the learning objects interconnectivity following different paths. The learning path-building process, which contains the sequence of objects exposed to a learner, is performed dynamically based on past learning experiences.

b) **LO Structure:** The LO structure reflects the educational effectiveness and pedagogic features of the LO. It consists of a sequence of learning tasks to accomplish the goals and objectives set up by the courseware author to understand the concepts presented in the LO. These are combination of learning resources similar to those listed in the educational component of the LOM specification (IEEE-LTSC LOM 2003), and can be: slideshows, examples, questions, problems, simulations, case studies, experiments, diagrams, graphs and so forth.

c) **LO Presentation:** LO presentation describes the way individualized learning materials embedded into the LO are dynamically presented to the learner. Multimedia contributes further to learning when instructional designers use the most effective medium to present specific information. Hence, there is a need for instructional designer to map a learning content to an appropriate media. A number of empirical studies suggest how to select specific media or a combination of media for successfully presenting specific kinds of learning content as summarized in Table 1.

The content-to-media mapping shown in table 1 has been confirmed through empirical experiments to provide the best media allocation for learning content (Najjar 1996). Assembly instructions are best comprehended when an assembly task is presented using a combination of illustrations and text highlighting the major steps. Procedural information for operating a particular device for instance, appears to be more helpful for learners to acquire when a combination of animation or video and text is presented to learners. For problem-based learning, an animation with verbal narration was shown to be effective. For instance, solving a mathematical equation may
be better illustrated through a graphical illustration. Pictures increase recognition accuracy especially when combined with text to drive the learner to focus on specific features of the pictures. Sound appears to be an effective way to communicate. For instance, in learning a particular foreign language, it would be more helpful for a learner to hear the words. But some words are context dependent and the context may be better understood if shown through video. And to help the language-learner further, a textual version of the words’ phonetic would reinforce the learning process of such verbal information. Finally, recalling story details would be more effective with a video or a soundtrack. The e-learning system presented in this paper provides opportunities to map knowledge imbedded in LOs in any of the above formats or a combination of the above formats.

<table>
<thead>
<tr>
<th>Learning Content</th>
<th>Media</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly instructions</td>
<td>Text with supportive pictures</td>
</tr>
<tr>
<td>Procedural information</td>
<td>Text with animation or video</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>Animation with explanatory verbal narration</td>
</tr>
<tr>
<td>Recognition</td>
<td>Pictures with text or verbal narration</td>
</tr>
<tr>
<td>Verbal</td>
<td>Sound or video and text</td>
</tr>
<tr>
<td>Story details</td>
<td>Video with a soundtrack</td>
</tr>
</tbody>
</table>

Table 1. Media Allocation

d) **LO Navigation**: LO navigation functionality ensures that different LO’s are allocated different navigation alternatives, depending on their type, role, content and structure. Here we describe the possible ways of navigating within a LO. For instance, a learner starting a problem solving LO is recommended to go through all problem solving steps, however, it is not recommended to explore all alternatives in a LO consisting of a number of examples/case studies describing the same concept. By doing so, the system guides learners implicitly and leaves the choice of the next knowledge item to be learnt and next problem to be solved, to the learners.

e) **LO Interactivity**: LO interactivity is an important aspect in the learning process. It may also differ from one LO to another depending on its type and role. The system allows learners to interact with most LOs, and especially with those LOs related to problem solving, questionnaires and self-assessment.

### 3.2. Courseware Structure

A courseware represents a particular course designed by the author. An example of a courseware is shown in Figure 3. The courseware is constructed by the author simply by identifying the sequence of learning objects references which participate in the courseware. Learning objects are classified as mandatory learning objects (MLOs) and secondary learning objects (SLOs). The mandatory learning objects are recommended objects in the sense that the learner should normally visit them to fulfill the courseware understanding requirements. However, secondary objects are those learning objects describing prerequisite knowledge. For the recommended path, that is the path formed by the MLOs, the courseware author considers each mandatory learning object individually to identify its correlative sequence of references to possible SLOs. The process of building a correlative sequences is re-iterated on each SLO. Secondary learning objects might be added to the learning path dynamically based on the learner interactions with the learning objects.

The above courseware structure represents a body of knowledge, which is highly structured. Full comprehension of a topic may be dependent on the understanding of one or several other concepts. In a properly organized course, a particular concept is presented only after all concepts, on which it depends, have already been presented. Furthermore, a competent instructor will not proceed before insuring that the majority of the students have mastered or at least have been exposed to the prerequisite concepts otherwise, the instructional process will not be very effective. However, since we are dealing with individuals and not a group of learners, there should be some flexibility in presenting the course material to meet personal abilities of learners. All this leads us to the conclusion that the organization of knowledge within a subject matter has the form of a directed graph, not unlike the PERT charts used in project management. The graph structure will give learners the choice to either follow the recommended leaning path, or to request an SLO.
4. Adaptive Learning Architecture

Instead of relying solely on the learner’s behavior and the acquired knowledge throughout a learning session, a learner modeler utilizes the specific knowledge of previously experienced learning sessions. A learning path experienced by a previous learner whose learning behavior matches the current learner is predicted to be pursued in the current learning session as well. A Learning Models Repository (LMR) stores a set of learning-models categories which are based on previously validated learning experiences. LMR is incrementally augmented to reach a maturity level where it covers a large scope of models used to dynamically profile an actual learner. The initial experiences are constructed by the learners themselves. At this stage, the learning construction process requires frequent interactions with the learning system to adjust the learning path and the learning content. At a later stage, the interaction frequency decreases with the maturity of LMR as learners are clustered apriori to specific learning categories in which the sequence of LOs is automatically proposed to the learner.

As illustrated in Figure 4, an effective integration of the abovementioned case-based technique to adaptive learning requires a well worked out set of methods in order to: i) extract relevant models from the memory of experiences (LMR); ii) integrate a model into that memory; and iii) index the inserted models for later matching with similar learning experiences. Central tasks that our case-based learning approach has to deal with are to identify the current learning session, find a similar past case, and use that case to elaborate an adjusted learning plan. To satisfy these roles, the system features three functional modules as shown in Figure 4. These modules are: the Interaction Manager (IM) which listens to learners’ initiated events, the Learner Modeler (LM) which plans a learning-path, and the Learning Object Adapter (LOA) which adjusts the depth and the style of the learning content of the LOs within the inferred learning path based on the learning category.

The architecture presented in Figure 4 targets two levels of adaptive learning: adaptive navigation and adaptive presentation. Adaptive navigation is performed by LM module following a case-based learner modeling technique which will be further elaborated in later sections of this paper. Adaptive presentation on the other hand is carried out by LOA based on an automatic learner-categorization approach which given a learning-path delivered by LM, it adjusts the content of the constituting LOs based on the actual learner category. This category is revealed to IM when a learner interacts with the learning unit map (or courseware). IM intercepts particularly correlation links invocations and interprets this invocation as an opportunity to adapt or to revise the learner model and to adjust the LO presentation based on the current learner state. The architecture proposed in Figure 4 features also two data repositories: Learner Models Repository (LMR) and Learning Objects Database (LOD). While LMR contains learning-paths which representatives of classes of learners, LOD provides various categories of each intervening LO in the learning paths maintained by LMR. This is a deliberate strategy to provide a horizontal learning adaptivity by selecting the appropriate sequence of LOs identified by their IDs. These IDs are used to index a class of LOs in the LOD which represent a vertical adaptivity level by selecting the intervening LO which matches the current learner skill or category. This is because learners have different backgrounds which require different learning sequences but also different skills and learning styles which require different types of presentations. The proposed architecture in Figure 4 aims at accommodating such bi-
dimensional learners’ heterogeneity. Next, we provide an in-depth description of the modules constituting this adaptive learning architecture.

4.1 Learning Models Repository

Learning by re-using past experiences is a powerful and frequent way used by humans for learning. This claim is also supported by results from cognitive psychological research (Osborne 1999). Several studies have given empirical evidence for the dominating role of specific, previously experienced situations in human learning based on retaining of experiences in a dynamic and evolving repository. Past learning experiences are used as learner models to dynamically profile current learners. A very important feature of this strategy is its coupling to learn from the learners. The proposed case-based learning approach does not only denote a dynamic learner profiling technique, irrespective of how the cases are acquired, it also denotes a paradigm that enables sustained learning by updating the learning paths database after a learning session has been completed. To be able to achieve this objective, the system needs to track the learner behavior and build a personalized learning model. Since no pre-assessment is required in our system, personalized learner modeling relies mainly on the route traversed by learners in the courseware map. Actually, the main assumption underlying the learner modeling is based on the fact that a learner level can be inferred according to the volume of additional material he/she requires to fully comprehend the courseware concepts. This volume is intercepted by the system to categorize learners into levels.

![Adaptive Learning Architecture](image)

**Figure 4. Adaptive Learning Architecture**

**a) Learner category**

Learners are classified into categories based on the volume of visited SLOs. The number of categories is a parameter in our system which may depend on criteria related to the nature of the courseware such as whether it is theoretical or practical oriented, whether or not it requires some prerequisite knowledge, etc. The courseware author decides a categorization scheme for learners of that courseware as well as thresholds used to upgrade learners from one category to another. This is done at authoring time. At learning time, learners are categorized according to the additional knowledge they request during the learning process. Learner categories are quantified as the proportion of SLOs over MLOs. To illustrate how learner categorization works let us consider a courseware with three sample learner categories: *advanced*, *intermediate* and *beginner*. Table 2 shows how the system identifies the different learner categories:
<table>
<thead>
<tr>
<th>Learner Category</th>
<th>G(t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginner</td>
<td>More than 50%</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Between 50% and 10%</td>
</tr>
<tr>
<td>Advanced</td>
<td>Less than 10%</td>
</tr>
</tbody>
</table>

Table 2. Example of A Learner Categorization Scheme

Where $G(t)$ represents the ratio $SO(t)/MO(t)$, $t$ is the current time within a learning session, $SO$ and $MO$ are respectively the number of SLO and MLO visited at time $t$. An interesting feature of $G(t)$ is its ability to dynamically adjust the learner category according to the number of SLOs and MLOs visited so far by a learner. Actually, during the learning process the learner category is evaluated at each invocation of a learning object by computing $G(t)$. This allows the system to upgrade or downgrade the learner category at each correlation invocation accordingly to adapt the learning-path construction process. The last computed $G(t)$ value when the learner has completed the learning session (i.e. he has reached the last mandatory LO) represents the actual learner category which is going to be used to link the learning-path traversed by that learner to a specific learner category.

b) Learning Models Repository Construction

A learner model is mainly a learning-path that has been validated for a specific learner category. Its validation comes from the frequency of learners within the same category who visited the same sequence of learning objects for a given courseware. As learners complete a courseware and reveal a specific category, the system increments the frequency of visiting that traversed path within that category. Whenever the frequency of visiting the same path within a category goes beyond a certain predefined threshold, a learner model is validated and added to LMR. This model becomes representative for a class of learners and will be considered as candidate in modeling future learners.

Learner models pending validation are temporarily stored in the Learning Models Database (LMD) structured according to learner categories (see Figure 5). As learners complete a courseware learning session, a category is inferred for each learner as well as a new learning model which is going to reinforce the validity of existing learning models within the inferred category. Hence, the system learns from new experiences to either reinforce an existing learning model pending validation, or to add a new learning experience in the LMD which could be further consolidated by future learners.

![Figure 5. Learning Models Repository Construction](image-url)
4.2 Learner Modeler

In this section, we describe the learning-path planning process which represents the core function of LM. The general cycle of LM is described by the following three processes given the current stage of a learning session for a particular learner (see Figure 6):

1. RETRIEVE the most similar learning models
2. SELECT the model which has the shortest learning path among the similar models
3. REVISE the proposed model according to the learner constraints, as shown later in Table 3.

In case no path is found, the learning process relies exclusively on the LOA adaptivity level to expose learners to self-adjusted LOs based on their current category. However, the LMR grows as it learns more from the learners themselves. At this stage, every courseware map may have been explored differently by multiple learners leading to a range of validated learning models for the same courseware. The first task of LM when invoked by IM is to retrieve similar cases. This is done by querying LMR for learning paths associated with the same courseware, and which include a contiguous segment of LOs similar to the segment of LOs explored (i.e. in the currently being constructed learning path). In other words, the retrieved models from LMR are profiles which share a common learning history with the current learner.

Once, LM has retrieved a set of candidate paths from LMR, it selects the candidate which has the shortest learning path. In doing so, LM assumes that the current learner matches the model of the most advanced learner who has a similar past learning experience. This statement is gradually revised by LM when the learner deviates from the proposed elaborated path allowing LM to incrementally build a tailored learning path for the learner.

In the process of revising a qualifying learning model, user-defined constraints are considered to provide opportunities to learners to intervene explicitly in the learning adaptivity process. These constraints are mainly subjective and may largely differ contextually among learners. For instance, the revision of a successful learning model match may consist in removing from that model a set of LOs, the learner may wish to exclude. These constraints are communicated to LM in the form of a message being exchanged among the three functional modules of system architecture shown in Figure 4. The message being exchanged among these modules is structured as a 5-tuple data-structure \([R, P, E_P, G, C, D]\) described in Table 3.

<table>
<thead>
<tr>
<th>Label</th>
<th>Legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>A sequence of references to mandatory learning objects representing the targeted learning concepts initially containing the mandatory learning objects for the courseware. ((P=[p_1,p_2,...,p_n]))</td>
</tr>
<tr>
<td>R</td>
<td>The actual learning path for the current courseware object containing initially an empty set ((R=[])) but will be updated during a learning session by the visited learning objects and their sequence.</td>
</tr>
<tr>
<td>(E_P)</td>
<td>Path constraints; i.e. a list of learning objects to be excluded from the learning path</td>
</tr>
<tr>
<td>G</td>
<td>Current Learner Category</td>
</tr>
<tr>
<td>C</td>
<td>Cost constraints; i.e. constraints such as the number of learning objects on the path or the maximum time the learner can afford to allocate to a learning session.</td>
</tr>
<tr>
<td>D</td>
<td>Accumulated cost along the learning path.</td>
</tr>
</tbody>
</table>

Table 3. Message Structure

A major field of the message being collaboratively exchanged among the system functional modules is the learning path \(R\) which is continuously updated by LM to ensure an adaptive navigation process. \(G\) represents the current learner category and is calculated as mentioned in Section 4.a. The learning-path planning process is subject to the following conditions which affect the selection process of candidate learning models performed by LM as well the selection of the constituent LOs performed by LOA:

1. The learning objects should not be in the path constraint \(E_P\)
2. The learning object has not already been visited
3. The learning object does not violate the cost or time constraints function \(C\).

The first condition is user-defined to explicitly exclude specific LOs from the learning path. For instance a learner is aware about some concepts and therefore he does not wish the corresponding LOs to be exposed throughout a learning session. The second condition above is maintained by the learning system to avoid cycles in the learning-path construction process. Finally, the last condition is set by the learner to optimize the learning...
process. The optimization process can be expressed in the form of the cardinality of the intervening LOs in the learning path or even the maximum duration of a learning session. This unique feature self-adjusts the sequence of the presented learning objects as well as their content based on the time a learner can afford to allocate to a learning session. The time attribute corresponding to each learning object is calculated based on the length of the continuous media attribute if any (i.e. video-clip time). This media play time is part of the standard LO attributes as described by the LOM specification (IEEE-LTSC LOM 2003). All of these constraints serve as pruning opportunities throughout the construction process of a learning path.

![Figure 6. General cycle of the learner modeler](image)

### 4.3 Learning Object Adapter

The next adaptivity level of the learning architecture presented in this paper consists in adjusting the LO content within the learning path recommended by LM by instantiating the LO metadata according to the current learner category. This intra-object personalization of the learning process represents the adaptive presentation dimension of the learning process. This dimension of adaptive learning adds to the adaptive navigation dimension provided by LM introduced in the previous section. LOA focuses on the content of the LOs to be presented to the learner. As shown in Figure 4 earlier LOD stores several versions of LOs. Each class of LO presents the same concepts but with different level of depth and learning style depending on the category an LO is associated with.

LOA is triggered by IM (see Figure 4) prior to play each LO in the learning path. IM may be invoked implicitly when a learner activates a correlation or automatically when transiting from one LO to the next one in the learning path. Basically, LOA runs whenever a new LO is about to be presented to the learner. At this stage, IM passes to LOA the message that contains the current learner category which is going to be used by LOA to retrieve from LOD the version of LO to be presented to the learner.

### 5. Conclusions

In this paper we have mainly proposed an extension to the LOM specification for learning objects to integrate learning adaptivity features. We have also shown a procedural methodology for LO construction as well as a hierarchy of learning units involving LOs. We also provided a procedural architecture to exploit these additions in order to root-out automatically learning deficiencies which may differ from one learner to another although they may be involved in the same courseware. The proposed architecture makes use of a learner modeler which learns about learners from the learners. The result of this process is a learning models repository which is used to
profile dynamically learners as they interact with the system. We have shown in this paper two levels of supported learning adaptivity namely navigation and presentation adaptivity. The navigation adaptivity relies on an incremental strategy that progressively builds a repository of learning models based on past learning experiences. Existing learning models are re-used to guide current learners. Presentation adaptivity complements the navigational adaptivity by adjusting the constituting LOs.

6. References


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Designing Training in Manufacturing Organizations Using the Genre-based Method

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Abstract
This paper discusses the analysis and design of training material in manufacturing organizations. Delivery of complex, large machines, such as airplanes, paper machines, or cabin cruisers, requires massive customer training, which must be tailored according to the specific training groups and features of the individual machine delivered. Hundreds of trainers and trainees can be involved. Thus the analysis and design of training is important. A small amount of automation or process improvement can lead to remarkable resource savings and free trainers’ resources for educational design. We view the content of training as modular and hierarchical. It is proposed here that the trainers should be allowed to define the content they produce. We present the way we operationalized the theory of genres of organizational communication for a participatory genre-based method for analyzing variances of topical content within genres of training. We also discuss the potential for enhancing the production of content for training by content reuse using XML transformation techniques. Due to variation in customized content we propose reusing raw content sources and topic structures, rather than re-using learning objects as such for the assembly of raw learning content.

Keywords
Learning objects, Training genres, Content analysis and reuse, XML

Introduction
Recent initiatives for learning technology standardization (e.g. IEEE-LTSC, 2002; IMS-GLC, 2002; ADLI, 2002) have provided the essential specifications for defining learning objectives and Learning Objects (e.g. IMS-LRMDI, 2000) or Learning Object Packages (e.g. IMS-CIPIM, 2001; SCORM, 2001), and definitions how to bind these specifications to XML (Bray et al., 2000) representations (e.g. IMS-CXPB, 2001). Multiple softaware vendors use these specifications or have defined combinations of them (e.g. Microsoft, 2002), and there is a multitude of different types of learning management systems available. However, these definitions developed for e-Learning have mainly focused on metadata necessary for describing learning intentions and defining units of learning content known as Learning Objects. It has remained somewhat vague what a learning object actually is (Polsani, 2003), and what the units of content within training are, and, more appropriately, who defines the units of content within learning, and how. All in all, there exist few methods for analyzing and designing content of training and combinations of content for various target audiences intended.

The purpose of this paper is to illustrate the complex and massive content of training in manufacturing organizations, and show how the units of content of training in manufacturing organizations can be analyzed. We discuss a study in which the broad and complex content of training of a manufacturing organization was designed for specified target training groups. For the purpose, we used the theory of genres as an analytical lens for studying organizational communication as suggested by Yates & Orlikowski (1992). The genre theory has been used e.g. for developing content and document management in organizations (Honkaranta, 2003a), and a genre-based method (Honkaranta, 2003b) has been explicated for analyzing content and studying requirements for content assembly. In the paper, the use of genre analysis is combined with studies of learning content, where the content and its objects are considered. We provide an example of a hierarchy of content units within a massive, complex content of industrial training, and provide an example on using the genre-based templates along with XML and XSLT languages (Clark, 1999) for fetching source content units and transforming them into raw training content intended for customer training of a large manufacturing organization.

The rest of the paper is organized as follows. In section two we discuss the content and its units in training materials. Section three discusses the theory of genres. Section four describes the manufacturing organization referred to as BIRD, and illustrates how the genre-based method was operationalized for studying the units of content within training for four training groups. Section five provides an example of using a genre-based...
template together with XML and XSLT for assembling content for training. Sections six and seven discuss the implications and conclude the paper.

**Content of Training Revisited**

The nature of human information processing has been studied in multiple disciplines from philosophy and education to information systems design. For example, a set of theories related to constructive view of learning (Korhonen & Väliharju, 1995) see learning as an activity, in which the learner has an existing repository of information content, and by metacognitive knowledge is able to seek for new pieces of information. Recognized, suitable new piece of information is added into the learner’s knowledge repository to accomplish a learning task. Information content is commonly represented by using concept maps (Mcknight et al., 1991) and abstract and concrete concept hierarchies (Rasmussen, 1985). Topic maps (Pepper, 1999) are kinds of concept maps that provide metadata over a set of content units called topics, as well as locators for content instances.

According to Holmberg, (1989) the learning content should be appended by elements of guided didactic conversation, such as communicating the learning objectives and motivating the learner. The guided didactic conversation is similar by nature to learning object definitions included in the recent e-Learning standards such as Learning Object Metadata (IMS-LRMDI, 2000) and Sharable Content Objects (SCORM). This content can hence be considered as metadata of the learning content. Partially due to this didactic conversation, a large portion of student communication can consist of other communication than the actual content provided by the instructor (Tyrväinen et al., 2003).

Holmberg (1989) has pointed out that a natural, logical model of content organization can be found for most learning areas, and the content should be clearly organized into content topics. The model of content is evident for experts in the area. The learnable content itself is a mix of several types of information, including examples, references, discussion, and assignments. The learning content should be divided into suitable units for learning: an amount of topical content that can be learned in one session should be enacted as a learning unit, or module. It should be easily navigable, from bottom-up to top-down and by general browsing, since the learners tend to use either inductive or reductive reading strategies. The content should also contain indexes, introductions and concluding remarks for quick browsing and top-down approach (Holmberg, 1989). Holmberg has also envisioned that if the content of learning were organized as a collection of independent content modules, the learners could construct the appropriate learning content themselves.

Polsani (2003) provides a well-founded discussion over the fuzzy nature of Learning Objects (LOs). The concept of an LO as an identified container of learning content is used in multiple standards for learning metadata, such as LOM and SCORM. Granularity of content units can vary a lot according to the domain or the definition used, which can confuse learning material content designers (Polsani, 2003). Polsani considers this to be the caveat of many definitions of LOs, limiting their successful reuse. Grain size of an LO is often based on learning time, and assets are often subjective and arbitrary. The grain size should be re-defined by asking the question: how many ideas about a topic can stand on their own, and can be reused in different contexts? Thus Polsani seems to indicate that an LO grain size should be defined by reasoning about topical content of training; an LO would preferably consist of one or a few content topics.

Furthermore, e-Learning LOs, should be accessed and reused independently from the delivery media or content/learning management system (LMS) used. An LO cannot become reusable if its creation is not separated from the instructional method used, therefore high level of abstraction for LO content should be emphasized. The content of LO itself consists of elements, i.e. smaller content parts such as text, video, animation, glossary, assessment, and multimedia. Polsani (2003) also points out that a content of an LO should be a combination of multiple types of elements. As XML is the standard for all future applications, it could facilitate creation of learning elements within LOs enabling cross-platform interoperability of LOs consisting of one or more XML elements. The inherent separation of structure, content and presentation in XML also allows the flexibility required for LO creation, deployment and manipulation. (Polsani, 2003)

As Polsani (2003) and Holmberg (1989) have provided descriptions of learning content, we can ask what are the LOs, topics, and their inherent ordering in some domains, and how they can be defined? Polsani emphasizes the abstract, self-standing nature of the LO, Holmberg refers to domain-oriented nature of content expertise that is needed for organizing the content and units of it in a certain domain. Given that existing definitions of LOs differ so much, is the reason for differences actually caused by the differing learning content domains? It seems that studies of learning content units in different types of learning domains are needed for comparison. There also
seems to be a lack of methods for defining the hierarchy of units of the content of training, and for identifying potential LOs.

Genres as Analytical “Lens” for Content Analysis

Content can be comprehended and analyzed from multiple perspectives. Documents, texts and speech used for communicating the content in organizations can be analyzed by focusing on the communication itself - hence emphasizing the human-oriented, non-technical aspect that provides a base by which contemporary technologies and media can be scrutinized. Following Yates & Orlikowski (1992) we propose using the genre theory as an analytical “lens” for scrutinizing communication within organizations. A genre can be defined as a typified communicative action, characterized by a similar substance and form, and enacted as a response to recurrent situations (Yates & Orlikowski, 1992). Genre substance defines the social motives, themes and topics, whereas form refers to the physical and linguistic features of the communication. A topic defines a name for a unit of content within a genre. Examples of commonly known genres include a memo, a business offer, and a meeting agenda. Recurrent situations, such as work tasks that occur repeatedly, can be typified. Genre rules associate appropriate elements of form and substance with a certain type of recurrent situation within a community of discourse (Yates & Orlikowski, 1992). Community of discourse can be considered as a type of a special interest group (SIG), that shares understanding of the communicative situations, and genre features that are to be applied (Swales, 1999). A community can develop a specific language with jargon and acronyms for both uniting itself and preventing outsiders for entering (Swales, 1999).

Yates & Orlikowski (1992) have pointed out that genres should be studied in their context, i.e. in the community using them, since genre rules and features are governed and evaluated by the community using them. Berkenkotter & Huckin (1995) noticed that genres and rules for enacting them can be strikingly different from one community to another, even if both communities refer to the genre with the same name. Genre studies, in which the users are allowed to define the genres they use themselves, are therefore needed albeit rare.

For the purpose of an analysis it is useful to group and categorize genres according to their features. For example, properties of genres in regard to substance and form can be thought of as genre-based metadata values, and substance and form can be thought of as metadata category names for the genres inspected. The 5W1H (Yoshioka et al., 2001) aspects of genres can be thought of as genre-based metadata framework, which can be operationalized for studying genres and their use with regard to others. The 5W1H considers the why (socially recognized purpose of communication), what (expected content), how (media, type of language), who(m) (who communicates, to who or whom), when (e.g. time schedules or deadlines, duration) and where (physical or virtual places; such as company building or URL) aspects of genre features. The framework can also be enhanced by developing categories according to the needs of the analysis, or by expanding the 5W1H aspects. For example, the “how” can consider technology or software used for enacting genres in addition to media and language used.

Multiple genres and combinations of them are commonly used in organizations (see, e.g. Karjalainen et al., 2000; Päivärinta et al., 2001). Genres that are used habitually in a community form a genre repertoire (Orlikowski & Yates, 1994), a collection of genres of a community, whereas genres that have a generalization (variant) relationship with respect to each other are considered as genre variants (Crowston & Williams, 1997). The theory of genres hence provides us with means for scrutinizing genres as communicational units of content, and also with means for expanding our inspection to the whole repertoire of units of content in an organization - from a genre repertoire as a broad content collection to a subtopic of a genre, which is a unit of content with a quite small grain size. Figure 1 visualizes the genre-related concepts and content units that can be operationalized for scrutinizing the communication and relationships between the communicational units of content. The figure uses UML class diagram (UML, 1997) notation.
The differences between a genre and its instance, and a genre and media used for delivering an instance of it should be clarified: a memo genre can be thought of as a model for numerous memo instances, which can be produced, manipulated and delivered as documents, views, web sites, files, mail bodies or databases. In a way, a genre can also be considered as a human-crafted model for a document type schema, which (e.g. DTD; Maler and El Andaloussi, 1996 or XML schema: Fallside, 2001) is a more exact definition prepared by using a formal notation, and meant both for human and computer comprehension.

**Training Content in Manufacturing Organizations: The Case of BIRD**

**Context of the Study**

The target organization of this study - i.e. BIRD - is a large, multinational enterprise producing and delivering production lines consisting of machines, which are customized for individual factories. There is a need to train the people working in customer factories for operating and maintaining the machine purchased. Training is organized as a project that starts with a training plan and an offer made to a customer. Course design considers the requirements set by the machine ordered by the customer and knowledge obtained about the employees to be trained. The actual training includes carrying out the training in various locations, possibly using multiple languages, and using a variety of training techniques. Duration of a training project can exceed a year and involve intensive communication between people at the customer organization and at the product design, marketing and customer documentation departments. In each training project, up to 100 experts of BIRD train 100-200 employees of a customer organization engaged in different types of work with a production line. BIRD has defined four separate training groups according to the types of work in factories: key personnel (such as managers and office workers), operators using the machines of the production line, mechanical maintenance staff, and automation staff maintaining software and ventilation systems.

The training domain is divided along two main dimensions: the four training groups and the maximum of 20 machines of the production line to be trained. Each of the about 80 training sessions pertains to one machine for one training group. Further, training customized to the features of customized machines adds the third dimension. Sessions are carried out in a certain order or in tandem. A training session can be carried out as a combination of lecturing and group work, factory visits, or group work with multimedia-enriched training materials. A session can last from two hours up to three days. The amount of training material to be managed can be high: from 20-60 pages of paper pertaining a session to 160-480 pages of content for each of the possibly 100 to 200 trainees.

A large portion of training content could potentially be reused from the Operation and Maintenance (O&M) manual. An action research study (Susman & Evered, 1978) was established to collect requirements for content assembly from O&M documents to training documents. An analyst who was assigned to the research of reuse requirements tried to apply the structured document content analysis methods – such as the Maler & ElAndaloussi (1996) method for the task, since the content of O&M manuals was defined by a SGML (predecessor and superset of XML) language. She studied the content of training materials and their production, but was unable to apply the method because of the heterogeneous nature of training materials. The existing content and material production processes varied from trainer to trainer in the recently established training department. One trainer producing the training for his training session reused the text and figures from O&M
documents with a copy/paste function producing a layout similar to the O&M documentation. Another trainer produced slide shows containing bullet lists and figures of a machine according to another layout definition. Trainers used the term training materials of a variety of content including a slide show presentations, spoken content, and multimedia presentations. The amount of training material and its variations seemed overwhelming. Even the manager of the training department stated that he could not define all the variations of a training session contents and requested for methods for making it explicit and harmonizing it.

The Genre-based Method

A preliminary method for the study was defined based on the theory and findings related to genres. Following Yates & Orlikowski (1992) the genres were studied in the domain they are used. As there is a lack for studies in which the domain experts design the genres they use themselves (Berkenkotter & Huckin, 1995), user participation was emphasized rather than utilization of existing studies of training content. The benefit of participatory collaborative design is that it ensures that the terms, definitions and domain-oriented language are all commonly shared in the community of training, and also transferred to the content analysts and designers. The findings of Tyrväinen & Pääväranta (1999) supported the selection of participatory analysis also: the authors point out that a single expert of an organization can usually define only a fraction of the genres used.

The method consists of four main phases, each containing multiple tasks. Figure 2 visualizes the phases. Three techniques are used within the method. Workshops (Coughlan et al., 2003) are used to allow trainers to reach consensus over the genres and the ways they should be enacted within the community. The metadata values are gathered using questionnaire forms filled up collaboratively. A wall-diagram technique (Saaren-Seppälä, 1997) is used for defining topics and subtopics of genres. In the following sections we first describe the phase in a general level followed by a description on how it was actually implemented at BIRD.

![Figure 2. The method used for analyzing training content.](image)

Describing the Domain of Interest

In Phase 1, expert groups for administrating and carrying out the development initiative, and for defining the genres of interest are defined. The 5W1H aspects for genres can be used as preliminary metadata categories for genre-based metadata definition.

In BIRD the analysis group established consisted of the manager of the training department, a development engineer from the customer documentation department, and a content analyst. The group listed and grouped domain experts available from BIRD and subcontractor organizations.
There were multiple perspectives from which to define the initial genres of training. A choice was made to use the training sessions for the four training groups as the genre candidates for further inspection. As some of the machines, due to their special characteristics, could require specialized training, there was a possibility that separate genres might be needed to be defined for some or all of the machines. Product structure of a production line seemed to form the common ontology of the domain, according to which the trainers seemed to organize their content (some machine designers worked as part-time trainers, too). The analysis group decided to scrutinize the training sessions pertaining machines as variant candidates for the four training group specific genres. Customer-specific variation was considered as an instantiation of the genre variants. Altogether, the final number of the genres that could be defined by the results of analyzing the candidate genre variants was expected to be between 4 and 80.

The group also studied the processes of content production, the relationships between the candidate and variant genres, and the machines. Reports of previous studies, organizational charts, and examples of training content and O&M documents were collected and analyzed. A workshop plan and preliminary metadata categories originating from the 5W1H framework were defined.

Defining Metadata and Producing Topic Definitions of the Genres

In Phase 2 the genres and metadata values pertaining them are scrutinized in workshops using questionnaire forms and the wall-diagram technique (Saaren-Seppälä, 1997). The metadata values are defined as the first assignment, and the wall-diagrams of topical content unit names within the genres as another. Results are presented and unified in joint sessions in between and after the assignments. Terms and ordering of topics are cross-examined across the groups and alternative definitions are evaluated and harmonized, when needed.

In BIRD a pilot workshop, six actual workshops, and two smaller working sessions were carried out. The genres were defined by producing wall-diagrams of topics and subtopics for a total of 21 genre variants. Most of the workshops involved training one machine for the four target groups. Thus there were four parallel expert groups each working on one variant of the four initial genres. Metadata values were collected collaboratively by filling in a questionnaire. Topic definitions for each genre variant consisted of 6-8 topics and 4-9 subtopics each. There were also sub-subtopics defined for a few genre variants.

Figure 3 represents an example of a topic definition of a genre variant. The top row defines the genre and the variant by the names of the target group and the machine, respectively. The topics and subtopics pertaining to the genre variant are recorded on the two columns on the left while notes and ideas are recorded on the right.

<table>
<thead>
<tr>
<th>Training target group: key personnel, production line component: presser</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Topic</strong></td>
</tr>
<tr>
<td>Introduction</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Structure</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Figure 3. An example of a topic definition of a genre variant

The time needed for negotiations in joint sessions decreased in later workshops, and the consistency of definitions increased. This implies that the people gained commonly shared and more explicit understanding of the genres and their use on the domain. For the analyst, the workshops provided a possibility to discuss with experts in an informal way and to learn about the domain and language used.
Cross-analyzing Topic Definitions and Metadata Values

Phase 3 is carried out with a selected group of domain experts in one or several collaborative workshops. It consists of three steps:
1. cross-examining and harmonizing the topic definitions of the genres
2. producing a metadata definition for the genres by gathering, analyzing and harmonizing the metadata values collected in workshops
3. scrutinizing the hierarchy of genres and topics in the domain by analyzing and possibly re-defining the genres, and defining the logical units of content for computerized manipulation.

In BIRD the analysis group studied the workshop memos, metadata values and topic definitions. A coherent metadata definition was prepared, and the topic definitions were re-defined for consistency again. The initial definition of the four candidate genres, one for each training group session, was shown to be feasible. Variations based on machines were recorded into topic definitions according to topics and subtopics, resulting in unified topic definitions for each of the four genres, including information about the variants. The division and grain size of the genres were also considered as appropriate unit for computerized processing in the case of BIRD, whereas processing needs pertaining to topics was studied on the next phase.

Defining Topic Templates

Phase 4 aims at locating potential source content units and their identifiers from existing content repositories for content reuse and assembly. The expert group carrying out this phase should include trainers and experts from all source content domains. Potential source content can be identified using tables of content, document schemas, as well as database schemas of source content repositories. The content is studied by scrutinizing definitions and example contents from content source repositories for each genre and topic and subtopic on the genre topic definitions.

In BIRD the analysis group studied the topic definitions with respect to the O&M manuals as a potential source of training content. The printed form of the manuals can consist of more than 40 folders of paper, and the content-oriented SGML DTD of the manual consists of about 200 elements and 130 attribute names. The customer documentation department had prepared a document, which defined the “sections, headings, subheadings and sub-subheadings” of the topical content of the manuals. Since the content for a genre could not be reused to form a unit of content in an O&M manual directly, the analysis group matched each topic and subtopic in the topic definitions against these listings for potential source content and its identifiers. For example, a topic “safety” on the training topic definition was studied with regard to O&M content by studying the O&M content definition document, example document instances, and possible element names and attribute values of the DTD definition. Properly identified source content heading or subheading names, DTD elements and attribute values for source identification were recorded in topic templates.

The documentation was published as “A trainer’s guide” in BIRD’s Intranet. The trainer’s guide consists of a metadata definition, topic definitions and topic templates with notes and examples. Metadata definition describes the four training groups, and provides other information on the timing and use of the training genres. A topic template is similar to a topic definition extended with the rightmost column for information of the topical (content headings, DTD elements) source content identifiers. Figure 4 provides an imaginary example of a topic template.

The topic templates resulting from the analysis process were made use of with manual copy-and-paste operations to assemble a couple of genre instances according to the templates. As this proved to be feasible, the analyst drafted a process of content assembly based on the use of XML and XSLT transformations.
with means for managing this complexity and for documenting the training content and source content topics in a reusable format. If we do not have the means for analyzing and unifying the multiplicity of training session content combinations, we can end up with the need to maintain tens of scripts or a large program, which cannot be based on using specifying attribute values that define the content for each target audience. However, Hillesund (2002) has claimed that using XML for producing multiple outputs from a single source, or a single output from multiple sources is not feasible for producing e-books for learning. She claims that the use of XML is too complex for trainers and training content designers, and that the separation of content, layout and structure by using XML is, in practice, impossible.

Heikkinen (2000) has envisioned a large repository of SGML documents, from which users could search, browse and pick up part content for producing tailored training materials. Personalization for target audiences could also be based on using specifying attribute values that define the content for each target audience. However, Hillesund (2002) has claimed that using XML for producing multiple outputs from a single source, or a single output form multiple sources is not feasible for producing e-books for learning. She claims that the use of XML is too complex for trainers and training content designers, and that the separation of content, layout and structure by using XML is, in practice, impossible.

In BIRD, the material to be reused includes heterogeneous content sources from multimedia presentations to SGML documents. Most of the source content can be located from the O&M manuals, which are structured in accordance with a single, content-oriented DTD. Each production line machine is documented as an instance of this DTD. As each machine and production line is a one-of-a-kind product, a new version of an O&M manual according to the variance of the individual machine is created for each. One cannot predict the parts whose content will remain the same as in previous O&M manual constructions. Neither can one predict the topics of training content that could be reused as such. Instead, one can define the O&M manual schema structures that can be used to point out the reusable units of content from O&M manuals as the raw source material for the topics of training material. We defined these in the topic templates by using the genre-based method. The next phase is to turn them into a machine-readable form called genre-based templates, which enable (semi-)automated content assembly of raw training material. This enables support for assembly operations by programs that locate the potential source topics, re-organize them, and add static content for raw training material output. If we do not have the means for analyzing and unifying the multiplicity of training session content combinations, we can end up with the need to maintain tens of scripts or a large program, which cannot be done by the trainers. In the following text we envision the use of the genre-based templates that provides us with means for managing this complexity and for documenting the training content and source content topics in a reusable format.

### Genre-based Templates in Action: an Example of Using XSLT Transformations

In XML, content parts are elements that are defined by using start and end tags as delimiting mark-up. Attributes are used for defining characteristics of elements. Allowed names for elements and attributes can be defined by a DTD or an XML schema, which also contains the rules for element and attribute organization with respect to each other. XML documents can be transformed by using a language such as XSLT. Within transformation process, content parts from the source document can be located by element names or attribute values. Located source content can be re-arranged and mixed with static content parts defined within a transformation script when producing an output document. A document assembly system can use a transformation script, such as an XSLT template, for producing different versions of the document content for separate target audience groups, or for delivery via multiple media, such as the Web or e-Books. By using the XML language the content can be separated from the layout, and we can produce multiple outputs from a single content source, or combine multiple sources for producing a single output.

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A genre-based template (GBT) is an XML document that defines the mix of source content units to be collected and static content to be added for producing a raw training content for a genre. It uses its own DTD, which describes the rules for copying the source DTD elements and attributes to raw training material output. By using the GBTs, the trainers can write and modify one XML definition document related to each training group. For example, a “Keypersonnel.xml” could consist of the GBT definition as an XML document for training the key personnel. Editing this XML document will change the content for the training group. Instead of writing a transformation script for assembling raw training material content for each training target group defined, we can use a single transformation script. The XSLT transformation script would read the content of a GBT document (e.g. “Keypersonnel.xml”) and produce an output document that consists of content topics defined for the key personnel.

Documents of raw training content for each genre variant (i.e. machine) can be produced by applying the same XSLT transformation script and the GBT of the training group to the O&M manual of the machine. Further, the variations of customized machines will produce new variants of the source XML documents. They all can be processed with the same transformation script and the same four GBTs for the training groups as they all use the same O&M manual schema.

Figure 5 illustrates the process for the example of the topic template visualized in Figure 4. In Figure 5 the source document (originating from an O&M manual) and the GBT in the form of an XML document are illustrated as document trees consisting of nodes (depicted by circles in the figure). Each node represents one XML element. The text written beside the document nodes refer to document element names and attribute values (written as attribute name=”value”). The rectangle on the right illustrates the output document. The “TRANSFORMER” depicted by a rectangle below denotes an XSLT transformation template document that produces the raw output for training material document.
kind of training content output document.

Discussion

The topic templates can be used as a human-oriented definition of genres and their variants for a training group, as well as models for defining the genre-based templates needed for assembling the raw content for training. The topic templates define the content units needed for producing indexes and navigating the content, and producing specialized versions of the content for training groups. Naturally, the raw content assembled from O&M manual content needs to be edited for training purposes. The O&M manuals and their content as a source provide trainers with a possibility to acquire knowledge from designers about each machine that is tailored for a customer.

The use of topics and subtopics proved to be useful from two viewpoints. First, it enabled analyzing the feasibility to use the four genres by providing the means by which to extract the variation from the genres. It was now possible to separate the variations inherent to the information content specific to each machine from the variations caused by individual preferences of the trainers. The variation due to preferences could be harmonized using the participative techniques. The machine-specific variation could later on be attached to the four unified main genres. Secondly, it enabled collecting information about additional sources of source content, which was made available by the experts of the related units participating in the workshops.

If the company in the future wishes to deliver content also as e-Learning materials via the Web, the XML-based training content can make the content production smoother. There is also a possibility for extracting XML-marked content from training documents, and adding this information into e-Learning content metadata definitions, such as SCORM and LOM, or content packaging manifests (e.g. IMS-CPIM, 2001) of the content by using XML-related languages for automated content processing.

In BIRD, the accurate grain size for a reusable content unit, i.e. a candidate for LO unit as defined by Polsani (2003), turned out to be a topic within a genre. As the topics can be marked-up within XML documents they are accessible for reuse and processing even though they are not stored as separate learning objects. For e-Learning, a training content for each of the training groups would be a suitable unit of content to be defined by using e-Learning metadata standards. It would consist of a package of training sessions. It seems that the needs for defining the units of content in BIRD differ from the perspective of e-Learning community. A great deal of source content is available as SGML, and the use of XML and content-oriented mark-up schemas reduce the need for defining LOs as physical, reusable content objects.

In BIRD, the reuse of content would also mean reusing structure of content rather than reusing content objects, as envisioned by the e-Learning community. For example, Polsani (2003) refers to the reuse of LO instances for creating learning content. In BIRD, each machine and production line is one-of-a-kind product, and changes to learning content are common. When the learning content reuse is designed, one can reuse the content structure and define the location of a reusable content for a topic by referring to a schema of O&M manual content. When a new version of the manual is produced a (semi-)automated content assembly script should be able to pick up the right instance.

From a methodology viewpoint the use of the genre “lens” provided a conceptual background for the study, and insights for analyzing the massive content of training. The genre “lens” focused the emphasis on user participation and collaboration thus providing support for Holmberg’s (1989) notion that the logical content of training can be defined by domain experts. Also the “5W1H” metadata framework (Yoshioka et al., 2001) proved to be usable for designing the metadata categories. The use of the workshop technique (Coughlan et al., 2003) was successful and in line with the findings of previous research promoting participatory design (Honkaranta & Lyytikäinen, 2003; Berkenkotter & Huckin, 1995) of a “specific interest group” (Swales, 1999) hindering the possible communication breakdowns between an analyst and the training community (Byrd et al., 1992). The methods used were also adopted by another unit of BIRD, the implication being that these methods were considered as feasible and usable.

Conclusions and Further Research

In this paper we discussed customer training in a manufacturing organization dubbed BIRD as a complex domain in which the genre “lens” and related findings from previous studies were extended with topic analysis.
for training content. In BIRD the variations of training genres were analyzed based on their metadata and topic structure. The machine-based variation of training content structures was captured in topic definitions, and potential content sources for the topics were identified in topic templates. The content of training in BIRD turned out to be massive and complex with multiple levels of content units. The content of training consisted of four content collections with respect to the four training groups. The content for each training group contains variations of content structures and content for separate machines of a production line - these were enacted as training sessions in the domain of BIRD. Use of the genre-based method allowed the definition of the main content units and gathering of contextual metadata, while extending it with the topic hierarchies enabled definition of the content unit hierarchy and study of potential source content units for content reuse. By using the method, the topics and subtopics of training genres were negotiated and defined amongst training experts. In the end, we described the use of genre-based templates for automating parts of content reuse from existing source content. Rather than reusing learning objects as such, we apply content assembly according to static transformations for producing raw learning material.

The results seem to encourage the use of the method and provide avenues for further research. Due to the lack of platform in which to test the assembly in BIRD, more detailed system development and testing was left to be carried out in a further research. For example, the content assembly was considered to be embedded into a product data management system at first, but later the company has considered purchasing a Learning Management System (LMS). Also the requirements for learning content types and elements, such as content indexes, examples, references, didactic conversation, assignments (Holmberg, 1989) and multimedia objects and glossaries (Polsani, 2003) need to reflected in a learning content. How these could be included in the existing methods or evaluated for learning-oriented schema design methods remains an interesting and challenging avenue for further research. Other interesting questions still open include:

- Should the O&M manual structure (i.e. the source DTD) be optimized for aiding production of LOs?
- How could the transformation approach presented here be combined with the use of existing, more abstract LOs in the best possible way?
- Could we embed the method to schema design methods, such as the Maler & El Andaloussi (1996) method, and how the learning content types and elements could be embedded in the design process?

References


A Personalisable Electronic Book for Video-based Sign Language Education

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Abstract
The World Wide Web (WWW) is an increasingly important source of educational material. However, only scant research has been directed towards making this educational information accessible to the deaf. Adaptive Hypermedia (AH) is an area of research that aims to enhance the functionality of hypermedia systems, such as the WWW, by enabling users to personalise their interaction with the digital content provided by such systems. In this paper, we present a personalisable electronic book, Kids Sign Online (KSO). KSO utilises AH techniques together with digital video content to assist in the teaching of British Sign Language to deaf children. By providing an example of an adaptive WWW-based sign language education system, we hope to broaden the accessibility of sign language learning materials and to illustrate how AH tools and techniques may be used to address issues related to the education of the deaf in online learning environments.

Keywords
Disability learning, Hypermedia, Adaptive hypermedia, Digital content, Online learning, Accessibility, Sign language

Introduction
A sign language is a language that uses combinations of hand shapes and hand, arm and/or body movements together with facial expressions to communicate without using sound (Sutton-Spence R & Woll B, 1999). In the last thirty years, sign languages have become the standard way of teaching language to deaf children. These languages have enabled deaf children to communicate well with other people, both hearing and deaf. It is now clear that, using sign language, deaf children can have perfectly normal language and communication skills (Fischer R & Lane H, 1993). For people brought up with them, sign languages play the role of native natural languages, composed of intricate syntaxes and vocabularies.

In the context of education, both spoken and printed information has historically been translated into sign language, in order to enable deaf students to have equal access to it. Today, the World Wide Web (WWW), a highly interconnected collection of computational resources, is a major source of educational information. School children routinely use the WWW for both information seeking tasks and discovery learning. There has already been some work done towards tailoring web resources to increase their accessibility for the deaf. The main strands of the research are: how to represent sign languages within the digital domain, for example Visicast (Visicast, 2003) and Vsign (Vsign, 2003), and how to devise writing systems for sign languages utilising such media as line drawings, symbols and photographs (Kramer & Ovadia 2000). This paper concerns an attempt to use more sophisticated techniques for tailoring online material for the needs of speakers of sign languages. Our approach is to use Adaptive Hypermedia.

Adaptive Hypermedia (AH) is a set of ideas and techniques aimed at extending hypermedia systems, such as the WWW, to enable a user’s interaction to be personalised on an individual basis (Brusilovsky P et al., 1998). AH systems use knowledge provided by, or inferred from the behaviour of, users to tailor what information is presented to the user and in what form. AH systems support users in navigating hyper-documents by limiting options for traversal, suggesting links to follow, and providing additional information about links and other resources. AH systems tend to be particularly useful in areas such as learning, where users have differing information seeking requirements and different histories and preferences.
In this paper, we present a personalisable electronic book, Kids Sign Online (KSO) (Naqvi, S et al, 2003), that supports the learning of British Sign Language (Flodin M, 1994) to deaf children and their tutors. The system’s uniqueness lies in its use of personalisation and adaptation (P&A) techniques, incorporated with digital video content, in the development of WWW-based electronic books for children. The British Deaf Association states that:

“Weal people have the right to a quality education throughout their lives, which accepts their linguistic, cultural and social identity, which builds positive self-esteem and sets no limit to their learning.” (British Deaf Association, 2001).

If such an aspiration is to be realised, we believe that it is crucial that educational materials found on the WWW are adapted to suit the needs of the deaf. The research reported in this paper is motivated by the view that through the application of P&A techniques, it will be possible to provide deaf students with equal access to WWW-based educational resources.

Through the use of P&A techniques and digital sign-language content, KSO aims to assist deaf students in the individualised learning of sign language. Within the system, the teacher is realised as a composer and tailor of digital content that makes personalised digital video, textual descriptions and exercises available to students. By providing an adaptive WWW-based sign language education system, we hope to broaden the accessibility of sign language learning materials. Furthermore, we aim to illustrate how AH tools and techniques may be used to address issues related to the education of the deaf in online learning environments.

The remainder of this paper is structured as follows. In section 2 we provide the motivations for our work in the areas of educational AH systems and sign language systems. Section 3 provides an overview of the Goldsmiths Adaptive Hypermedia Model, which provides the framework and architecture for KSO. In section 4, we describe how the system dynamically generates personalised educational sign language material. Section 5 describes how P&A features of KSO are implemented, and how they are made available to students. This section also describes features that enable students to search for personalised video content and describes the assessment subsystem used to provide students with exercises to assess their learning. Section 6 provides a brief overview of additional features that are found within KSO. These are an online sign language dictionary and digital video fairytale stories. Section 7 highlights related work and compares it to the work contributed by this paper. Finally, section 8 contains conclusions and future directions for research.

Background and Motivations

The potential for using AH systems to address issues of learning has long been recognised (Beaumont I & Brusilovsky P, 1995; Brusilovsky P et al, 1996). The predominant application area has been education (Kay J & Kummerfeld R J, 1994; Brusilovsky P et al, 1996; De Bra P, 1997; De Bra P, 1998). Early lab-based systems, such as these, were concerned with how AH techniques could be applied in an educational context. With the emergence of large-scale distributed hypermedia systems, such as the WWW, many online AH educational systems have been proposed (Weber G & Specht M, 1997; Steinacker A et al, 1998; Brusilovsky P, 1999; Stern M K & Woolf B P, 2000; Ng M H et al, 2002). Broadly, all these systems have a similar goal: to provide features that allow users to personalise, or have the system adapt, digital educational content. P&A features implemented by systems include: link hiding and annotation (Culver & De Bra P, 1997; Kay J & Kummerfeld B, 1995), the incorporation of visual clues to assist learners (Brusilovsky P & Pesin L, 1995), the tailoring of content and its presentation (Specht & Oppermann, 1998; Ng M H et al, 2002), selective content (Ohene-Djan J & Fernandes AAA, 2002), and tailoring options for traversal through the inclusion of additional supplementary links (De Bra P & Calvi I, 1998). A review of recent AH concepts and issues can be found in (Brusilovsky P, 2001).

In this paper, we define personalisation to be the user-initiated tailoring of hyperdocuments. Adaptivity is defined to be system-driven personalisation.

In order to understand how AH research can benefit the design of sign language educational systems, it is first useful to consider some of the reading, writing and teaching issues associated with the education of the deaf. Historically, deaf children were only taught to lip-read and speak (Fischer R & Lane H, 1993). As a result of their impediment, the reading levels of the deaf are generally of a lower standard than those of their hearing counterparts (Schleper D R & Mahshie S N, June 1997). Furthermore, those who are taught sign language as their primary mode of communication are potentially further disadvantaged when reading printed books or WWW-based textual content.
A sign language is not a word-by-word translation of a spoken language, but is a language in its own right. Sign languages, such as American Sign Language (Sternberg M L, 1996) and British Sign Language (Sutton-Spence R & Woll B, 1999), differ significantly in their syntax and semantics from American or British English. Therefore, the relationship between written English and sign language is very different from the relationship between written English and spoken English. Written English is a foreign language to native speakers of sign languages. In sign languages movements, body positions and expressions are integral parts of the syntax. These do not easily translate to written texts. Furthermore, printed text often uses phraseology and grammatical constructs that make word by word translation difficult, if not impossible (Coleman J R & Wolf E E, 1991). As a result, printed text must nearly always be translated, by the teacher, into sign language, on behalf of the student, in real time. This process is expensive in terms of time and teaching resources and requires a high level of expertise.

One approach to making printed, or WWW-based, educational materials accessible to deaf children is to establish a pictorial representation of the vocabulary and syntax of a sign language. These representations are called writing systems (Sutton V, 1996). Specifically, sign language writing systems use a set of visually designed symbols that record how people sign, thereby representing the visual subtleties of sign language. Although several proposals for sign language writing systems have been made (Sutton V, 1997), and tentative steps have been taken towards providing software-based sign language translators such as the SignWriting Markup Language, SWML (da Rocha Costa A C, 2003), to allow for the automatic generation of electronic texts written in sign language, there is still no universally accepted writing system for sign languages.

In the absence of a universally accepted writing system, video has emerged as the primary technological platform used to present educational material to the deaf. Signing books (Pragma, 2002) are video presentations of textual material. They are analogous to talking books for the blind. In such books, a narrator is recorded on videotape while signing the content of the book. The signing may be complemented by subtitles and other visual clues (i.e., graphics, animations, etc.). As signing books are presented via video, they inherit the inherent weaknesses of the medium. Videotape is inefficient to navigate through: a user must linearly shuttle backwards and forwards through the tape, as no direct access mechanism is available. Furthermore, users are unable to search for a specific phrase or topic. There are no contextual links for browsing and no table of contents to locate particular subjects. Finally, videotape degrades with repeated use. These weaknesses become particularly evident when such books are used for educational purposes.

The deficiencies in videotape technology are a motivating factor for our use of hypermedia technologies as a platform for the delivery of sign language learning materials. The ability of hypermedia systems to make non-linear context based navigation available to users, through the inclusion of hyperlinks, and their ability to make use of computational resources to dynamically manage content, suggests that this medium may be a more appropriate delivery platform. Furthermore, content accessible via hypermedia systems is stored digitally and is therefore not subject to degradation through repeated use.

In the case of AH, we propose that users could benefit from possibilities, not only related to the medium, but to the design of the software itself. Adaptive hypermedia technologies are starting to prove effective in performing information retrieval tasks when users have different information seeking goals and histories (Karagiannidis C et al, 2001; Bajraktarevic N et al, 2003). The ability of these techniques to tailor the content made available on an individual basis and the ability to adapt this content to the specific knowledge that a user has of a subject could yield similar advantages to the deaf learner. Furthermore, the ability of adaptive hypermedia systems to tailor link presentation, in order to direct and assist users in their online learning, appears to make adaptive hypermedia techniques and technologies good candidates for use in the development of sign language education systems.

KSO Electronic Book Framework and Systems Architecture

In this section, we outline our view of electronic books, and provide an overview of the Goldsmiths Adaptive Hypermedia Model. This formal model was used as the systems architecture in the design of the KSO adaptive electronic book.

In this paper, we define the content of an Electronic Book (E-book) to be a hyperlinked network of digital information units. When these information units are rendered, they provide the user with optional links to other information units. A rendering unit in an E-book is viewed as a hyperpage, and a collection of units as a hypermedia presentation. Such presentations are accessible via a WWW-browser (e.g., Galeon, Firebird,
More generally, an E-book is viewed as an electronic version of a paperback book, whose digital content may be dynamically generated. This content is made accessible via the Internet, and is read using an E-book reader, such as a WWW-browser. In the case of KSO, an E-book reader is limited to be any device that is capable of displaying a WWW-page.

Although there have been many impressive proposals for the development of E-book technologies (Harrison B L, 2000; Press L, 2000; Ohene-Djan J & Fernandes A A A, 2003), and much research has been conducted into their deployment (Landoni et al, 2000a) and design (Landoni et al, 2000b; Landoni et al, 2000c; Landoni et al, 2001) a significant limitation of many WWW-based E-books is their inability to address users information needs on an individual basis. For example, when a user interacts with a paper-based book, they are given the opportunity not only to read its content in a linear manner, but also to annotate it, insert and delete content, and to make, in context, cross references to parts of the book and other books. Such functionality is rarely found in E-books using the WWW and is a further motivating factor for the research reported in this paper. The KSO homepage is shown in Figure 1.

![Figure 1. The KSO Homepage](image)

**An Overview of the Goldsmiths Adaptive Hypermedia Model (GAHM)**

The Goldsmiths Adaptive Hypermedia Model (GAHM) (Ohene-Djan J, 2000), (Ohene-Djan J & Fernandes A A A, 2000; Ohene-Djan J 2002; Ohene-Djan J and Fernandes A A A, 2002a) is a formal characterisation of personalisation and adaptation within hypermedia systems. Its originality lies in its formal specification of personalisable, adaptive hypermedia, when loosely coupled to user interface and database servers. Induced from a formal definition of hypermedia specifications, used for the presentation of digital content, is a formal model of hypermedia personalisation and adaptation.

The model defines a rich set of user initiated personalisation actions, which enable individual users to personalise how information seeking tasks are performed. This is then extended with additional functionality to allow for the specification of a user model and decision making algorithm. These additional components allow for adaptivity to be realised. In GAHM, personalisation is viewed as the process of handing over to the user the ability to take actions to tailor hyperpages, thereby overriding aspects of a hyperpage’s content and presentation. Adaptivity is viewed as the process of allowing the system to take the initiative in tailoring actions in the light of its inference of a user’s information seeking goals and history. In GAHM, adaptivity is, therefore, as expressive as personalisation, but requires the addition of user modelling and decision making technologies.

**Architecture of KSO**

Figure 2 depicts the open architecture for hypermedia systems (this, and all subsequent figures use classical UML notation), upon which KSO has been designed and implemented. This architecture reflects the
predominant approach to the design of WWW-based hypermedia systems. A core of AH functionality is viewed as a client technology of one or more user interface and database servers (UISs and DBSs, respectively). In the case of KSO, the UISs are WWW-browsers, such as Galeon, Firebird and Internet Explorer, and the DBS used is PostGreSQL (Momjian B, 2001). The personalisation functionality implemented in KSO is represented by the shaded package.

Broadly, once a request has been captured, from a user, for a hyperpage, it is channelled directly into the core of AH functionality. If the request is simply for a hyperpage to be shown, the core responds by composing a hyperpage specification and then rendering its digital content into a hypermedia presentation that can be displayed by a UIS. This composition process includes the querying of the PostGreSQL DBS, in order to fetch references to digital content. In KSO, hypermedia presentations consist of signing video clips, textual descriptions and assessment exercises. Other requests allow users to tailor hyperpage specifications and thereby personalise their hypermedia presentations. Such personalisation requests utilise meta-data, in the form of annotations, which provide semantics for the content of hypermedia presentations.

Hypermedia Presentations within KSO

A hypermedia presentation is defined to be a collection of hyperpages, whose topology enables navigation between them. Within KSO, hyperpages are dynamically generated from hyperpage specifications. A hyperpage specification specifies a sequence of information units, known as chunks. Chunks contain digital content, such as video clips, text and graphics. Each chunk is comprised of a specification of its content and a specification of how to present (or render) this content. Content specifications may be comprised of the content itself (as is the case with many of the textual descriptions in KSO) or a reference, in the form of an SQL query, that, when executed, evaluates into content, as is the case with the signing digital video clips available in KSO.
Each chunk may be associated with a set of **entry points** and a set of **exit points**. An entry point enables the hyperpage where the chunk occurs to be referenced in a request. An exit point enables the chunk to establish a navigable link to a hyperpage denoted by the exit point. In WWW parlance, an entry point can be thought of as a Uniform Resource Locator (URL), or as an anchor within a hyperpage, and an exit point as a hyperlink, e.g., an `<A HREF>` tag in HTML. The structure of a hyperpage is shown in Figure 3. A possible rendering of the chunk specification, for which a formal language has been defined (Ohene-Djan J, 2000), is shown in Figure 4.

Dynamically Generating Hypermedia Presentations

When a user issues a request to view a hypermedia presentation via a UIS, the KSO system generates it by retrieving, in sequence, each of the hyperpage specifications for that presentation from a data store, referred to as a hyper-library (see Figure 5). A composition function then parses each hyperpage specification into a set of instructions that, when interpreted, assemble that part of the presentation as a renderable text. This interpretation process involves fetching digital content specified as an SQL query to the PostGreSQL DBS. Once this digital content is returned it is woven, using the binding mechanism of variables, into a renderable text. Once each hyperpage specification in the sequence has been composed the completed hypermedia presentation is returned to the UIS, which issued the original request. Figure 5 illustrates the dynamic generation of hypermedia presentations. A formal model and associated semantics for the specification, and dynamic generation, of hyperpages can be found in Ohene-Djan J, 2000). Figure 6 shows an example of a hypermedia presentation containing assessment exercises in KSO.
Personalising Hypermedia Presentations

In KSO, the requests a user can issue to personalise hypermedia presentations are based on the annotating and rewriting of hyperpage specifications. An annotation pairs a hyperpage specification with notes of interest. These notes assign user-specific values to user-generic attributes of interest (e.g., The level of difficulty is high, the presentation medium is video, etc.). The existence of annotations allows for the personalisation of a specified chunk, a hyperpage, or a complete hypermedia presentation. Annotations are meta-data that describe the content and/or behaviour of a hyperpage or its component parts.

In KSO, both hyperpages and their associated annotations are stored in the hyperlibrary. The hyperlibrary is implemented as a database (using the PostGreSQL relational database management system), comprised of relations over the relational schemas for hyperpages and hyperpage annotations. Further details on the modelling of the hyperlibrary can be found in (Ohene-Djan J, 2000).

Personalisation Engine

We view personalisation as the process of handing over to the user the ability to take actions to tailor hyperpages and, therefore, hypermedia presentations. The personalisation engine is initially set using a static user-model (Fischer G, 2000), which is a representation of a user’s knowledge of sign language knowledge. This is initially set, as a result of a student’s answers to a series of sign language exercises, when a user first registers with the system. This user model provides the means for a user to feed preferences into the personalisation engine. These details are then used to tailor which hypermedia content is made available for further personalisation by the user.

Personalisation in KSO is implemented as a software mechanism that is responsible for providing the functionality required to tailor hypermedia presentations. Such tailoring causes a personalised version of a hypermedia presentation to be created. The dynamics of the personalisation mechanism may be understood as follows. The personalisation process starts when a user issues a personalisation request, via a UIS, to KSO. A personalisation request is comprised of a scope, which denotes the collection of hyperpages in the hyperlibrary for which the request should apply, and an action list, containing the tailoring actions to be executed over the scope. The interface used to issue such requests is shown in Figures 7 and 8. The example personalisation request shown in Figure 7 may be represented in natural language as “I wish to be presented with all pages that contain the string ‘1997’; subsequently delete the second chunk of each of these pages.” Figure 8 can be represented as “I wish to be presented with all pages in the hyperlibrary. Of these pages, only keep those that contain the string ‘1998’ in the second chunk.”
On receiving this request, the composer and tailoring engine parses it to determine which hyperpages should be personalised and how, thereby generating a personalisation program. In the case of KSO, this program is a sequence of SQL statements, which are subsequently executed over the content of the hyperlibrary, thereby realising a state transition, in the hyperlibrary, that reflects the intended meaning of the personalisation request.

<table>
<thead>
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<th>scope</th>
<th>attribute</th>
<th>not condition</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select-page id</td>
<td>page</td>
<td>none</td>
<td>contains</td>
<td>1997</td>
</tr>
</tbody>
</table>

<table>
<thead>
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<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>true</td>
<td>none</td>
<td>contains</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>action</th>
<th>pos</th>
<th>scope</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Delete</td>
<td>2</td>
<td>chunk</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 7. Personalisation Request #1**

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<th>attribute</th>
<th>not condition</th>
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</thead>
<tbody>
<tr>
<td>Select-page id</td>
<td>true</td>
<td>none</td>
<td>contains</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>pos</th>
<th>scope</th>
<th>attribute</th>
<th>not condition</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>retain-f</td>
<td>2</td>
<td>chunk</td>
<td>none</td>
<td>1998</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>action</th>
<th>pos</th>
<th>scope</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td></td>
<td>chunk</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 8. Personalisation Request #2**

**KSO signing dictionary and fairytales**

During preliminary research conducted in conjunction with the British Deaf Association (BDA), Frank Barnes (Barnes, 2003) school for the deaf and Hawkswood (Hawkswood, 2003) School for the deaf it became apparent that there is a significant lack of BSL online dictionaries for deaf children. Furthermore, there are few educational materials, in the form of digital video content, that address the learning needs of children under the age of ten years available via the WWW. As a result of these observations, it was decided that KSO would be designed to be bi-lingual (i.e., supporting the education of English as well as BSL) and would incorporate an online dictionary for the deaf and educational materials targeted towards children under the age of ten.

**KSO Signing Dictionary**

Although the BDA is currently working on the development of a large scale British dictionary for sign language, this dictionary is targeted at deaf adults. KSO incorporates an online dictionary that has been designed primarily for use by children. The KSO dictionary (Shown in Figure 9, 10, 11 and 12) enables a child to select a letter of the alphabet or choose a category (i.e., Animals, Food etc). As a result of this action the KSO displays a hypermedia presentation comprised of a selection of words which are within that category or which begin with the letter chosen, together with associated digital video, signing each word. Figures 9, 10, 11 and 12 show examples of the KSO online dictionary in operation.
A key feature in the design strategy for KSO was that the system’s content, as far as possible, reflected the learning needs of deaf children up to the age of 10. Therefore, a decision was made that educational materials, in the form of assessment exercises, would be supplemented by further materials that facilitated discovery-based learning and general browsing for this age group. An example of this is the inclusion of a section comprised of classical children’s fairy tales, in the form of signed digital video. It was felt that such content was important because it reflected the type of learning materials offered to hearing children of this age group. Each fairy tale is presented as both textual descriptions and signed digital video. An example of a fairy tale as a hypermedia presentation is given in Figure 13.

**Figure 12. KSO’s Signing Dictionary**

**Figure 13. Fairy Tales in KSO**

**Signing fairytales**

This section compares and contrasts the work reported here with that of other online sign language learning resources and that of AH systems in general. It is in no way exhaustive, but aims to give the reader a sense of where future technological developments may lie. As stated in the Background and Motivations section, the vast
majority of deaf learning materials are paper, or videotape (Allsop L & Mason C), based. Some work has been done on WWW-based learning materials for the deaf (Deafchild International; Lapiak J A, 1996; Gaertner S, 2003). Although these systems are valuable educational resources, they do not address users on an individual basis. Instead, they provide all users with the same information, regardless of an individual user’s ability, or knowledge.

The KSO system utilises digital video clips to represent sign language in the digital domain. Recent research efforts have aimed to incorporate 3D animations of signers in contrast to video. Vsign (Vsign, 2003), part of the MultiReader project (www.multireader.org), is a project consisting of a builder to create 3D animated avatars that perform sign language motions, together with a player for such avatars. The Vsign builder allows users to build animations from a model of a human. Users may specify the complete range of body movements used in sign language. However, it is still not possible to include facial expressions. VisiCast (Visicast, 2003) is a project to develop a 3D model of a signing person to accompany subtitles and teletext information on digital television. Signs are digitally captured via advanced technologies, including a body suit and digital helmet. The VisiCast system is an extension of earlier work on the development of “Simon”, a prototype system that signed in English, as opposed to BSL. Although the VisiCast system uses 3D animations, these are displayed in 2D form for performance reasons.

Vcom3D (www.signingavatar.com) is currently developing leading edge software for the teaching of reading to the deaf. Their signing avatars, developed using 3D Studio (Murdock K, 2001), allow users to choose the perspective and signing speed. A particular point of note is Vcom3D’s ultimate goal; to develop a machine translation system that will take a website and output an animated, signed website.

Although the authors of this paper accept that 2D representations may not completely represent all aspects of human signing that may be captured by a 3D model, it was felt that the benefits associated with digital video outweighed the costs associated with the construction of a 3D model. In particular, the use of digital video enabled KSO to show digital signing presentations by deaf children to deaf children. This, it was felt, is an important aspect of learning by example. The capture of digital video is, at present, relatively cheap in terms of time and cost, compared with that required to produce, and subsequently animate, 3D characters, such as those used by Vcom3D, VisiCast, and Vsign. Furthermore, the use of digital video, in contrast to 3D animations, enabled KSO to be available to a wide base of users, many of whom we found, during preliminary research, did not have the latest internet technologies available to them (i.e., up to date players, such as Flash and Shockwave, and the high performance hardware required to support these players).

KSO’s use of digital video in the development of sign language dictionaries may be compared to that taken by the Personal Communicator (http://commtechlab.msu.edu/index.php), a CDROM-based ASL dictionary. Originally developed using Hypercard (Goodman D, 1998) at Michigan State University, this, now commercially available, software makes available to users over 2500 signs as digital video clips. In addition to ASL, the Personal Communicator also provides English synonyms. The Personal Communicator, now developed using Macromedia Director, is available for both the Macintosh and Windows platforms.

The personalisation features of KSO are similar to those made available by implemented AH systems such as Adaptive Hyperman (Mathe N & Chen J, 1996), Joint Zone (Ng M H et al, 2002), and the AHA (De Bra P & Calvi L, 1998). These personalisation features include customisation via a static user model, the insertion and deletion of digital content, and the ability to express searches which result in tailored hypermedia presentations. Since the GAHM (Ohene-Djan J, 2000), the formal model upon which KSO is based, characterises a complete set of possibilities for personalisation actions on WWW-based hyperdocuments, it is possible to implement all P&A actions described in (Brusilovsky P, 1996) and many of those described in (Brusilovsky P, 2001). It is envisaged that in future versions of KSO a broader range of P&A actions will be implemented.

A significant difference between KSO and other AH systems is its application domain, namely sign language education for deaf children. Due to KSO’s application domain, its design incorporates several usability features not generally found in AH systems. For example, KSO allows children to customise their interface, in terms of colours and fonts. It also enables children to personalise pages with the child’s chosen identity.

Finally, the design aspects of the hypermedia presentations contained within KSO, and their usability features, are derived in part, and shared by those of (Landoni et al, 2000b). However, in KSO, we use personalisation as a value added strategy, in contrast to, for example, visual clues (Landoni et al, 2000c).
Conclusions

To date, relatively little work has been directed towards providing online educational resources for the deaf, although the WWW is now a major source of educational information for the hearing. We believe, that for deaf children to have quality education throughout their lives, information contained within the WWW must be tailored to address their accessibility needs. The research reported in this paper is motivated by the view that, through the application of P&A techniques, it may be possible to provide deaf students with equal access to WWW-based educational resources.

In this paper, we present KSO, a personalisable electronic book for the teaching of British Sign Language to deaf children and their tutors. The novelty of KSO is that it incorporates advanced P&A techniques into the development of a WWW-based electronic book. Through the use of the P&A techniques employed during the development of KSO, we aim to broaden the accessibility of online sign language learning materials. In this paper, we have illustrated how, through a combination of digital video, textual descriptions and assessment exercises, it is possible to devise an individualised learning environment for the deaf.

KSO is a demonstration system, whose architecture is based upon a complete formalisation of P&A actions in hypermedia systems. We aim, through future development, to test the effectiveness of various P&A actions in the application area of deaf online learning.

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Dynamic Composition of Math Lessons

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Abstract
In this work we describe an architecture that supports the composition of web based lesson plans for math based on a database of fine grained mathematical components. Lessons can be tailored for different communities of users. For this research, the principal target community of users is middle school mathematics teachers. Our goal is to build a web accessible resource of pedagogical material for grades K-12 math that can be used and reused in a variety of contexts from teacher remediation to lesson preparation through to student use of the lesson. The web based lessons are generated on the fly from a database of fine grained components that include explanations, interactive activities, worksheets, images, videos, audio, FAQ's, online questions and challenges. We present a prototype system based on this architecture that includes functionality for teachers, students and parents. The prototype also includes a graphical interface for easily creating and reusing lesson content.

Keywords
Online education, Web access, Mathematics, Dynamic composition.

Introduction
Educators have a long history of using technology, from the abacus to the Internet, to enhance teaching and learning. The advent of the Internet has resulted in the creation of many educational web sites, both commercial and academic, targeting a wide variety of audiences. Some sites focus on students and parents, with interactive games and tutorials, while other sites are aimed at teachers, providing class activities, lesson plans and other pedagogical content. Other sites are simply hub sites, directing visitors to several other sites of interest on a topic.

Mathematics is a subject with great potential to exploit the Internet in creative and innovative ways in both content delivery and functionality. It is a subject area with a recognized hierarchy of topics, which can be introduced with varying degrees of depth to a wide range of users. Additionally, much of mathematics relies on computation to arrive at answers and visualization of results for dramatic impact with functionality provided by computing platforms.

In this work we describe an architecture that supports the composition of web based lesson plans for math learning based on a database of fine grained mathematical components that can be tailored for communities of users. For this research, the principal target community of users is middle school mathematics teachers. These teachers are not only responsible for preparing and delivering lessons but often need support and remedial material themselves to gain the necessary confidence to present material or lead a class through particular topics. Typical web material provides either predefined packaged lessons or independent tools, such as applets or text, on a range of topics in math.
Our goal is to build a web accessible resource of pedagogical material for math that can be used and reused in a variety of contexts from teacher remediation to lesson preparation through to student use of the lesson. In this paper we present an architecture designed to support interactive math web lessons and resources for grades K-12. The web based lessons are generated on the fly from a database of fine grained components that include explanations, interactive activities, worksheets, images, videos, audio, FAQ's, online questions, and challenges.

The intended user groups include teachers who suffer from anxiety when it comes to teaching math, teachers preparing new lessons, students, and parents. Developed together by educators, mathematics specialists, and computer scientists, our design supports different teaching and learning styles. People have characteristics that affect their learning success, such as field dependence/independence, visual and textual cognitive preferences, ability to abstract, and individual mathematics components reflect this diversity (Dunn & Dunn, 1978; Ford, 1995). A multidimensional feature set of attributes that represent these individual differences is stored in the database, in addition to type, and related topic of each component that can be used to guide the composition of individual lessons.

This architecture allows teachers to tailor the material to their students learning styles, their own teaching styles (for example, collaborative or independent learning), and their students' current level (enriched, curriculum, remedial). Students can then use selected material at home with their parents or at school to further enrich their learning experience.

The contributions of this paper include:

- A web based architecture that allows teachers to design and develop online math lessons using re-usable learning components.
- An educational web site that contains content for three audience types: teachers, students and parents, although the primary focus is for teacher remediation and classroom preparation for a wide spectrum of math topics.
- An educational web site that integrates different learning tools (for example, applets, audio, video, and chat and discussion rooms) to enhance learning and the user experience.

Background

The web is currently populated with a variety of mathematics web sites. Sites (or portions thereof) are aimed at teachers and students such as Drexel University's Math Forum (Drexel, 2002a), NCTM's Illuminations (National Council, 2002), ENC (Eisenhower, 2002), Ask Dr. Math (Drexel, 2002b), Mega-Mathematics (Los Alamos, 2002), and MathResources (2002). These sites offer resource material, links to other web sites, interactive activities such as applets or videos, homework help and some allow students to submit questions to which answers are posted on the web site. The content is not generally tailored to a particular school's curriculum or current coursework and these sites are often bewildering to a teacher wishing to prepare a lesson plan and deliver that plan in the classroom.

Often the first requirement for any lesson plan is that the teacher reach a level of confidence in the material. Without this level of confidence, even the best lesson is not likely to succeed. This is particularly relevant to elementary and middle school teachers who are not likely to have taken advanced mathematics in university. Just as many students suffer from math anxiety, math teachers can also suffer from the same kinds of anxiety. When a teacher is unsure of the material he or she is presenting, students pick up on these insecurities. This may easily result in what Wu (1997) terms a “non-productive learning atmosphere”.

Once a teacher has a good grasp of the material to be presented, he or she may want to tailor a particular lesson plan to best suit the students. Baloian, Pino and Hoppe (2000) found that one of the largest failings of the earlier computer aided instruction systems was that once teachers authored educational material, it could not be re-used by other educators. By dividing text, image, audio, and other content into individual components, material can easily be reused and tailored for a specific lesson or classroom. Dahn and Schwabe (2002) were able to personalize electronic textbooks by dividing the content into reusable meta-tagged “slices”.

A student's learning style can have a significant impact on how much he or she learns in the classroom (Felder, 1995). Although students must be exposed to a variety of learning style modes to become successful students (Felder, 1996), they must also be given the opportunity to work in their preferred learning style mode. In recognition of this, different activities may be required to support different learning styles. Active learners, for example, may prefer working with applets, where they can experiment for themselves, whereas reflective
learners may prefer reading from a textual description. Visual learners may prefer images and video while verbal learners may prefer an audio description.

In addition to learning styles, cognitive styles may play an important role in the quality of learning (Chen & Macredie, 2002). Parkinson and Redmond (2002) found “Internet-based learning environments have tremendous potential and much to offer from a pedagogical point of view if proper account is taken of the individual’s Cognitive Style”. A student's cognitive style dictates how well they organize and represent information. Field-Dependent learners rely heavily on pre-existing structure and hierarchy while Field-Independent learners prefer to develop their own representations. In a hypermedia system, users have the ability to create their own paths and structure, which may be overwhelming for the Field-Dependent learners. The use of predefined paths, trails and menus provide Field-Dependent learners a structured path to follow while Field-Independent learners are still free to navigate as they wish.

Our goal, then, is a system that merges the technology with the pedagogy and provides for the dynamic presentation and composition of lessons in math that are configured across several dimensions including content type, learning style, and content functionality.

Architecture

In this section we describe an architecture that supports the dynamic generation of math learning web lessons using a variety of content types to a range of users from remedial material for teachers to students. The architecture is based on a database of fine grained components with a multidimensional feature set. The architecture is built on the three tier web model, shown in Figure 1.

The Data Layer

The data layer has two major parts: the content components and the user profile information. The content components are fine grained content units to provide the maximum flexibility and reuse of these components in a variety of combinations. Each content unit is associated with a multidimensional feature set that guides its selection and use. The profile information contains all personal user characteristics including learning preferences, if any; usage data and histories; and “handed in” answers, where applicable.

Content Data

The database is designed to reflect the organization of a math unit, such as Shape and Space, which is made up of a number of lessons, such as Quadrilaterals or Triangles. The lessons of a given unit are ordered for use into logical paths, such as the one shown in Figure 2. A path provides the user with a lesson context as well as a navigational path for the lessons within a given unit. In the example in Figure 2, the default path is D1, D2, D3,
D4, D5, where Dx is a lesson. Users may, however, prefer to try out lesson E1 or to replace D2 with E1, or in fact, just jump around. Lessons often rely on knowledge from a previous lesson in the path as well as lessons from other units, which also may have a default order. From the path, users can see what lessons they’ve already visited (D1 and D2 in this example) as well as which ones are ahead. A unit may have multiple instances of lesson paths to reflect differences in intent and/or learning characteristics. When a user logs out, their current location and history are recorded so that they can return to the same lesson in the same path. Teachers are able to define new paths and able to make new instances of a given path by changing the default order or adding or removing lessons to an existing path.

A lesson is defined by a set of components within a structure, such as that shown in Figure 3, where each lesson would contain the following semantic components (described in the Prototype Section): Play, Explore, Challenge, Learn, Look Back, Go Further, PreTest, PostTest, Worksheet, Teacher’s Room, Chat, Discussion, and FAQ. The semantic components of the lesson are generated by combinations of atomic component types.

Atomic components include: text, applet, video, image, link, and audio. Each semantic component of the lesson is built from an ordered set of atomic components. For instance, a page of the Learn section (classic lesson description) may be made up of a textual component, followed by an image component, followed by an applet and lastly followed by another textual component. By identifying the type of components and storing each as an independent item, components can be reused within the lesson and within lessons of different math units.
These atomic component units may be nested and combined to create instances of semantic components: explanations, experiments, questions, discussions, chats, and FAQ's. Questions, for example, have subcomponents: question, hint, and answer. Each of these subcomponents may be composed of one or more content units, such as text, images, or applets. Lessons are defined as sets of semantic components and paths are defined as ordered sets of lessons. More than one instance of a lesson can be archived with variations on the individual components.

To facilitate the combination of atomic data components into semantic components each atomic component is stored with a set of multidimensional features. Currently, the feature set representation does not comply to a meta-data standard. In the future, we will examine educational meta-data standards such as the IMS Metadata Specification (IMS, 2001a), the CanCore specification (CanCore, 2002) or the IEEE LTSC-LOM (IEEE, 2003). These features, shown in Table 1, include the following: type, task, level, setting, timeframe, context, learning style, goal, and content keywords.

Table 1. Feature Set Dimensions

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Feature Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>Remedial</td>
</tr>
<tr>
<td></td>
<td>Curriculum</td>
</tr>
<tr>
<td></td>
<td>Enrichment</td>
</tr>
<tr>
<td>Task</td>
<td>Preassessment</td>
</tr>
<tr>
<td></td>
<td>Concept learning</td>
</tr>
<tr>
<td></td>
<td>Presentation</td>
</tr>
<tr>
<td></td>
<td>Problem solving</td>
</tr>
<tr>
<td></td>
<td>Creating new instances</td>
</tr>
<tr>
<td>Setting for use</td>
<td>In class</td>
</tr>
<tr>
<td></td>
<td>Out of class</td>
</tr>
<tr>
<td>Time Frame of Intended Use</td>
<td>Synchronous</td>
</tr>
<tr>
<td></td>
<td>Asynchronous</td>
</tr>
<tr>
<td>Context</td>
<td>Independent</td>
</tr>
<tr>
<td></td>
<td>Collaborative</td>
</tr>
<tr>
<td></td>
<td>Teacher directed</td>
</tr>
<tr>
<td></td>
<td>Parent directed</td>
</tr>
<tr>
<td>Learning Style</td>
<td>Deep or surface</td>
</tr>
<tr>
<td></td>
<td>Collaborative or Independent</td>
</tr>
<tr>
<td></td>
<td>Visual or Textual</td>
</tr>
<tr>
<td></td>
<td>Passive or Active</td>
</tr>
<tr>
<td>Cognitive Style</td>
<td>Field Dependent</td>
</tr>
<tr>
<td></td>
<td>Field Independent</td>
</tr>
<tr>
<td>Goal</td>
<td>Geometric or Arithmetic</td>
</tr>
<tr>
<td></td>
<td>Math anxiety reducing</td>
</tr>
<tr>
<td>Content concepts</td>
<td>Keywords</td>
</tr>
</tbody>
</table>

This database driven architecture lets us take advantage of feature attributes associated with both the content components and the users to create individual and community views of math lessons and resource material. Teachers are able to search for component types based on selected keywords and feature set characteristics so that components to be reused in several different lessons and in multiple situations within a given lesson to create individual student worksheets and lesson plans.

**Middle Layer**

The middle layer software selects components from the database to create lessons and provides interaction with the user.
Lesson Creation

Lessons are defined as default paths based on standard curriculum or by individual math teachers. Often the first step in lesson creation is to add new content components. Textual content is broken up into paragraphs, which are stored as HTML markup. Links are also stored as HTML markup. Applet, video, image and audio components simply store a file pointer to the object. Components are assigned a distinct component ID and tagged in the database for keywords, cognitive styles and other feature styles. Alternatively, existing components can be reused within a new lesson.

Each lesson, or variation, is given a distinct lesson ID and atomic content components are assigned roles and presentation order to define semantic components. The role represents the lesson section to which a component belongs (e.g.: Play, Learn) and components may be assigned several roles. Presentation order denotes the order of the components within the semantic component on the web page. As an example, in Table 2, the Learn section is made up of 3 components (for instance, two text components and one applet) to be displayed in the following order: component 1, component 2 and component 3. Notice that component 3, the applet, is used in both the Learn and Play sections. Each unique lesson is assigned a topic ID and may be added to either an existing path or a new path may be created.

Table 2. Sample Semantic Component Definition

<table>
<thead>
<tr>
<th>Lesson ID</th>
<th>Component ID</th>
<th>Role</th>
<th>Presentation Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1</td>
<td>Learn</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>Learn</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>Learn</td>
<td>30</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>Play</td>
<td>10</td>
</tr>
</tbody>
</table>

Interactive Data

A large amount of data is captured from both the teachers and students using the web site. This data is stored in the database and in log files. This data can be used by teachers when assessing student progress, planning new lessons and paths, and storing student work.

Student’s answers to Explore and Challenge questions are captured from a text area when the student submits their answer. The recorded answer is associated with the appropriate question and stored in the database with the student's login name, time and date. The answer can then be handed in later or examined by the teacher to look for common problems or misunderstandings that can be addressed in the classroom.

The Chat and Discussion sections log all interactions for further review by teachers. The discussion boards and chat can have multiple forums, divided by grade level, class or topic. The chat room logs are recorded daily and are accessible through the Teacher's Room.

For a new lesson to be created, new components must be added to the database. To add a new component, the following information must be submitted to the database through HTML forms: component content, component type, presentation order, lesson number, and the section to which the component belongs. Teachers can also use the component search engine to find existing components that they would like added to a lesson. Lessons can be created which support specific learning or teaching styles by searching for components based on their learning or teaching styles.

Page Generation

All pages displaying lesson content are generated dynamically from the information stored in the database. Long sections are divided into multiple pages to reduce the amount of scrolling by the user with Next and Previous links for navigation. When a page is requested, for example Learn, all of the content components corresponding to that role and lesson are selected. The components are arranged by presentation order and the web page is generated for the user.
Presentation Layer

Teacher Remedial

One of the primary contributions of the web site is to serve as a remedial resource for math teachers. Through this web site, math teachers can solidify their understanding of particular math topics before presenting the material to their class.

Several resources are available for teachers, such as Play, Learn, and the Teacher’s Room. These are semantic components that allow teachers to review and explore the concepts of the class material. Teachers can use whichever supporting content best suits their learning styles, such as text, audio, images, or video. For example, a teacher with only a vague memory of the "triangle inequality property" can visit the Learn section of the lesson on Constructing Triangles and refresh his or her memory by interacting with the applet to explore this property and/or read the explanatory text.

Teacher Class Preparation

The design supports an easy tool to create and modify lessons to accommodate a particular class. As teachers are the best judges of student ability levels, it is important that teachers be able to create their own lessons or modify current lessons to reflect the abilities and learning styles of their students as well as their own teaching styles. For instance, teachers could have students work together using applets, worksheets or paper-based activities.

Through the interactive data sent to the web site by the students, teachers can determine their students' areas of strength and weakness and prepare their lesson accordingly. Remedial lessons can be used to further explore a topic that needs extra reinforcement while advanced lessons are available for more eager students.

Student

Although students are not the primary focus of this prototype, there is significant content available for students. Students can use the web site during class or at home for review, to complete coursework or to look ahead. Printable content is available for students to complete paper-based work at home.

Prototype

A prototype has been developed using Perl/CGI/DBI to generate the dynamic HTML content from a Microsoft Access database. This prototype will be used by teachers and students from several Canadian schools for a field study of effectiveness in the fall school term of 2002. The sample used includes components from lessons in a large math unit called Shape and Space [2D and 3D], which is at a grade 5-6 level. Currently the database is populated by over six hundred atomic components.

The lesson content found in the prototype is primarily original content developed by the mathematics educators working on this project, although some content was retrieved from the web. Video and audio clips were created using a variety of tools. Applets were developed using the software program Cinderella (http://www.cinderella.de), an end-user tool for the creation of geometric applets in Java.

A template of semantic components is used for the lessons in the prototype, where each lesson has the following semantic components, some of which are available only for teachers while others are available for all user types. The basic layout of each lesson is shown in Figure 3. The top left corner has a visual representation of the lesson components of the current unit path.

The left frame lists the semantic components: Play, Explore, Challenge, Learn, Look Back, Self Check, Go Further, PreTest, Post Test, Worksheet, Teacher’s Room, Chat, Discussion and FAQ. The main frame is the working part of the selected semantic component. In Figure 3 the interactive or Play component is shown.

The Play component (Figure 3) features an interactive object (usually an applet) for students. Although every Play component would include an applet, any given Play component may include other atomic content units, such as text, image, or multiple applets. The Play component is the default selection when the user first enters a
lesson so that users are encouraged to play and explore with the concepts before reading an explanation or description.

The Learn component contains the bulk of the traditional lesson content. Text, images, audio, video and applets are presented in an ordered fashion within the web page to present the lesson. In the sample Learn page shown in Figure 4, the components are placed on a sequence of pages to minimize scrolling. Pop-up definitions are visible in Figure 4, providing definitions of keywords. In the page shown two atomic content components are presented, a text component and an applet component. Learn components are not only useful for presentation to students but also serve as review material for teachers and parents. Both Learn and Play components can be used in the classroom by the teacher to present material.

The Explore and Challenge components are groups of questions for which students can input answers and check their response with a sample answer. The answers are captured for the teacher's benefit or for printing or handing in later. In Figure 5, the student response is displayed in the text box while the Answer below is a component that occurs in another section of the lesson. The Explore and Challenge questions are both meant to focus the student's interaction with Play. Both Explore and Challenge questions are displayed as pop-up windows so that students can use related Play components while answering questions. The Explore questions are tightly applied to the lesson material while the Challenge questions which come with optional “hints”, are more challenging and exploratory. Notice that the answer in Figure 5 is a textual unit that is also used in the Learn section shown in Figure 4.

Figure 4. The Learn section of the prototype

Self Check consists of a set of multiple choice questions related to the lesson. Students are given immediate feedback upon completion of the test.

Pre-Test and Post-Test are composite question units designed for the user to check that they have the required skills and knowledge to be in this lesson and to check their understanding level with respect to the learning objectives of the given lesson.

The Parents’ Notes component is made up of computer and non-computer based activities that students can work on at home, either by themselves or with their parents. A large selection of activities is made available, targeted to a wide variety of learning styles. For example, in the Constructing Triangles Lesson, students have the choice of using spaghetti to work with triangles, or to work with triangles on paper. These are two different activities
that appeal to two different learning styles. Each worksheet has semantic components that have been reused from the lesson and question components, are printable, and have a means, electronic or paper based, for the student to record results and analysis.

![Figure 5. Explore Question and Answer.](image)

The Teacher's Room is a collection of resources meant for teachers, and would not necessarily be seen by student users. Most importantly, review content is available to ease teachers' math anxiety by gaining confidence in using the material and a teacher's only discussion board. Additional lesson questions and details of computer based and non-computer based activities are also made available. In the Teacher's Room teachers can create their own lessons or modify lessons that can be saved as new instances for use by particular user groups. Chat logs from student's chat session are available for teachers to review and pinpoint common problem areas.

**Lesson Development**

A web based graphical interface in the form of an applet was developed for teachers to input lessons into the database. The applet is directly linked to the database and allows teachers to easily enter new lesson information and edit existing lessons. When teachers enter a new lesson component they must identify the math unit, lesson title, section (role) and its file type. Teachers can quickly enter component information using drop down boxes available for all static information, as shown in Figure 6 for File Type. The actual component content is entered into the text box (Figure 6). The component content, such as text or a file name, can be entered manually or cut and pasted from a master lesson document. Each component is marked in HTML.

If a lesson component is being re-used (i.e. it is already used in the current lesson or an alternative lesson), a search facility is available to locate relevant component. This allows teachers to search for lesson components based on a variety of the feature sets stored in the database. Figure 7 shows the results of a search requesting all textual components that have been associated with the keyword “equilateral”. A link to the context of the component opens up a new browser showing the context in which the component has last been used. Teachers can search for existing components using this search facility and then create new lessons using the lesson development tool.
Lesson components are entered in the order they are to appear in the online lesson. When the “Add Component” button is selected, the component is committed to the database and automatically given a component ID used to identify the unique components. As well, the order of the components is maintained and used to dynamically generate web pages as requested by users. Teachers can edit both the content of each component and order the components. Each section of the lesson (e.g.: Play, Learn, etc) for the online session is divided into pages to reduce scrolling. Teachers indicate which page each component is to be placed for flexible layout entry of the components. Initially, this was going to be done automatically however, certain components needed to be grouped together without a page break.
Conclusions

In this paper we have described an architecture developed to support web based math lessons that are composed dynamically from a database of fine grained components that include text, images, audio, video, applets, questions, challenges, worksheets, chat, and discussion groups. The components are classified not only by type and math topic but also using a multidimensional feature set that reflects a diversity in learning styles. A key principle of the system and the prototype is to integrate the activities of math exploration and math learning into all phases of the lesson preparation and presentation including remedial and review activities for the teachers themselves.

A field study is currently underway using a complete math unit, each composed of multiple lessons, at the grade 5-6 level across Canada. The study will use quantitative and qualitative measures to examine the patterns of use and effectiveness of this approach. Following the field study, work will begin to examine learning content specifications.

A second prototype is currently in development based on the architecture presented in this work. The prototype has been developed to support a collaborative of learning modules for health informatics available on the broadband CANARIE network across Canada. This extended architecture has been embedded in a more complex system; the contents of the data layer have been replaced by a learning object store and the presentation layer consists of an e-Learning Management System. This work also includes the use of the IMS Metadata Specification (IMS, 2001a) and IMS Content Packaging Specification (IMS, 2001b) for greater reusability and interoperability.

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References


A Usability Study for Promoting eContent in Higher Education

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Abstract
eContents used in education can be from a number of sources: from traditional electronic journals (eJournals), and electronic books (eBooks) to more specific formats such as: electronic research reports (eResearch-reports), electronic lecture modules (eLecture-modules), electronic lecture notes (eLecture-notes), and electronic lecture slides (eLecture-slides). This paper discusses a number of issues relevant to publishing of eContent. The first section describes the advantages, as well as the disadvantages of such contents. It also elaborates on how eContent can be promoted through the use of Internet, WWW and SMS. Next, related issues on the usability of eContent on the Web are discussed. Four popular usability design guidelines are studied and critically reviewed. The final part concludes that although designing and publishing eContent is more complex than the printed version, eContent has a huge potential in education.

Keywords
Digital content, usability

Introduction

Electronic content (eContent) or digital content is defined by those involved in creating, providing and distributing information as the digitised content, which is viewed on screen and not on paper. Contents that are produced and stored electronically rather than in print are the result of electronic publishing (e-publishing). The contents can be in any of the following forms:

- any one information type (for example fully textual, only graphics content, or only audio content);
- multimedia or hypermedia (i.e. mixing more than two information type).

Each category according to Borchers (1999) can be used in education (e.g. textbooks, research reports, theses), as reference (e.g. dictionaries, encyclopaedias), leisure (e.g. novels, magazines, comics), browsing (e.g. newspapers) and advertisement (e.g. brochures).

eContents use in education can be from the usual electronic journals (eJournals), and electronic books (eBooks) to electronic research reports (eResearch-reports), electronic lecture modules (eLecture-modules), electronic lecture notes (eLecture-notes) and electronic lecture slides (eLecture-slides).

Upon deciding to produce eContent, authors should then select the file format from various alternatives. eContents are available in a wide range of formats, the simplest of which is plain ASCII-standard text. However, this format is extremely unappealing to read, cannot preserve formatting and cannot handle graphics. To solve these problems, the following formats can be used (Allen, 2000; Armstrong & Lonsdale, 1998; Hawkins, 2000):

- Adobe Acrobat’s Portable Document Format (PDF);
- Microsoft Reader’s Literature (LIT);
- Rich Text Format (RTF);
- Night Kitchen’s Tool Kit 3 (TK3);
- Markup Language (e.g. HyperText Markup Language - HTML, Standard Generalised Markup Language - SGML, eXtensible Markup Language - XML);
- Software for PDAs such as AportisDoc for Palm Pilots and Pocketbooks, Palm Reader and MobiReader for Palm Hand-held, Handspring Visor, and Window CE devices.
The most popular formats according to Hitchcock et al. (1997) are either HTML or PDF. Although their study is now rather dated, in general the findings still hold as throughout Norshuhada’s (2002) research, the dominant formats encountered in existing eContent are still the ones mentioned earlier. However, this may soon change as LIT format is becoming widely used.

This paper discusses a number of issues relevant to publishing of eContent. The first section describes the advantages, as well as the disadvantages of such contents. It will also elaborate on how eContent can be promoted through the technology of Internet and Web sites. Next, usability of eContent on the Web will be explored thoroughly. The final part concludes that although publishing eContent is more complex than the printed version, eContent has a huge potential in education.

Advantages of eContent in Higher Education

Many higher education (HE) institutions publish books, research reports, lecture modules, theses and other information for academic purposes. All these publications are usually in-print form and stored in the university’s library for fellow lecturers, researchers and students use.

Are there compelling reasons why these in-print publications should be in electronic form? To answer this it is necessary to identify the advantages and disadvantages of printed content (pContent) and eContent. According to Bonime and Pohlmann, (1998) eContents benefit from:

- hyperlinking - contents can be linked to other pages inside and outside the book;
- non-linearity - i.e. the order of access can be determined by users.
- addition of multimedia - i.e. content presentation is enhanced by mixing information type (i.e. sound, video and so on);
- data density - storage capacity is decreased while at the same time increasing portability;
- searching - the usefulness of the content is enhanced by the ability of the users to locate any piece of information, or to access any section instantly.

A comparison of paper book and electronic book features (see Table 1) provided by Bonime and Pohlmann (1998) and Rawlins (1991) can be used as a guideline when considering the possibility of converting printed information to eContent.

<table>
<thead>
<tr>
<th>Features</th>
<th>pContent</th>
<th>eContent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tactile</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Portable</td>
<td>Yes</td>
<td>Yes &amp; No</td>
</tr>
<tr>
<td>Access without devices</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Easy random access</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Multiple access at one time</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Customisable (font size, annotations etc.)</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Hyperlinks</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Text</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Pictures</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Audio</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Animation/video</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Instant search facility</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Easily and conveniently read</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Easily damaged (i.e. tear)</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Content updated easily</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Go out of print</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Highly interactive</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Good legibility</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Easily reproduced with the same quality</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

[*Random access in eContents requires less effort, thus probably is easier than pContents.*]
Students can take advantage of this new type of content presentation. Results of some studies suggest that involvement with computers through the use of eContents and other new technologies, can promote positive attitudes towards learning and higher achievement among learners (e.g. Ebersole, 1997; Causey, 1996; AlKahtani, 1998; Cakir, 1999; Govil, 1997; Espinosa & Chen, 2001; McCreary et al., 2001). Studies also show that computer-based learning tools lead to significant gains in learner’s performance in reading, mathematics, computer knowledge and grammar (Shields & Behram, 2000). Furthermore, computers and technology tend to have more positive effects than negative effects (Seniuk, 2001).

The existing academic publications in most HE institutions are in printed and bound forms which pose some disadvantages as outlined in Table 1. In addition, the publications have not been widely promoted and as a result their accessibilities have been very limited. Many researches and textbook publications by academics of the institutions, for example, have not been publicised properly and thus not noticed locally, and more importantly, internationally. These problems are easily tackled by producing eContents and distributing them through various strategies as discussed in the next section.

**Promoting and marketing eContents**

Promoting, publicising and marketing eContents are accomplished through electronic bookstores (eBookstores) such as Ecampus.com, Amazon.com, Barnes and Noble, Alibris, and McGraw Hill, electronic libraries (eLibraries) for instance eLibrary.com, Iowa State University library, and E-Library of Science of the University of New Mexico, company Web sites, personal Web sites and electronic shopping malls (eMalls) such as Walmart and Books on tape. These platforms are developed as a portal for eContent community, for the readers, authors, and publishers. In particular, eBookstores and eMalls provide a marketplace and alternative channel for authors and publishers to market and sell their publications online without heavy cost and risk, at the same time extending the reach to the mass readers globally.

Normally, the Website features of eBookstores, eLibraries and eMalls are powered by an exclusively advanced custom-built engine. All revenues are based on profit sharing basis. Royalty is paid based on each item sold. Authors will get certain percentage (for instance 40%-50% depending on the content) from the retail price as royalty. Transactions are usually made by credit cards with authentication being done in real-time (with secured industry standard SSL encryption). Each publication which has been bought is downloaded by the customer.

To meet the demands of today’s information user, customers want and expect extensive eBookstore/eMalls features such as in Table 2. These features are now available in most eBookstores.

<table>
<thead>
<tr>
<th>eBookstore/eMalls features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point-and-Click Browsing</td>
</tr>
<tr>
<td>Multi-Parameter Searching (configurable search criteria, quick search, advanced search)</td>
</tr>
<tr>
<td>Highly Relevant Search Results</td>
</tr>
<tr>
<td>Purchase Options</td>
</tr>
<tr>
<td>Flexible Account Types</td>
</tr>
<tr>
<td>Tracking (authors’ submissions)</td>
</tr>
<tr>
<td>Usage Analysis</td>
</tr>
<tr>
<td>Content Partitioning</td>
</tr>
<tr>
<td>Electronic Delivery</td>
</tr>
<tr>
<td>User Registration</td>
</tr>
<tr>
<td>Account Maintenance</td>
</tr>
<tr>
<td>Shopping Cart</td>
</tr>
<tr>
<td>Publication and Service Subscriptions</td>
</tr>
<tr>
<td>Archives</td>
</tr>
<tr>
<td>Trials and Promotions</td>
</tr>
<tr>
<td>Discounts</td>
</tr>
<tr>
<td>Multiple Payment Options</td>
</tr>
<tr>
<td>Electronic Receipts</td>
</tr>
<tr>
<td>Transaction History</td>
</tr>
<tr>
<td>Online Help</td>
</tr>
</tbody>
</table>
Accessing, marketing and delivering eContents through the Internet are emerging scenarios. A good example of an eBookstore that offers users with advanced features is McGraw Hill’s Primis Online system (www.mhhe.com/primis/online) (see Figures 1 and 2). One unique feature is that students can purchase books in several ways as described below, offering them greater flexibility:

- traditional printed text sold at bookstore;
- download file from eBookstore;
- view textbook online with proprietary eBook reader.

There is a huge potential in marketing eContents to students through the Internet and Web sites. Both parties (i.e. academics and students) can take advantage of this technology. For instance, academics could study new research area and promote their work easily. Students could get fast access to materials at cheaper cost.

To give an example, if lecturers were to market their lecture modules in electronic form, then “student-oriented” marketing strategies are required. Paying by credit cards is inappropriate, as students (especially the undergraduates in many Asian countries such as Malaysia) are not normally qualified to apply for the cards. Bank debit card also has yet to be introduced in this part of the world. May be the technology of wireless short message service (SMS) using mobile-phones could be utilised because the phones have been used extensively by the students. SMS is simple, inexpensive and widespread. Messages stating buying interests, which must be no longer than 160 alphanumeric characters and contain no images or graphics, are sent to an SMS centre (ADC, 1999). The SMS centre will then inform the HE institution and further actions will be taken (see Figure 3). This obviously requires further investigation and collaboration with the related corporations to decide on billing models and tariffs. We are currently working and researching in this area to market and provide eJournals, eBooks, eResearch-reports, eLecture-modules, eLecture-notes, and eLecture-slides to our students and community at large (Norshuhada et al., 2003).
You can take notes on any page for future reference.

You can bookmark any page that you want to return to for studying.

Reader Tools

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Figure 2. On-line reading features
Different formats of eContent require different design and publishing strategies. For example, contents which are in PDF and LIT are produced to imitate the traditional versions (i.e. to follow the structure and appearance of a printed book). Whereas for contents in HTML format, the design should be different from the pContent style. The issue of usability for eContents in HTML format in particular, has to be considered highly, and this is discussed in the next section.

**Usability of eContent on the Web**

Usability is a very broad concept in information system design. Generally, the word 'usability' suggests that it be related to how convenient, usable, and practicable an information system is for a user. According to Webster dictionary (1999), usability originates from the word ‘usable’ which means ‘capable of being used’ or ‘convenient and practicable for use’.

The Institute of Electrical and Electronics Engineers (IEEE, 1990) defines usability as the ease with which a user can learn to operate, prepare inputs for, and interpret outputs of a system or components. In agreement with that definition, Marcus (1999) states that usability can be defined in terms of how easy or efficient a product is for a user to recognise, learn, remember, use, and enjoy. Apart from its' broad concept, usability is also defined differently by different Human Computer Interaction (HCI) scholars. Shakerl (1991), Nielsen (1993), and Lu and Yeung (1998) define usability as an attribute to a product or system acceptance.

International Standard Organisation (ISO) 9241 part 11 also provides a good definition of usability and its dimension. With no reference made on other aspects or attributes of system acceptance, usability is defined as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use (ISO 9241-11, 1998)". From this definition, ISO 9241 suggests three aspects of usability as follows:

- **Effectiveness**: refers to the accuracy and completeness of users' tasks while using a system;
- **Efficiency**: refers to users' level of performance in completing the tasks, and;
Satisfaction: refers to users’ subjective perception of a system in terms of comfort and acceptability.

Although the approach towards defining the concept of usability is slightly different between each other, all models tend to have agreements on the dimensions of usability that cover aspects of effectiveness, efficiency, learnability, and user satisfaction.

One important issue with regards to usability definition is the question of whether content coverage of a system should be included as one of the elements of usability. Some people regard usability as an important area of systems' interface rather than the content, while others see content coverage as one of the aspects of systems' usability. Unfortunately, there is no clear explanation on this in the usability literature.

Nonetheless, most models of usability (e.g. Shakel, 1991; Nielsen, 1993; Lu & Yeung, 1998; ISO 9241-11, 1998) include 'user satisfaction' as one of the usability criteria. This element has indirect relationship with the need for content quality of a particular system. User satisfaction is related to users' subjective assessment on a particular system in terms of its ease-of-use as well as its usefulness. This is to say that users will be satisfied if a system is not only easy to be used but also useful in terms of its contents. From this, it can be said that both user interface and content together determine users' level of satisfaction.

Based on these arguments, it can be concluded that usability, one of the main attributes of systems' acceptability, is related to both systems' interface and content quality. Therefore, with respect to the discussion in this paper, we define the following:

- **Effectiveness** – relates to the accuracy and completeness of users’ tasks while accessing a particular eContent in WWW environment;
- **Efficiency** – relates to users’ level of performance while accessing a particular eContent in WWW environment;
- **Learnability** – relates to users’ ability to learn a particular system containing the eContent, and;
- **User Satisfaction** - refers to users' subjective assessment concerning how useful and easy to use is the eContent.

### Factors affecting Web usability

The concept of usability in terms of its definition, models, and scope has been discussed earlier. This section investigates the general factors that affect eContent usability by reviewing four major Web design guides as follows:

- **Web Design: The Complete Reference (Powell, 2000);**
- **Designing Web Usability: The Practice of Simplicity (Nielsen, 2000);**
- **IBM Web Design Guidelines (IBM, 2000), and;**
- **Improving Web Usability and Appeal: Microsoft Web Workshop (Keeker, 1997).**

The first two references were selected because both of the authors have a lot of experience in Web design and usability areas. Powell is the president and founder of PINT (www.pint.com), an instructor at the Computer Science department, University of California, and a recognised leader in Web design and development. He has been involved in more than 150 Web development projects throughout his career. Meanwhile, Nielsen's popularity in Web usability field is widely known. He is considered one of the usability gurus due to his massive experience in many usability projects. Both Powell and Nielsen have been actively participating in conferences, seminars, and workshops, and writing many books in computer related areas. The books used in this review are the most recent ones written by them. The other two references were selected because they are published by two leading companies in computer industries and Internet technology - IBM and Microsoft Corporation.

According to Powell, there are at least six factors affecting usability – site structure, navigation, linking, screen appearance, interactivity and local searching (Powell, 2000). Powell classifies site structure into two – logical structure and physical structure. Logical structure relates to the way in which documents are linked within a site. While physical structure describes the physical location of files within a site. Powell states that logical structure is more important in the usability aspect because it affects the way users navigate the content.

He also considers navigation as an important factor for usability. Good navigation helps users find their way within the content. It provides users with answers to questions such as:  
Q1: Where am I?  
Q2: Where should I go next?
Q3: Where have I been?

Navigation aids such as precise URL location, page label, and page title are Web elements that could provide answer to Q1. On the other hand, Q2 and Q3 relates to the question of whether users are informed of their whereabouts at all time and whether they know how to get back to the previous location. Web elements such as coloured links, history, and home link are examples of navigational aids for Q2 and Q3. Equally important is proper placement of navigational aids on the screen. According to Powell, there is no specific location for navigation elements but usually designers would place them on the top, left or right of pages depending on their creativities. In addition, he also emphasises the need for consistency in the use of navigational aids to avoid confusion on behalf of users.

Efficient page linking is a key to eContent usability. It not only affects the content structure, but could also determine whether users accomplish their goals. Page linking is created normally through text links, buttons, icons, and graphics. Screen appearance is another factor that needs to be considered. Powell outlines five major areas that are related to this factor - page layout, text, colours, image and background. Proper page layout concerns with elements such as page size, resolution, page type, header and footer. Besides page layout, designers also need to use text effectively in terms, for example, fonts, alignment, spacing, headings and sub headings, paragraph, and effects. Finally, effective use of colour and images is also said to have an effect on usability.

Equally important is the interactivity element such as user control, feedback, and dialogue. Additionally, providing local search could also be a factor to make a site usable. Powell's theoretical concept on factors affecting web usability is visualised in Figure 4.

![Usability factors](image)

**Figure 4**: Powell's factors of Web usability

Unlike Powell, Nielsen (2000) describes Web usability in terms of page and content design. He emphasises the need for providing Web pages that can be assessed by different screen sizes and resolution. This argument is based on the fact that users get access to the Internet from different devices that have different screen types such as personal computers, hand-held computers, hand phones, and digital television. Based on years of researches in usability areas, he also concludes that users prefer pages that can load quickly (Nielsen, 2000). In other words, designers should design for speed of pages downloading to improve usability. Nielsen also sees effective use of linking between pages as a contributory factor towards usability. Proper linking would help users find information within the eContent. On the other hand, broken and inaccurate linking might force them to turn away from a particular content.

Apart from page design, Nielsen also emphasises on content design. He strongly believes that users prefer to scan for information before reading it. Hence, he recommends using short text, skimming features such as bold, italic and highlighted words, and page chunking. In term of language, he suggests using simple and plain language to accommodate different type of users' educational background.

Unlike Powell, Nielsen outlines the importance of proper integration of multimedia elements into pages. Despite the fact that multimedia elements such as video and animation could enhance presentation, they should be used properly so as not to affect usability. Additionally, unnecessary media should be avoided to prevent long downloading time. Nielsen's view on factors that affect usability is depicted in Figure 5.
Figure 5: Nielsen's factors of Web usability

IBM Web design guidelines focus on five major factors. Three of which are Web structure, navigation and visual layout that have been described by Powell (Powell, 2000). The two other factors are proper use of text and effective use of media, which are related to content design as discussed in detail by Nielsen (2000).

IBM guidelines suggest designers to use structure that is suitable for the type of information being presented (IBM, 2000). The information needs to be organised in such a way that it makes sense to the users. Good navigation is also considered very important because it helps users moving around the site easily. Several tips are given to promote good navigation system such as using clear labels for links, providing feedback to users, and the use of ALT tag for images. The guidelines also suggest several ways for designing good visual layout.

Like Nielsen, IBM guidelines also remind designers to consider users' different use of technology to access the Internet. Hence, designers should anticipate users' different screen resolution settings and sizes of their monitors. There are also other elements of visual layout that are not discussed by Powell and Nielsen, for example, the need to avoid long scrolling and horizontal scrolling. One of the most important aspects of visual layout that is not discussed clearly by either Powell or Nielsen is the consistency of visual identity throughout one's Web site.

IBM guidelines also present information on how to use text on the Web. Most of it is explained by Nielsen (2000) that focuses on elements that improve scannability and readability. However, there are a few areas that are not mentioned by Nielsen, for instance, the need to design for default browser fonts. Although Nielsen proposes to use media effectively, he does not provide clear guidelines on how it can be implemented. IBM guidelines however outline clearly how media elements should be used to enhance usability. Some examples are as follows:

- Provide user control;
- Inform users of the content and size of media objects;
- Use animations to attract attention, and;
- Use animations to enhance explanation.

One important aspect of Web usability that has been described by all the three guidelines is accessibility. The word 'accessibility' in this context does not refer to aspects of Web pages that provide access specifically to the less privilege users but to different technology used by users to access the Internet. Cross platform design, speed of access, and proper use of text are examples of this.

Microsoft also provides Web design guidelines to the public by presenting its research on Web site usability and appeal. Despite some similarities in terms of the usability factors compared to the previous guidelines, there are also some significant differences that are worth mentioning. One of the main focuses of Microsoft guidelines is content quality (Keeker, 1997). Based on its research, it was found that content quality significantly determines the usability of Web sites. Contents that are provided should be relevant and timely. All media elements especially animations should be used effectively and attractively. In addition, designers should ensure that they employ appropriate depth and breadth. By this, it means that links (number of clicks) to particular information
from the main page should not be too many and any information presented in a particular page should not be too long.

![Usability factors]

**Figure 6**: IBM's factors of Web usability

Unlike the other three guidelines discussed earlier, the Microsoft guidelines claim that designing for emotional response could also contribute towards usability. This means that a Web site should always be exciting and enjoyable whenever they are being visited including the regular visitors. One example of the elements of emotional response is the contents that are challenging. Nonetheless, this factor might not be applicable to all Web sites especially those that provide static information.

Besides content quality and emotional response, the guidelines also explain about Web structure. Microsoft believes that having simple and clear structure would improve users' navigation within a Web site. The word 'structure' used in this document is slightly different with Powell and IBM guidelines. While the former refers 'structure' to the logical structure of HTML documents within a Web site, the later refers it to the way information and navigational aids are presented on the screen. In other words, the structure here is more related to the visual appearance of a Web site. As a result, most of the checklist items provided under this category are associated with navigational issues such as the use of labels for navigation buttons, positioning of navigation bar, and avoidance of menu scrolling. Microsoft also suggests developers to provide feedback to users such as page titles, download warnings and reminders to avoid uncertainty on behalf of the users. The summary of the Microsoft usability guidelines is depicted in Figure 7.

![Usability factors]

**Figure 7**: Microsoft's factors of Web usability
Based on the analysis of the four guides, it can be concluded that, there are at least seven general factors of usability which, for the purpose of this paper, are called the SCANMIC factors (Hassan & Li, 2001). Each of these is described below:

- **Screen Layout or Appearance**
  Content should be structured and designed in such a way that users will find information easily and effectively.

- **Consistency**
  Consistency in design is vital in determining users' familiarity in terms of for example, navigation icons, colouring scheme, and page structure.

- **Accessibility**
  Having good design and useful content are inadequate without considering the accessibility factors. This means that designers should take into consideration of whether their information are accessible to all target users who use different technology to access the Internet.

- **Navigation**
  Good navigation will help users find information easily and quickly especially for large amount of information.

- **Media Use**
  The use of multimedia elements could enhance information presentation if used properly and effectively.

- **Interactivity**
  Visitors should be provided with interactivity elements such as giving response, feedback, and searching for information.

- **Content**
  Content provided should be useful, relevant, and up-to-date.

We have shown that publishing and accessing eContents through the Web involved special consideration on usability issues. Many issues have to be considered during authoring process as summarised in the SCANMIC factors. By suggesting to use the SCANMIC paradigm as a guide during the initial design of eContent for education we are in line with the findings of a previous research we did about usability of e-resources for teaching and learning in HE with a project called EBO NI (Wilson at al, 2003). EBO NI has produced a very detailed list of guidelines for the production of good resources that can be used by designers both in order to inform the design process and to set up the evaluation of the final system. We believe that the production of eContent is such a crucial process to require as much guidance as possible. Bad design can really alienate users and give eContent a bad name, and for this reason we have been paying all this attention to existing paradigms and come up with what we believe sums up all the essential components. Designers work under pressure and need effective and easy to use guidelines to support them during the various stages of development.

Thus while pContent has naturally evolved, over centuries of use, in the present formats where authors and publishers have been following well known paradigms for designing layout and appearance, in order to maximise readers’ satisfaction. eContent has still to undergo a process of trial and errors where designers, authors and readers will have to validate a number of possible forms of presentation. The SCANMIC paradigm is a starting point and we believe will provide a step further toward users’ satisfaction.

**Conclusion**

eContent use in education benefits from hyperlinking, non-linearity, addition of multimedia, portability, customisation and automatic searching.

All the above advantages have huge potential in increasing the satisfaction of students, as well as academics. As many HE institutions are introducing electronic learning (e-learning) environment through the Web to their students, it is essential that we investigate issues concerning the presentation, appearance, navigation and accessibility of eContents. Other relevant issues are marketing strategies of eContents and features of eBookstores, for the sole purpose of satisfying the authors and readers.

We believe that eContent can help promote academics work worldwide, assist students to immediate access to lecture notes, modules, and textbooks, and be designed to equally satisfy authors and readers. We also believe that in order to achieve these quite ambitious goals, good design is crucial and for this reason we have proposed the SCANMIC paradigm to help designers producing successful eContent.
References


Guidelines for the Development of Computer-based Instruction Modules for Science and Engineering

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Abstract
The design and development of a prototype computer-based instruction (CBI) module is described. The module covers introductory structural analysis techniques and demonstrates the practicality of CBI for undergraduate engineering education. The module’s generic learning objectives are used to develop a set of guiding principles for CBI development. Choice of authoring software and the module architecture are presented, followed by the details of the user interface, logic, and screen layout. The module design and software development process outlined here are easily extended to computer-based tutorials that present problem solving methods for engineering, mathematics, and the natural sciences.

Keywords
CBI, Learning object, Engineering education, Statics, Structures, Structural analysis, Strength of materials, Problem-solving, Macromedia Authorware

Introduction
Computer based instruction (CBI) is increasingly used in science, mathematics, and engineering education, and the reported benefits include higher learner interest, increased participation in coursework and improved outcomes (e.g., Croft et al. 2001; Edwards et al. 2001). CBI is generally most effective when used as a supplement to, rather than a replacement for, traditional engineering and mathematics education (Croft et al. 2001; Hummer et al. 1996), and there is certainly increased interest in using CBI in this fashion. As an integrated curricular component, CBI can be used in nearly any stage of the instructional process, including concept introduction and explanation, individual tutorial practice, and testing. For example, Holzer et al. (2000) reported using multimedia-rich CBI as a component of an engineering workshop learning environment, and students and teachers both reported favorably on the learning experience and educational outcomes.

In view of the above, the goal of the present work was to develop a CBI module that incorporated emerging “best practices” for module development that could also be used as a prototype for other modules in engineering, science and mathematics. That is, within the scientific literature, there appears to be a general consensus on those attributes that successful CBI modules should contain, i.e., modules that are received favorably by students and which result in a demonstrated higher level of learning. Our aim was to document these, incorporate them into a specific module and, in so doing, develop a generic architecture that could readily be reproduced in other content areas. Engineering statics, which is the study of rigid bodies at rest, and which is primarily concerned with the determination of the force distribution within bodies (structures) subjected to various external forces and constraints, was chosen as the initial focus area. Statics is perhaps an ideal application for CBI. Statics courses are taken by engineering students in a wide variety of disciplines and form the basis for many higher-level engineering subjects. Further, understanding statics is problematic for a reasonably large percentage of students.
Due to the level of demand, class sizes are typically quite large, thereby making high levels of student-instructor interaction outside of the classroom quite difficult. A quality CBI module focusing on statics therefore would have the potential of significantly improving outcomes for a high percentage of engineering undergraduates, not only in their statics courses, but in a variety of upper division courses that rely on this material. Also, a significant portion of statics education involves the learning of a specific problem solving methodology and then applying this method to a variety of generic applications. Thus, the subject matter is well suited for CBI, yet there are relatively few statics CBI modules reported in the literature. This is perhaps in part due to the fact that a commonly used introductory statics textbook is packaged with an interactive computer program for students to practice their problem solving skills (Beer & Johnston, 1997). However, although this program is quite good, it serves only as a database of problems; it does not review the concepts required to complete the practice problems, nor does it contain related and important reference information. There are other statics or statics-related CBI modules that have been reported (e.g. Holzer et al. 2000; Negahban 2000; Rais-Rohani 2001; Rojiani et al. 2000), but these demonstrate specific theory rather than emphasizing the problem solving methodology that was our focus. Based on our perception of the need for supplemental CBI in the area of engineering statics and our limited findings of existing modules that addressed this, it appeared that this subject provided an ideal pilot project for our work. We expect to subsequently expand this module to include more advanced topics in structural analysis, and for this reason the name “Structural Analysis Review and Tutorial” (START) has been chosen. The current module is a prototype, both in the local sense that it only covers a portion of the field of structural analysis, as well as in the more global sense that developers of learning modules in other areas of engineering, science and/or mathematics may readily adopt its architecture.

In what follows, the design of the START module is first described in a manner that makes the approach readily applicable to a wide variety of content areas. To this end, the module’s generic learning objectives are used to develop a set of “guiding principles.” These are extracted from the literature and may also be used to guide the development of other modules that focus on teaching problem solving methods. Next, the first level of development is described, which includes choice of authoring software, content and architecture. Finally, the details of the user interface, logic, and screen layout are presented, followed by a discussion of the practical issues surrounding implementation and assessment.

Learning Objectives and Guiding Principles

The first step in module design is to define the learning objectives; these objectives should then drive the design of the final application. In this case, the goals for the module are for users to learn the general method for obtaining reaction forces on a statically determinant rigid body subjected to a set of known loads and boundary constraints, and then to demonstrate the ability to apply this knowledge in a variety of applications. Fundamentally, these goals are that users learn, practice and retain a specific skill set. Kristof & Satran (1995) indicate that realization of these goals is best accomplished through simple, clear presentation of content that provides remediation when deemed necessary by the user. Maintaining user orientation with a cohesive screen design is key to providing this straightforward content presentation. This is accomplished, in part, by a screen design that brings new content to a user’s current screen, instead of sending the user to a new content screen (Kristof & Satran, 1995). In addition, a graphically embellished screen design should be avoided, i.e., one with excessive use of loud or contrasting colors, patterned backgrounds, and/or animated features, as this distracts the learner from both the content and the learning goals. As pointed out by Tufte (1990), such a design places the emphasis on the data container rather than the data. In extreme cases, such a design can even discourage the learner from using the module.

Balanced against the goal of a straightforward design is the goal of maintaining user interest. While the design should avoid distracting users from the content, it must at the same time interest users enough to keep them focused. One way to keep users engaged is to make them an active part of the learning process rather than passive recipients (Schank, 1993). Thus, a successful CBI module must have a high level of interactivity in order to maintain user interest and therefore successfully achieve its learning goals. The user’s main interaction and learning control lies in his or her ability to navigate the content. Navigation must provide direct access, with a minimal number of steps between content, yet at the same time not overwhelm users with an excessive number of navigation options. Kristof and Satran (1995) suggest two design rules that should be used for each content link created. The first of these applies to cases where the link sends a user to a different location, in which case navigational controls must be provided so that the user can return to their original position without getting lost. The second rule states that if the link brings in additional content material to the current location, then that content must be designed to fit within the current location.
To maintain a high level of interactivity, an intuitive interface is necessary. Otherwise, users will be distracted from the subject matter content by spending time learning how to interact with the module. In addition, it has been shown that CBI modules can reach a wide range of learners at varying ability levels by allowing users to customize their learning experience. CBI should therefore provide an interactive interface that balances program control, in which users follow dictated learning sequences, and learner control, in which users select both the path and the pace through the material using self perception of their needs (Lin & Hsieh, 2001). If users are given complete control without guidance, then a novice user may become lost in the material. Conversely, if experienced users are forced to review material which they deem too easy or irrelevant, they are likely to avoid using the module. Thus, learner control and software pacing must be carefully balanced to maintain the interest of both novice and experienced users. Hannafin (1984) performed a review of the above issues and concluded with the following set of criteria for successful implementation of learner control: the audience must be older (success was reported with college-age students) and generally familiar with the content, the educational goals should be those of teaching a skill set, not imparting factual information, and advice must be provided to assist users in making decisions about the path and pace of instructions. Finally, like any other design process, CBI development requires an iterative approach. After a module is developed, feedback from both professionals and end-users must be solicited so that appropriate revisions can be made. Once a module has been implemented, continual assessment is necessary, which allows for the quality of both the content and the presentation to be increased. Table 1 summarizes the issues described above and provides a set of “guiding principles” for module design.

**Table 1. Summary of guiding principles for module design**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goal for Users</td>
<td>Teach a skill set</td>
</tr>
<tr>
<td>Presentation</td>
<td>Simple, clear, straightforward without the use of loud colors or patterns; consistent screen design that brings new content into the current screen</td>
</tr>
<tr>
<td>Architecture</td>
<td>Default path for novices, high degree of learner control for advanced users</td>
</tr>
<tr>
<td>Navigation</td>
<td>Controls so that user can return to original position; direct access to all content</td>
</tr>
<tr>
<td>Interface</td>
<td>Intuitive; high level of interactivity</td>
</tr>
<tr>
<td>Design Method</td>
<td>Iterative; solicit feedback from both professionals and end-users</td>
</tr>
</tbody>
</table>

**Authoring Software, Content, and Architecture**

With the module’s learning objectives and guiding design principles defined, Macromedia Authorware 6 was selected as the authoring software. Authorware allows a designer to create stand-alone media-rich executables that accept user input, provide feedback based on this input, and foster total user control through the use of hyperlinked screens. In addition, user data and progress can be stored for later retrieval. Authorware executables can be delivered via the World Wide Web, a local area network, or CD-ROM. One of the most powerful features of Authorware is the easy access to the underlying program structure afforded to future designers and other members of a design team. Any designer familiar with the software can view the flowchart that was used to create a module. This is in sharp contrast with the lines of code that must be considered when using a low-level programming language. Also, as a result of the uniform data structures provided by this flowchart-authoring environment, Authorware readily allows integrating of components from different applications. Thus, members of a design team can work on components and integrate them seamlessly. These aspects of Authorware will allow future designers to use the architecture of START as a baseline template to create modules in other content areas.

Once Macromedia Authorware 6 was selected as the authoring software, the START module’s statics content was organized for delivery. START reviews introductory structural analysis, illustrates the method for analyzing problems, and provides a series of practice exercises that gradually increase in complexity. START is not intended as the only educational medium on these introductory engineering topics, but rather is envisioned as an integrated component of a “typical” statics class that meets for lecture and perhaps recitation (problem solving sessions). The analytical method taught in START is described in Table 2. It is applicable to all statically determinant bodies at rest, and represents the building block for all advanced structural mechanics analyses to which students will be exposed.
Table 2. Analytical method taught in START

<table>
<thead>
<tr>
<th>Step No.</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Resolve external forces into vector components</td>
</tr>
<tr>
<td>2</td>
<td>Set up a free-body diagram (F.B.D.) of the body to be analyzed</td>
</tr>
<tr>
<td>3</td>
<td>Set up the equations of equilibrium for the body</td>
</tr>
<tr>
<td>4</td>
<td>Solve the equilibrium equations for the unknown reaction forces</td>
</tr>
</tbody>
</table>

The next step was to develop the module architecture, which is shown in flowchart format in Figure 1. By determining a cohesive top-level architecture, the design and formatting of individual screens is a natural progression within that structure. The top-level architecture is defined by the general organization of information within the module, and the navigation between different blocks (or chapters) of the module. The “default path” through the module is the horizontal path through the four blocks along the top of this figure. Users do not have to follow this path, but for those that do, the progression is the introductory block, particle vector mechanics, equilibrium of a rigid body, and structural equilibrium & other advanced applications. The introductory block serves to introduce the entire module, and successive blocks introduce analysis methods for problem classifications of increasing complexity. Each block that follows the introductory block has its own introductory screen that describes its content and learning goals. Each of these blocks then presents content-specific information, e.g., the problem solving methodology and associated background material and definitions, followed by an example problem. Users then navigate through a series of practice problems. There is also a default path for practice problems associated with any particular block, which presents that series of problems in order of ascending complexity. In this manner, the learner is allowed to master a method for solving problems, rather than simply memorizing the module’s content. In many respects, the architecture of the module parallels chapters in a typical statics textbook, and for this reason should fit in readily with the preconceived notions of its users; this aids in providing an intuitive navigational framework. However, unlike a textbook, there is the ability for a user to tailor his experience to his own needs and learning style, as well as to obtain immediate feedback regarding his mastery of the subject matter. Additional details on the blocks and the way in which they adhere to the guiding design principles are provided below.

![Figure 1. START system architecture](image)

The introductory screen (Block I) describes the overall goals of the module to the user, provides a brief description of the module architecture so that the user knows what to expect when navigating through START, and defines materials that the learner may want to have on hand before starting (scratch paper, a calculator and a reference textbook). In keeping with the guiding principles, the introductory screen is straightforward with the minimum required amount of text. This screen is perhaps of critical importance to a successful module: if the introductory screen is too complex, users may choose to skip it, missing important information about the module, or perhaps dismiss the module in its entirety.

Forces on a particle are the simplest form of structural analysis: by definition, all forces act through the same point in space and no moments are introduced. These types of analytical problems are solved using only particle vector mechanics, i.e., Step 1 of Table 2, and START’s second block therefore covers this topic. In Block II’s introductory section, the concept of a vector is reviewed, and the principles and procedures for resolving the numerous external forces that may act on a body into a single vector are presented.
The third block of START introduces the mechanics of rigid bodies. Here, external forces no longer act through the same point; moments may therefore exist in the body, and all four steps of Table 2 are required for the problem’s solution. Only beam-type bodies are considered in this block. Beams are chosen as they allow the basic method to be conveyed without unnecessary geometric complexity. In addition, beams are a commonly occurring engineering structure, and beam theory is often used for problems as diverse as a construction I-beams, an aircraft wing or a bridge deck; as such, most engineering students see beam problems repeatedly throughout their education. This block first introduces the concept of static equilibrium due to forces only. This is followed by the definition of a moment, a review of the calculation of the magnitude and direction of a moment due to an outside force, and the addition of the moment equilibrium equation. Standard boundary support conditions for beams and their meanings are also introduced. As in the other blocks, an example problem and a set of practice problems of increasing difficulty are then provided.

The fourth and final block introduces distributed loads as well as bodies of more complex shapes than the beams used in Block III. The local architecture of this block is identical to the previous two: an introduction, a description of the necessary analytical methods, an example problem, and practice problems of increasing difficulty.

As indicated by the lowest row of encapsulated text in Figure 1, the default path through START is also supplemented with pop-up reference screens. This material constitutes an unnecessary review for many advanced users, but inexperienced users may require supporting information. These windows, which “pop-up” from the main content screen when a user selects the corresponding navigation button, consist of screens that list the START objectives, describe the unit systems used in START (SI and US customary), include a table of standard boundary condition notations, provide a multimedia glossary of terms for structural analysis, and provide general instructions on module interface usage and providing feedback to the module administrator. Figure 2 provides a typical reference screen; it illustrates the forces that exist at two standard beam supports used within START.

**User Interface Design**

Learners interface with the START module through a variety of buttons that control navigation, hints, and pop-up screens, as well as by typing numerical answers in response to practice problems. With respect to this latter mechanism, users are expected to perform numerical calculations outside the START executable; most students are proficient at performing calculations on their personal calculators, so there was no desire to force them to adhere to a new calculation method within START. Once answers are calculated, users type their results into a text box located immediately below the problem statement. The standard requested input for START is the magnitude of a single force, although a variety of other input options can be utilized with Authorware.

![Figure 2. Structural boundary condition notation screen](image)
The logic governing START’s evaluation of user input is presented in Figure 3. This is perhaps best understood with the aid of Figure 4, which shows a typical problem presentation where the final solution has been displayed. When any problem is first presented, only the uppermost diagram, the problem statement below it, and “hint buttons” are displayed. This all represents the “Begin” ellipse and “Request Input” rectangle within Figure 3. At this point, users can enter a numerical answer, press a hint button, or press a navigational control button along the left hand panel. Upon receiving any input, the first determination made by START logical scripts is whether the type of input is a button press or if numerical data has been entered. In this latter case, answers are determined to be correct if they fall within a designer-specified accuracy. This is intended to account for errors produced by unit conversions and/or round-off during the solution phase, with a default of ±1% of the correct answer. A random number generator is used to select a positive feedback phrase from five possible phrases for those answers that are found to be correct. The feedback phrase and the answer are then displayed, which allows a user to see how close his or her input came to the correct result.

If the input is not within the acceptable range, the evaluation script generates the phrase “Not quite.” The computer then suggests that the learner may want to use the answer hint system, which is presented as a series of hint buttons on the screen. Hint options include seeing a free body diagram, the equilibrium equations, or the final answer. That is, hints are arranged hierarchically according to the analytical method that is taught and which is displayed in Table 2. The hint buttons appear directly below the problem statement. If the “Show FBD” button is pressed, then the free body diagram below the hint buttons appears. If the “Show Equilibrium Equations” button is pressed, then these appear below the FBD. The “Show Solution” button will cause the solution at the bottom of the screen to be displayed. Figure 4 illustrates the problem presentation when the final level hint button (“Show Solution”) has been pressed. Once this third tier of the answer hint system has been initiated, a user no longer has the option of entering answers into the input box. In Figure 4, one can see that the buttons and input box have been shaded grey, to indicate that they are no longer available. When the final answer has been presented, the user interactions on the screen are frozen to allow only navigational control. However, since the goal of this module is to build proficiency in a skill set, not to test user expertise, the user is under no requirement to use these hints, and may make an unlimited number of solution attempts until he or she obtains the correct answer or is no longer interested. A user may also navigate to the next problem regardless of whether a correct answer for the exercise has been accepted. This allows the requisite user control to approach the material in accordance with their own personal learning style, pre-existing knowledge, and learning goals.
In addition to accessing hints, learners use a variety of other buttons to navigate and access content. This makes the experience inherently interactive; to produce an intuitive interface (Table 1), it is common to associate screen icons with physical objects that are familiar to users. For example, most word processor users recognize that the floppy disk icon will save their document and the icon depicting a printer will print it. The task of associating icons that are intuitively obvious to users becomes more difficult, however, for tasks that are more mental than physical. The START interface icons were chosen to be as intuitive as possible, but for some tasks there was no choice that would readily be apparent to all users. Thus, all icons are also labeled so that users are not required to memorize which icon depicts each pop-up feature. All interface icons appear in the left side navigation panel of each screen. As shown in Figure 4, readily associable objects are used for certain tasks, such as a magnifying glass to represent the “Find” option, and book-shaped icons and geometric designs are used for other tasks for which no obvious physical objects could be associated. Referring to Figure 4, the Objectives icon brings a pop-up window to the user’s screen which contains a brief list of the module objectives. The Menu icon brings up a hyperlinked hierarchical menu window, through which the user can navigate to any screen of the START module. The availability of the menu screen balances learner control with the program control provided by the default path. When learner and program control are balanced, the user is neither a passive recipient of the content, nor required to make complex decisions about the order of presentation of material he or she has not yet mastered. As described in the section on guiding principles, the combination of a default path with a high degree of learner control is essential to maintaining user interest. Also available is the Formulae icon, which initiates a pop-up window of common engineering formulas that might aid the user in completing the module. If the user presses the Glossary button, an interactive hyper-linked glossary is available in a pop-up window. Similarly, pressing the Find icon initiates an interactive search feature for the module. Finally, the Bookmark icon, when pressed, brings up a virtual bookmark system in which the user can mark screens and navigate to previously marked screens.

Figure 4. Typical START problem presentation
Presentation Design

The final step in module development consisted of presentation design, which included the choice of the screen template used for the relative size and position of all the screen components, screen aesthetics such as font and resolution, and the multimedia components integrated into the module. All of the presentation design steps were completed in light of the principles presented in Table 1. For example, in order to give the impression that the various links cause new content to be brought into the current page, every screen of the module displays identical anchor components. With reference to Figure 4, these anchors include the panels containing the left side icons, the START name and block name on top, and the page number. Equally important to achieving this perception, the content area is always the same size, positioned as shown in Figure 4 in relation to the anchor components. Each screen devotes precisely the same area to each logical portion of the presentation, from the problem statement and diagram, to the textual input box, to the space for displaying the various hint options.

The color palette chosen for START is relatively small and was chosen for accurate reproducibility within the widest possible variety of computer color display settings. The screen-to-screen color selection is consistent, allowing users to instantly recognize the components of each exercise. Yellow and red texts are used against the dark background provided by the anchor panels. Content is presented in dark colors, ranging from black to red, with a white background area for maximum contrast. Different font colors are used to differentiate the various textual components of START, such as problem descriptions, numerical equations, and problem answers. For all drawings, dark blue is used for the body under consideration, red for the arrows indicating external forces, and black for dimensions and other geometric notations. There is also an intentional minimal use of multimedia. This keeps the presentation uncluttered and streamlined, avoids distracting users from the technical content, and reduces the overall storage size of the module.

Implementation and Assessment

Initial feedback from selected users of the START module has been quite positive. After the module is introduced to engineering students, instructors with a knowledge of the Authorware program will be able to further customize and increase the number of problems presented in the START module. The longer the lifetime of the software, the more extensive the problem database will be. However, prior to a more widespread introduction, we wish to complete the development of the module’s assessment and evaluation tools and associated metrics, as well as to determine and design into the module the way in which tracking data is to be used as part of the assessment process. That is, in addition to solicited and unsolicited user feedback, the module can record such information as the frequency and duration of logins, screens viewed, student responses, time spent per exercise, or the number of answer attempts made per exercise. The challenge is to combine all of the information into a quantitative measure of the module’s effectiveness to establish, for example, whether (1) students access, and report favorably on, the resource, (2) students report that the resource is enriching, and (3) educators report that the resource promotes a higher level of learning (Soon et al. 2001). We are currently working to develop an initial version of this, and plan to shortly introduce the module in a limited fashion to assess both the module and the evaluation tools.

Conclusions

A number of guiding principles were extracted from the relevant literature and used to develop what are believed to represent a set of best practices for developing CBI that will generate positive learning outcomes. START, the computer-based instruction module designed using this approach, achieves the design goals and provides a clear, simple, and straightforward user interface, imparts the appropriate balance between learner and program control, and offers a high level of interactivity. In addition to developing assessment and evaluation tools, future work on this module will include expansion of the content to more advanced structural analysis techniques. It is envisioned that this process will both improve the specific content and efficacy of this module, as well as help to develop generic approaches for the development of highly effective computer-based instruction modules in a variety of problem solving applications.
Acknowledgements

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References


Experiences with Learning Management Systems in 113 European Institutions

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Abstract

This article presents the major findings from six regional analyses conducted within the framework of the European Web-edu project (http://www.nettskolen.com/in english/webedusite/index.html). It analyses the experiences of European institutions with the Learning Management Systems that they have purchased or developed themselves. Data was collected from in-depth interviews with 113 European experts, usually the systems managers in the institutions, in 17 countries. The analyses of the interviews revealed as many as 52 different commercial and 35 self-developed LMS systems. The article presents the data from these interviews and includes a series of important findings from the study. One conclusion is that there is a host of commercial and self-developed systems that seem to work satisfactorily in various educational institutions throughout Europe. The systems are not able to handle all the functions the institutions want, and they can be improved in many ways. But most systems encountered in the analyses seem to be good enough for handling online education successfully. Another conclusion is that the European market is not dominated by the American LMS systems. In countries that do not use English as the first language, locally developed LMS systems have successfully ousted the American products. Remarkably, a large number of the LMS systems used in Europe are commercial systems developed locally, or self-developed systems built by the institutions.

Keywords

Learning management system (LMS), Virtual learning environment (VLE), Online education, E-learning, Web education, Europe

Introduction

Evidence of the worldwide spread of e-learning in recent years is easy to obtain. In April 2003, no fewer than 66,000 fully online courses and 1,200 complete online programs were listed on the TeleCampus portal from TeleEducation, New Brunswick, Canada (http://courses.telecampus.edu). It is also interesting to observe that 4,500 of the courses were listed as free. The portal includes information about a very broad range of courses with URLs for each course, making it easy for prospective students to study course summaries with a view to enrolling. In spite of the comprehensiveness of the TeleEducation database, up till now about 90% of the listed courses have been from the United States and Canada. Even though the courses represent 17 different languages, it is unlikely that the portal lists many of the courses provided by the 113 European institutions studied in this report.

Much of the success of e-learning can be attributed to the availability of Learning Management Systems (LMS), also known as Virtual Learning Environments (VLE) or learning platforms. An LMS enables an institution to develop electronic learning materials for students, to offer these courses electronically to students, to test and evaluate the students electronically, and to generate electronically student databases in which student results and progress can be charted.

Hall (2003) defines an LMS as: "software that automates the administration of training events. All Learning Management Systems manage the log-in of registered users, manage course catalogs, record data from learners, and provide reports to management.” The definitions of LMS systems and related terms encountered in this article are further discussed in the article Online Education: Discussion and Definition of Terms (Paulsen, 2002).

The focus of the Web-edu project is on the satisfaction, or lack of satisfaction, that European institutions have with the LMS systems that they have purchased or developed themselves. This is a timely analysis because in the English-speaking world the major American LMS providers dominate the e-learning industry. This is in spite of the fact that a number of these originated in Europe. WebCT, was developed by Murray Goldberg at the...
University of British Columbia in Vancouver, Canada and then sold to an American company in Pennsylvania. TopClass originated as a European project at University College Dublin, in Ireland, before becoming an Irish campus company and then migrating to the United States.

A number of important themes emerged during the analyses. These are especially discussed in the following:

- Internet penetration and use of LMS systems
- Large-scale providers of online education
- Commercial LMS systems
- Regional preferences and market leaders
- Competitive issues
- Self-developed systems
- E-learning standards
- Course creation tools
- Student and tutor support tools
- Administrative
- Technology
- Economy issues

**Interviews and Regional Analyses**

This article represents a meta-analysis of six regional analyses conducted within the framework of the European Web-edu project. The regional analyses are listed in Table 1 and published at the project web site (http://www.nettskolen.com/in_english/webedusite/index.html). They are also available in printed English (Paulsen, 2002) and Portuguese (Keegan et al., 2002) versions.

<table>
<thead>
<tr>
<th>Regions</th>
<th>References to regional analyses</th>
<th>Number of institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northwestern Europe</td>
<td>Keegan (2002)</td>
<td>18</td>
</tr>
<tr>
<td>The Nordic Countries</td>
<td>Paulsen (2002)</td>
<td>20</td>
</tr>
<tr>
<td>Norwegian Universities and Colleges</td>
<td>Runnestø and Ristesund (2002)</td>
<td>24</td>
</tr>
<tr>
<td>Germany</td>
<td>Fritsch and Föllmer (2002)</td>
<td>17</td>
</tr>
<tr>
<td>Southern Europe</td>
<td>Dias, Dias, and Pimenta (2002)</td>
<td>20</td>
</tr>
<tr>
<td>The Czech Republic and Slovakia</td>
<td>Mičincová (2002)</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>113</td>
</tr>
</tbody>
</table>

All regional analyses are based on in-depth interviews with systems managers or systems experts at the user institutions. The interviews were conducted in the Fall of 2001 and Spring of 2002 as face-to-face meetings, telephone interviews, or e-mail interviews. All interviews were based on a common interview guide, and many of them are available at the project’s web site.

The researchers had no intentions of selecting interviewees that constituted a representative selection of European system managers. Data is provided for Norway, which virtually includes all the universities and colleges in that country, but it was not a goal of the project that every European country be included in the project or that every institution in a country could be covered. However, it is considered that the total of 113 institutions throughout 17 European countries gives an fairly large database for important, tentative findings on the satisfaction of European institutions with the LMS systems they have developed or purchased.

The researchers were encouraged to find interviewees in various types of institutions. However, in some countries and types of institutions, it proved hard work to find interviewees that were both competent and willing to take the necessary time to participate.

Table 2 lists the types of institutions in the study. A majority (67 out of 113) of the institutions are universities and colleges of higher and further education. Other types of institutions are more or less under-represented. This reflects the willingness of systems managers in universities and colleges to co-operate in the study.
### Table 2. Types of institutions. Sorted by total number of institutions

<table>
<thead>
<tr>
<th>Type of institution</th>
<th>North-western Europe</th>
<th>The Nordic Countries</th>
<th>Southern Europe</th>
<th>The Czech Republic and Slovakia</th>
<th>Germany</th>
<th>Norwegian Universities and Colleges</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Universities</td>
<td>4</td>
<td>8</td>
<td>10</td>
<td>8</td>
<td>7</td>
<td>1</td>
<td>38</td>
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<tr>
<td>Colleges of higher and further education</td>
<td>7</td>
<td></td>
<td></td>
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<td>29</td>
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<tr>
<td>Private companies</td>
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<td>2</td>
<td>6</td>
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<td>Distance education institutions</td>
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<td>3</td>
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<td>1</td>
<td>3</td>
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<tr>
<td>Nonprofit institutions (training)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td>Institutes of technology</td>
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<td>Primary and secondary schools</td>
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<td>University centers</td>
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<td>Training organizations</td>
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<td>Government training agencies</td>
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<tr>
<td>Commercial providers of LMS-related services</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
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<td>Anonymous</td>
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<td></td>
<td></td>
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<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>20</td>
<td>20</td>
<td>14</td>
<td>17</td>
<td>24</td>
<td>113</td>
</tr>
</tbody>
</table>

### Internet Penetration and Use of LMS Systems

Table 3 shows that 113 institutions in 17 European countries were interviewed. It also gives the official languages, population, and Internet penetration in the countries. These factors influence the selection and use of LMS systems. The data presented are compiled from various sources used in the regional analyses. The primary sources are CIA World Factbook 2002 and Eurostat 2002.

From this analysis we would like to emphasize the differences between the Internet use in northwestern and southeastern Europe. The Internet users range from 50% of the population in the Nordic countries to 33% in Northwestern Europe, 30% in Germany, 18% in Southern Europe, and 10% in the Czech Republic.

### Table 3. List of countries including official languages, inhabitants, and Internet penetration. Sorted by Internet users per 100 inhabitants

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of institutions interviewed</th>
<th>Language</th>
<th>Area in square km</th>
<th>Inhabitants in millions</th>
<th>Internet hosts per 100 inhabitants</th>
<th>Internet users per 100 inhabitants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden</td>
<td>5</td>
<td>Swedish</td>
<td>449 964</td>
<td>8.9</td>
<td>7.0</td>
<td>56.4</td>
</tr>
<tr>
<td>Norway</td>
<td>28</td>
<td>Norwegian</td>
<td>324 220</td>
<td>4.5</td>
<td>11.2</td>
<td>52.7</td>
</tr>
<tr>
<td>Finland</td>
<td>4</td>
<td>Finnish</td>
<td>337 030</td>
<td>5.2</td>
<td>13.6</td>
<td>44.5</td>
</tr>
<tr>
<td>Denmark</td>
<td>5</td>
<td>Danish</td>
<td>43 094</td>
<td>5.3</td>
<td>13</td>
<td>43.0</td>
</tr>
<tr>
<td>Great Britain</td>
<td>6</td>
<td>English</td>
<td>227 480</td>
<td>57.6</td>
<td>13.6</td>
<td>33.5</td>
</tr>
<tr>
<td>Northern Ireland</td>
<td>4</td>
<td>English</td>
<td>14 120</td>
<td>1.6</td>
<td>1.6</td>
<td>33.5</td>
</tr>
<tr>
<td>Germany</td>
<td>17</td>
<td>German</td>
<td>357 021</td>
<td>82.2</td>
<td>2.3</td>
<td>29.6</td>
</tr>
<tr>
<td>Ireland</td>
<td>8</td>
<td>English</td>
<td>70 280</td>
<td>3.8</td>
<td>2.3</td>
<td>27.5</td>
</tr>
<tr>
<td>Italy</td>
<td>6</td>
<td>Italian</td>
<td>301 230</td>
<td>57.8</td>
<td>2.7</td>
<td>23.3</td>
</tr>
<tr>
<td>France</td>
<td>4</td>
<td>French</td>
<td>547 030</td>
<td>59.5</td>
<td>1.7</td>
<td>16.9</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1</td>
<td>German</td>
<td>41 290</td>
<td>7.2</td>
<td>4.4</td>
<td>24.0</td>
</tr>
<tr>
<td>Spain</td>
<td>1</td>
<td>Spanish</td>
<td>504 782</td>
<td>39.5</td>
<td>1.4</td>
<td>13.9</td>
</tr>
<tr>
<td>Slovakia</td>
<td>4</td>
<td>Slovak</td>
<td>48 845</td>
<td>5.4</td>
<td>0.7</td>
<td>12.1</td>
</tr>
</tbody>
</table>
There are significant regional differences within Europe with regard to how far the institutions have come in their use of LMS systems. The differences seem to follow the regional statistics for Internet users, which means that Southern Europe, the Czech Republic and Slovakia seem to be less developed with regard to use of LMS systems than the other regions.

The analyses for Northwestern Europe and the Nordic countries show that these regions already have come far in their use of LMS systems. The systems seem to be widely used in Nordic higher, further, and continuing education. It is in fact not easy to find Nordic institutions without experiences with LMS systems. In the United Kingdom and Ireland there is a very extensive implementation of e-learning via LMS systems. This includes provision at degree and diploma level. It seems that very many universities and colleges have purchased an LMS, and many corporations too.

The analyses for Southern Europe indicate that this region is less developed. It is, however, clear that the rising number of Internet users in Southern Europe is expanding the e-learning market. There is a growing number of institutions with web presence and e-learning offerings, and the analyses show that Southern European institutions are further developing their existing e-learning offerings. The pilot projects are no longer dominating the e-learning field in Southern Europe. But, the research still shows that 50% of the institutions analyzed have less than 15 courses online.

The analyses for the Czech Republic and Slovakia also indicate that these countries are less developed. E-learning is not widespread in these countries, and public opinion about online education is not always positive. Online education providers are often associated with curious educational experiments. In most cases online education is used as an addition to traditional face-to-face education. However there are some fully online experiments. One institution would like to improve the LMS so that it could offer paid courses as lifelong education to the public. Of the 14 institutions interviewed, nine had used their LMS for less than one year, but the results are nevertheless visible. Recently, a virtual university collaboration was started by three Czech universities.

Large-scale Providers of Online Education

It is interesting to distinguish between institutions that can be characterized as large-scale providers of e-learning and those in which provision is, as yet, on a smaller scale. The analysis shows that there is a clear trend towards large-scale online education in the Nordic countries. It shows that 12 of the 20 institutions offer at least 50 online courses. According to a 1998-99 analysis (Paulsen, 2000), only 3 of 22 Nordic institutions surveyed offered more than 50 online courses three years earlier. Further, the interviewees talk about LMS systems as large-scale systems capable of handling thousands of users.

A regional overview of large-scale providers, in which provision of 50 or more online courses is considered to represent large-scale provision, is presented in Table 4. It shows that 30 of the 89 institutions (34%) data is available from are large-scale providers. The table also shows that the trend towards large-scale online education has come further in the Nordic countries (60%) than in the other regions.

<table>
<thead>
<tr>
<th>Regions</th>
<th>References to regional analyses</th>
<th>Number of institutions that offer at least 50 online courses</th>
<th>Percentage of large-scale providers</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Nordic Countries</td>
<td>Paulsen (2002)</td>
<td>12 out of 20</td>
<td>60</td>
</tr>
<tr>
<td>Germany</td>
<td>Fritsch and Föllmer (2002)</td>
<td>7 out of 17</td>
<td>41</td>
</tr>
<tr>
<td>Northwestern Europe</td>
<td>Keegan (2002)</td>
<td>6 out of 18</td>
<td>33</td>
</tr>
</tbody>
</table>
Table 5 compares the number of online courses found in the Web-edu analysis with a previous international analysis of web-based education conducted in the CISAER-project (Paulsen, 2000). This comparison indicates that there is a clear trend that institutions offer more online courses today than they did three years ago. One may say that the trend goes from small-scale to large-scale online education.

Table 5. Distribution of institutions per number of courses

<table>
<thead>
<tr>
<th>Number of courses</th>
<th>The Nordic Countries</th>
<th>Germany</th>
<th>Northwestern Europe</th>
<th>Southern Europe</th>
<th>The Czech Republic and Slovakia</th>
<th>Sum Web-edu analyses</th>
<th>CISAER analysis (Paulsen, 2000)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>#</td>
<td>%</td>
<td>#</td>
<td>%</td>
<td>#</td>
<td>%</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>6</td>
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<td>10</td>
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<tr>
<td>2-4</td>
<td>5</td>
<td>1</td>
<td>18</td>
<td>3</td>
<td>11</td>
<td>2</td>
<td>10</td>
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<tr>
<td>5-15</td>
<td>10</td>
<td>2</td>
<td>24</td>
<td>4</td>
<td>22</td>
<td>4</td>
<td>33</td>
</tr>
<tr>
<td>16-99</td>
<td>35</td>
<td>7</td>
<td>35</td>
<td>6</td>
<td>17</td>
<td>3</td>
<td>38</td>
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<tr>
<td>100-</td>
<td>40</td>
<td>8</td>
<td>24</td>
<td>4</td>
<td>22</td>
<td>4</td>
<td>0</td>
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<td>No Answer</td>
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<td>2</td>
<td>0</td>
<td>0</td>
<td>22</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>20</td>
<td>101</td>
<td>17</td>
<td>100</td>
<td>18</td>
<td>101</td>
</tr>
</tbody>
</table>

Commercial LMS Systems

Altogether, the 113 institutions had experiences with 52 different commercial systems. It is however important to observe that only a few systems are used by several institutions. The analyses found only four European and four North American systems that five or more institutions had experiences with. So, the analyses indicate that these eight systems are among the most used commercial LMS systems in Europe:

European systems
- ClassFronter (16 institutions)
- TopClass (7 institutions)
- LUVIT (5 institutions)
- Tutor2000 (5 institutions)

North American systems
- WebCT (20 institutions)
- BlackBoard (14 institutions)
- FirstClass (7 institutions)
- Lotus Learning Space (6 institutions)

There seems to be an overall satisfaction with the most used LMS systems. The analyses in Northwestern Europe show a general satisfaction with WebCT as a user-friendly, competent product. Blackboard has given general satisfaction, but is less widely marketed than WebCT. The strong position of these two North American systems is not surprising, since they might be the two dominant systems on the international market:

Some higher education institutions continue to develop in-house systems or buy into open source alternatives, but an ever-larger majority is purchasing licenses for proprietary platforms. Indeed, two vendors, Blackboard and WebCT currently dominate the market, not only in their native North America, but internationally. Yet both have been trading for little more than five years. Market consolidation is also underway. (Observatory on Borderless Higher Education, 2002)

FirstClass is a Canadian system that seems to have a strong position in Scandinavia, and Lotus Learning Space is an IBM product that is also much used in Europe.
The analyses found that four European LMS systems seem to be significant competitors on the European market. TopClass may have a strong position in Europe since it originated in Ireland, and it is praised for its student and records database. ClassFronter is a Norwegian developed system that has a very dominant position in Norwegian universities and colleges. The system is available in a number of languages and sold to institutions in several countries. In Norway, there is great confidence among the users of ClassFronter with regard to the service offered by the contractor. LUVIT originated at the University of Lund in Sweden, before it became a Swedish commercial company with reasonable success in Scandinavia and some other countries. Tutor2000 seems to be a successful LMS provider in the Czech Republic.

Table 6 lists the 52 commercial LMS systems identified in the study with their origin, URL and extent of usage.

<table>
<thead>
<tr>
<th>Commercial LMS systems</th>
<th>Original nationality</th>
<th>URL of LMS</th>
<th>Number of institutions using it as primary LMS</th>
<th>Number of institutions using it as additional LMS</th>
<th>Sum of institutions using the LMS system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ascot CourseMaster</td>
<td>British</td>
<td><a href="http://www.ascot-systems.co.uk">http://www.ascot-systems.co.uk</a></td>
<td>1</td>
<td>0</td>
<td>1</td>
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<tr>
<td>Aspen</td>
<td>American</td>
<td><a href="http://www.click2learn.com">http://www.click2learn.com</a></td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Aulanet</td>
<td></td>
<td></td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>BettyCOM</td>
<td>Swedish</td>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
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<tr>
<td>BlackBoard</td>
<td>American</td>
<td><a href="http://www.blackboard.com">http://www.blackboard.com</a></td>
<td>9</td>
<td>5</td>
<td>14</td>
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<td>Centra</td>
<td>American</td>
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<td>1</td>
</tr>
<tr>
<td>ClassFronter</td>
<td>Norwegian</td>
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<td>16</td>
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<tr>
<td>Clix campus</td>
<td>German</td>
<td><a href="http://campusonline.uni-freiburg.de:8181">http://campusonline.uni-freiburg.de:8181</a></td>
<td>1</td>
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<td>COM-C</td>
<td>Danish</td>
<td><a href="http://www.conc.dk">http://www.conc.dk</a></td>
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<td>1</td>
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<tr>
<td>Corporate learning</td>
<td>German</td>
<td><a href="http://www.global-learning.de">http://www.global-learning.de</a></td>
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<td>0</td>
<td>1</td>
</tr>
<tr>
<td>CourseKeeper</td>
<td>Norwegian</td>
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<td>Decus System</td>
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<tr>
<td>Destinations</td>
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<td>1</td>
<td>1</td>
</tr>
<tr>
<td>DLS from ETS</td>
<td>German</td>
<td><a href="http://www.click2q-online.com">http://www.click2q-online.com</a></td>
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<tr>
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<td>Danish</td>
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<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>FDL Learning Environment</td>
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</tr>
<tr>
<td>FirstClass</td>
<td>Canadian</td>
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<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Fle3</td>
<td>Finnish</td>
<td><a href="http://fle3.uiah.fi/">http://fle3.uiah.fi/</a></td>
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<td>0</td>
<td>1</td>
</tr>
<tr>
<td>GLN – Global Learning Network</td>
<td>American</td>
<td><a href="http://cisco.netacad.net">http://cisco.netacad.net</a></td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Granada Learnwise</td>
<td>British</td>
<td><a href="http://www.oakwise.oakland.ac.uk">http://www.oakwise.oakland.ac.uk</a></td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Imaker</td>
<td>Norwegian</td>
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<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Interwise-ecp</td>
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<td><a href="http://www.learnnetz-sh.de">http://www.learnnetz-sh.de</a></td>
<td>1</td>
<td>0</td>
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<td><a href="http://www.intralearn.com">http://www.intralearn.com</a></td>
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<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Intranets</td>
<td>American</td>
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<td>1</td>
<td>2</td>
</tr>
<tr>
<td>IT Campus</td>
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<td></td>
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<td>0</td>
<td>1</td>
</tr>
<tr>
<td>It’s Learning</td>
<td>Norwegian</td>
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<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Kark</td>
<td>Norwegian</td>
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<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>LC Profiler</td>
<td>Finnish</td>
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<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Learning solution</td>
<td>German</td>
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<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Learnlink evoeye</td>
<td>American</td>
<td><a href="http://www.learnlink.com">http://www.learnlink.com</a></td>
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<td>0</td>
<td>1</td>
</tr>
<tr>
<td>LEKTOR</td>
<td>Swedish</td>
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<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Lotus Learning Space</td>
<td>American</td>
<td><a href="http://www.lotus.com">http://www.lotus.com</a></td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>LUVIT</td>
<td>Swedish</td>
<td><a href="http://www.lu%D0%B2%D0%B8%D1%82.com">http://www.luвит.com</a></td>
<td>5</td>
<td>0</td>
<td>5</td>
</tr>
</tbody>
</table>
### Regional Preferences and Market Leaders

In the countries that use English as the first language, the American LMS systems seem to dominate. The overall impression is the domination of the scene by the major American-based LMS systems, notably WebCT, Blackboard and TopClass. This is likely because of the use of English in the United Kingdom and Ireland. WebCT has pushed hard to become the market leader with extensive promotion and presence at e-learning conferences.

In Australia, another English speaking country, WebCT seems to be the most widespread LMS system and Blackboard seems to be the first runner-up. A NCODE-FLA (http://ncode.mq.edu.au) LMS survey (NCODE-FLA, 2002) of 34 Australian institutions conducted by Sue McKnight shows 25 instances of WebCT, 12 instances of BlackBoard, and seven instances of self-developed LMS systems. This is supported by a briefing on leading learning platforms (The Observatory on Borderless Higher Education, 2002) which claims that Australia is the country with the highest penetration of BlackBoard and WebCT licenses in the world since 76 percent of the country’s 34 universities have such licenses.

In countries that do not use English as the first language, the American LMS have many user institutions. The research indicates that the Norwegian ClassFronter, and the North American WebCT, FirstClass, and BlackBoard seem to be the most used LMS systems in the Nordic countries. In the Czech Republic and Slovakia, five interviewees referred to the Czech TUTOR2000, three stated that they had developed their own systems, and the last six applied American commercial systems (BlackBoard, Click2learn, GLN, Intralearn, Learning Space and WebCT).

But, the analyses show that locally developed systems have a strong position in the countries that do not use English as their first language. Nordic institutions seem to prefer LMS systems developed in the Nordic countries. Among the 25 different LMS systems that were identified in the Nordic analysis, 16 were of Nordic origin. All other systems were of American, Canadian, or Irish origin. According to Runnestø and Ristesund (2002), ClassFronter is by far the market leader in Norwegian universities and colleges. Of those that offer online education, 65% used ClassFronter. In the Czech Republic and Slovakia, institutions are converting to the national LMS vendors as these commercialize their products, since their systems are provided in the national language. Language is an important issue also in the Southern European countries and LMS systems that are not translated into their national languages are disadvantaged.
Competitive Issues

There were some interesting findings, which showed that customer loyalty, user-friendliness, cost-effectiveness, integration, openness, and adaptability could be of special interest to LMS providers that want to compete in the future market:

- The institutions do not seem to be especially loyal to, or dependent on, one LMS provider. The majority of the institutions had changed system, planned to change system, or operated additional systems.
- LMS systems could have reached a point where user-friendliness, cost-effectiveness, and integration with other systems are more important than new features.
- The open source strategy may have an impact on the future LMS market.
- Adaptability and management facilities on the level above individual courses are requested.

It should also be noted that many systems could be improved with regard to linguistic issues, assessment tools, pricing, content creation and management. The Southern European analysis showed that the commercial systems can be very easy to start with, but they may have problems with linguistic issues, as well as with assessment tools, suitability to target groups, and pricing. Many systems seem to have problems with content creation and content management, student monitoring, and assessment tools. Online administration and integration with other systems and platforms were also insufficient.

Self-developed Systems

The analyses revealed as many as 35 self-developed LMS systems. They are all listed in Table 7. From this, one may infer that there are remarkably many European institutions that use self-developed LMS systems. It is however not always easy to distinguish between commercial and self-developed LMS systems. Many systems have started as self-developed systems that after a while have been commercialized. Other self-developed systems are shared among several partners. So, some of the LMS systems listed here as self-developed systems, could be included on the list of commercial systems.

Table 7. List of institutions with self-developed LMS systems

<table>
<thead>
<tr>
<th>Name of institution</th>
<th>Nationality</th>
<th>Web address</th>
<th>Self-developed LMS systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Czech-Swiss Institute</td>
<td>Czech</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Danmarks Netskole</td>
<td>Danish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CNED</td>
<td>French</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Netzentwurf</td>
<td>German</td>
<td></td>
<td>ILIAS</td>
</tr>
<tr>
<td>TU Chemnitz</td>
<td>German</td>
<td></td>
<td>Lernen-im-netz</td>
</tr>
<tr>
<td>Akademie</td>
<td>German</td>
<td></td>
<td>Planetux</td>
</tr>
<tr>
<td>Virtus</td>
<td>German</td>
<td></td>
<td>VC Prolog Tutor</td>
</tr>
<tr>
<td>Akademie</td>
<td>German</td>
<td></td>
<td>VU</td>
</tr>
<tr>
<td>Virtuelle Universität</td>
<td>German</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Osnabrueck</td>
<td>German</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LVU</td>
<td>German</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Darmstadt</td>
<td>German</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aristoteles University of Thessaloniki</td>
<td>Greek</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instituto Formazione Operatori Aziendali</td>
<td>Italian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anonymous</td>
<td>Italian</td>
<td><a href="http://www.esperienze.net">http://www.esperienze.net</a></td>
<td>Experienze</td>
</tr>
<tr>
<td>Sinform1</td>
<td>Italian</td>
<td><a href="http://www.greenteam.it/greenteam/education">http://www.greenteam.it/greenteam/education</a></td>
<td>Greenteam</td>
</tr>
<tr>
<td>University of Trento</td>
<td>Italian</td>
<td></td>
<td>Proprietary</td>
</tr>
<tr>
<td>Høgskolen i Narvik</td>
<td>Norwegian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Høgskolen i Oslo</td>
<td>Norwegian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Høgskolen i Sør-Trøndelag</td>
<td>Norwegian</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
It is interesting to observe that most of the respondents expressed satisfaction with their self-developed systems. But, one should be aware that there might be many covert or vicarious reasons for choosing self-developed LMS systems. The German analysis stated that there is a tradition saying that a high-quality computing center does not need to buy programs developed by others. The need to buy external programs would question the center’s qualifications.

But the analyses also indicate that institutions with self-developed LMS systems perceive the commercial systems as expensive and complex. The self-developed systems avoid linguistic problems and they are regarded as supportive of local needs and target groups.

Several Nordic institutions prefer self-developed systems. They perceive the commercial systems as expensive and complex and want to develop the systems to support their local needs. They wanted cost-effective systems with the ability to handle continuous enrollment and integration with student administrative systems and economy systems.

A Norwegian large-scale distance education institution using a self-developed LMS expressed it this way:

> SESAM is developed by NKI to support the services that are important to NKI. We have based the work on evolutionary systems development over a period of 15 years. As a result, we have a system that is very well adapted to our special needs. SESAM is excellent for handling continuous student enrollment 365 days a year. The major, additional advantages we have over the commercial systems, is the focus on cost-effectiveness and the integration with our critical student administrative systems and economy systems.

The Southern European analysis found that self-developed systems could be simpler and directly adapted to the target groups; they avoid the linguistic problems of the commercial systems and are constantly updated, being able to improve their features according to trainers, trainees and administration evolution. Besides the linguistic advantage, national marketing strategies together with competitive pricing contribute to the widespread use of those self-developed LMS systems.
E-learning Standards

E-learning standards intend to make LMS systems and learning content less proprietary. The analyses show that there is an interest for standards and standardizations that can make it easier to exchange content and data between LMS systems and between LMS systems and other systems. Some of the interviewees spoke about the importance of standardization in general terms. Many were concerned with the possibility of using, importing, and exporting standardized course content and learning objects. Two German experts talked about the importance of XML and meta-tagging. And many references were made to standards specifications and initiatives such as SCORM, IMS, AICC and IEEE.

All the analyzed institutions in Northwestern Europe are sensitive to the SCORM and IMS standards and they are considered almost as a norm. The Nordic interviewees are aware of the standards, and several claim to follow them. But few state that the standards are important to their institution, and e-learning standards do not seem to have had much impact on online education in the Nordic countries. The German analysis states that standardization will play an important role in the future.

In Southern Europe there seems to be a considerable ambivalence with regard to e-learning standards. Interviewees stressed the absence of both de facto and formal technical standards. One interviewee claimed that standardization would have a positive impact on internationalization of the e-learning businesses. Another argued that since courses often are country specific, standards are not yet relevant. But standards are welcomed for marketing reasons, for cost reduction, and for LMS migration.

Course Creation Tools

Even though many LMS systems provide internal course creation tools, the analyses showed that a broad range of external tools is used to develop the content before it is published in the LMS system. The interviews show that the LMS systems use text, multimedia, audio, html-pages, graphics, and tests that are developed with external software. The software tools for course creation referred to in the interviews are listed in Table 8.

<table>
<thead>
<tr>
<th>Software tools</th>
<th>Type of content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word</td>
<td>Text</td>
</tr>
<tr>
<td>PowerPoint</td>
<td>Text</td>
</tr>
<tr>
<td>Macromedia Authorware and Director</td>
<td>Multimedia</td>
</tr>
<tr>
<td>Flash</td>
<td>Multimedia</td>
</tr>
<tr>
<td>Windows SoundRecorder</td>
<td>Audio</td>
</tr>
<tr>
<td>Wimba</td>
<td>Audio</td>
</tr>
<tr>
<td>Flash</td>
<td>Multimedia</td>
</tr>
<tr>
<td>FrontPage</td>
<td>HTML-pages</td>
</tr>
<tr>
<td>DreamWeaver</td>
<td>HTML-pages</td>
</tr>
<tr>
<td>Netscape Composer</td>
<td>HTML-pages</td>
</tr>
<tr>
<td>Viewlet</td>
<td>Graphics (Screenshots)</td>
</tr>
<tr>
<td>Coral</td>
<td>Graphics</td>
</tr>
<tr>
<td>PhotoShop</td>
<td>Graphics</td>
</tr>
<tr>
<td>PaintShop</td>
<td>Graphics</td>
</tr>
<tr>
<td>Autotest</td>
<td>Tests</td>
</tr>
<tr>
<td>Webwinder</td>
<td>Tests</td>
</tr>
<tr>
<td>Learner Interface</td>
<td>Tests</td>
</tr>
<tr>
<td>Questionmark perception</td>
<td>Tests</td>
</tr>
<tr>
<td>Hot potatoes</td>
<td>Tests</td>
</tr>
<tr>
<td>ToolBook</td>
<td>Tests</td>
</tr>
<tr>
<td>Quia</td>
<td>Tests</td>
</tr>
</tbody>
</table>

The Nordic analyses show that LMS systems are not usually used for development of course content. According to some Southern European interviewees, LMS systems are mainly used for support and sharing of information.
Other institutions need to use external tools and specialist support for course production. In the majority of the German cases, there is no course creation with or inside neither the commercial nor the self-developed LMS systems. Finally, the analyses also indicate that there is a lack of available course content.

A few of the interviewees pointed out that they especially wanted more flexible solutions because they felt too dependent on the systems’ intrinsic structure and design. One especially wanted better control of graphical design, logos, etc. Another would have liked to have access to the system’s source code.

**Student and Tutor Support Tools**

There is a host of student and tutor support tools included in the LMS systems. However, the availability and quality of specific tools vary. Many interviewees were concerned about the need for better and more advanced communication and collaboration tools. Two simply stated that they wanted better communication possibilities and secure communication. Others requested better support and more tools for teamwork and collaboration. In addition, some especially focused on the need for better tools for synchronous communication and immediate feedback.

The analyses indicate that several LMS systems should improve their test and assignment tools. They could also be improved with regard to evaluation, e-portfolio, commenting on student presentations, knowledge management, assessment tools, and reports. The German analysis did not find one LMS system using an integrated examination procedure, and the North West European analysis found that the concept of quizzes and multiple-choice questioning, a feature of most American LMS systems, is not considered adequate for European academic evaluation.

The analyses in the Czech Republic and Slovakia pointed out that not all LMS systems have tools to track student progress and monitor their performance. Existing tools are not good enough. Student data are not available for tutors who have to contact the system administrator in order to get the data they need.

**Administrative Systems**

The need for sophisticated administrative systems increases with the administrative workload, and there is a general need for better administrative systems and tools. The analyses show that many systems could have better tools for administration of students, tutors, and content. The interviewees asked for better group management tools, student record systems, improved course management, and better password management facilities. Some interviewees more specifically want better services for student tracking and reporting functions.

The Southern European analysis revealed that the administration facilities seem much more important for professional training institutions that usually provide short, repeated courses in several versions, than for universities. The university model, with year-long courses, requires less frequent administration since it has a more stable association between course, teacher, and student.

With the introduction of large-scale online education, the need for integration between LMS systems and other online education systems increases. The analyses revealed a general lack of such integration.

The Nordic analyses show that the LMS systems need to be integrated with a number of other systems in organizations that aim at providing efficient, large-scale, online education. Integration between the LMS systems and the student administrative systems seems to be relatively poor, and the integration between the LMS systems and the economy systems seems to be very poor. In addition, several interviewees are concerned about the opportunities and challenges regarding integration with the administrative system that records student grades.

It is also interesting to see that the Nordic universities have standardized on a few national student management systems. The systems are LADOK (Sweden), MSTAS (Norway), FS (Norway), STADS (Denmark), INNA (Iceland) and to some extent Oodi (Finland). The high levels of national system coordination, or governmental coercion, in these countries may possibly result in more collaboration among the universities and a competitive advantage on the international market.

Some interesting integration efforts are in progress, but Runnestø and Ristesund (2002) confirmed that there is a general lack of integration between the LMS and the student management systems in Norway. Their analysis
showed that some LMS systems have no possibility for integration, others have the possibility to import data from the student management system, but only one system (SESAM, a self-developed system by NKI Distance Education) has full integration both ways.

The analyses of the Northwestern European countries showed that data produced by the LMS systems are not yet generally integrated into the institutions' administrative databases. Further, there are many German projects where university enrollment is the only prerequisite for access to the LMS system. But this does not mean that the LMS is integrated with the normal university enrollment procedures. On the contrary, in most cases they are completely separated. The German analyses also showed that record or test-databases are separated from the enrollment databases. Because of the privacy laws of data protection, it is not easy to change these procedures.

**Technology**

The analyses found three categories of server solutions, and all seem to work well. In the first category, the institutions have access to commercial service providers that host the LMS. In the second category, the institutions host the LMS for internal use. And in the third category, the institutions host the LMS for internal use and as a service for other institutions. The institutions that have access to service providers that host the LMS seem to be positive to the solution, but they experience some problems with limited access. Several institutions have chosen to host the LMS internally. They are typically either the institutions that have self-developed systems or larger institutions with high internal competence that can operate commercial LMS systems locally. The users of the commercial systems claim that the systems are stable and reliable. The users of self-developed systems also experience few problems. Virus attacks and firewalls, however, are mentioned as serious problems. A few institutions that have self-developed systems host the LMS for internal use and as a service for other institutions.

The interviewees talk about LMS systems as large-scale systems capable of handling thousands of users. The interviewees are confident that the systems can handle a large number of users without special technological problems. The interviewees did not seem to be concerned with how the systems technically could organize the administration of large numbers of students, courses, and tutors. One mentioned, though, that large-scale operations could impose some pedagogical challenges.

Some comments point out that students have all kinds of connections to the Internet, ranging from low speed modems to broadband access. But the speed of the LMS system does not seem to be any problem. The bottleneck seems to be the network bandwidth and local lines. To handle this, the institutions adapt their bandwidth requirements to the users’ equipment. Due to the bandwidth limitations, several of the institutions limit their use of high bandwidth content. At the same time, many interviewees expressed a wish for higher bandwidth to be able to provide more multimedia content and services. Several interviewees wanted to include video services such as streaming video, video-conferences, web-cameras, and moving pictures. Audio services such as voice communication and audio files were also requested. Some of the interviewees especially focused on multimedia tools such as video-conferencing and voice chat for better synchronous communication.

**Economy Issues**

E-learning is not cheap, and cost-effectiveness becomes more important as the institutions become large-scale providers of online education. Recent price rises, often quite considerable, have made the commercial LMS systems a reasonably costly investment. Prices in the range € 20,000 to € 50,000 are being quoted. The cost and pricing structure for the commercial systems vary from system to system. This could make it difficult to compare real costs.

The staff time for the development and maintenance of self-developed systems proves to be a costly investment too. The German analysis shows that installing a complete system often includes buying a new server and database software, which easily sums up to some €100,000. But many respondents hide these costs behind the statement that it is self-developed, open source, or not available information.

Expenditure on LMS systems is only the first stage of spending. Hardware and software to run them is necessary too. The respondents list considerable sums for the staffing and maintenance of the system, and others add that the provision of content is at least as much again. Expenditure on staff and student training is, however, much less onerous.
The interviewees have only a vague knowledge about the maintenance and operation costs. Many interviewees mentioned that economic aspects are hard to identify. The issue is perceived as complex and hard to estimate. Further, it seems they have little knowledge about how much time and money is spent on training staff and students to use the LMS systems.

Conclusions

There are significant regional differences within Europe with regard to how far the institutions have come in their use of LMS systems. The differences seem to follow the regional statistics for Internet users, which means that Southern Europe, the Czech Republic and Slovakia seem to be less developed with regard to use of LMS systems than the other regions.

The analyses show that there is a clear trend toward institutions offering more online courses today than they did three years ago. One may say that the trend goes from small-scale experiments to large-scale operation of online education. If one characterizes institutions that offer at least 50 online courses as large-scale providers of online education, 30 of the 89 institutions (34%) we have data from could be characterized as large-scale providers. The analyses indicate that the trend towards large-scale online education has come further in the Nordic countries (60%) than in the other regions.

One striking conclusion is that there is a host of commercial and self-developed systems that seem to work satisfactorily in various educational institutions throughout Europe. The systems are not able to handle all the functions the institutions want, and they can be improved in many ways. But most systems encountered in the analyses seem to be good enough for handling online education successfully. It is however important to observe that only a few systems were used by several institutions. This probably means that many system providers could have a fragile economy.

The Southern European analysis showed that in almost all cases, neither the commercial nor the self-developed systems were able to provide all the services the institutions needed. Administrative aspects, integration with existing software and content management are some of the problems encountered in most of the LMS systems.

The analysis in the Czech Republic and Slovakia also showed that there were cases in which certain facilities were not available (e.g. synchronous communication). However, it must be taken into consideration that the institutions choose their system according to their needs. So, in spite of the fact that a system seems to have a shortcoming, it is actually not the case, because the system is suitable and satisfactory for the institution.

Another conclusion is that the general position that the market is dominated by the American LMS systems is not the norm throughout Europe. In the countries that do not use English as the first language, locally developed LMS systems have successfully ousted the American products. Remarkably, a large number of the LMS systems used in Europe are commercial systems developed locally or self-developed systems at the institutions. However, very few of these systems seem to have more than a few user institutions.

The analyses indicate that BlackBoard, ClassFronter, FirstClass, Lotus Learning Space, LUVIT, TopClass, Tutor2000, and WebCT are among the most used commercial LMS systems in Europe. Four of these are of European origin. TopClass originated as a project at the University College Dublin, in Ireland, before becoming an Irish campus company and then migrating to the United States. ClassFronter is a Norwegian-developed system that has a very dominant position in Norwegian universities and colleges. The system is available in a number of languages and sold to institutions in several countries. LUVIT originated at the University of Lund in Sweden, before it became a Swedish commercial company with reasonable success in Scandinavia and some other countries. Tutor2000 seems to be a successful LMS provider in the Czech Republic. It seems that the four European systems may have a competitive advantage in their local markets since they often have a relatively good local representation and support of local languages.

There are remarkably many institutions that use self-developed LMS systems, and there may be many covert and vicarious reasons for choosing them. But the analyses indicate that these institutions perceive the commercial systems as complex and expensive with escalating licensing costs. The self-developed systems avoid linguistic problems and are regarded as flexible and supportive of local needs and target groups. One may also expect that a self-developed system is one reason for expertise to stay in-house.
With the introduction of large-scale online education, the need for integration between LMS systems and student management systems increases. The analyses revealed a general lack of such integration. It is however interesting to see that the Nordic universities have standardized on a few national student management systems and that interesting integration efforts are in progress.

Cost-effectiveness becomes more important as the institutions become large-scale providers of online education. The interviewees have, however, only a vague knowledge about the system's maintenance and operation costs. The cost and pricing structure for the commercial systems varies from system to system. This can make it difficult to compare real costs. Some interviewees were concerned about high and increasing prices for the commercial LMS systems.

The analyses indicate that there is a need for increased focus on LMS knowledge, policy, and strategy in Southern Europe. In particular university e-learning managers are concerned with the university policy in this field. Apparently they mean that Southern European universities are not dedicating enough importance and attention to this subject. The analyses further indicate that the introduction of LMS systems could be a source for conflict between administration and academia.

The analyses show that there is an interest for standards and standardizations that can make it easier to exchange content and data between LMS systems and between LMS systems and other systems. The institutions in Northwestern Europe are sensitive to the e-learning standards and they are considered almost as a norm. The Nordic interviewees are aware of the standards, and several claim to follow them. But few state that the standards are important to their institution, and e-learning standards do not seem to have had much impact on online education in the Nordic countries. The German analysis states that standardization will play an important role in the future. In Southern Europe there seems to be a considerable ambivalence with regard to e-learning standards.

References


Abstract
In order to exchange learning resources via educational mediators, resources need to be described with metadata in a coherent manner. Metadata for learning resources has become a widely discussed research topic, but the concept is still too loosely defined to provide guidelines for its use. With this paper we aim to contribute to the design of metadata models, which serve as vehicles for defining educational offers in exchange environments. In the context of educational mediators, the learning object notion is clarified using a taxonomy, which differentiates between educational activities and educational material. The model is derived from two exemplifying use cases of educational mediators implemented in the EducaNext portal: “exchange of educational material” and “mediation of cross-institutional educational activities”. The paper targets developers and stakeholders of educational mediators as well as educators and technologists dealing with metadata standards in general.

Keywords
Educational mediators, Learning resource reuse, Modelling, Learning object metadata, Standards, Interoperability, Brokerage

Introduction
The aim of this paper is to present a use-case based model for educational offers. To exchange learning resources via educational mediators, resources need to be described in a coherent manner in order to make systems interoperable and to facilitate reuse. With this paper we aim to contribute to the design of metadata models, which serve as vehicles for defining educational offers in exchange environments. Based on use cases we introduce a taxonomy for learning resources, which differentiates between the notions of educational activity and educational material. The term "educational activity" is used to refer to an educational event of which the primary objective is to educate or train persons with the help of some human agent (instructor, lecturer, etc.) at a pre-defined timeframe. Courses, seminars, tutoring or training sessions, lectures, etc. are examples of educational activities. The term “educational material” is used to refer to any type of content that supports educational activities.

In order to illustrate the context of our work the paper starts with a brief introduction to educational mediators. From this description two exemplifying use cases, “exchange of educational material” and “mediation of cross-institutional educational activities”, are derived. Before a model describing the artefacts subject to exchange is introduced, related work is delineated and a taxonomy-based definition of educational activities and educational material is provided. Finally, a reference implementation of our model — the EducaNext Portal — is presented. It illustrates how a variety of educational offers supported by the model can be instantiated in an educational mediator.
open, component-based frameworks for learning (e.g. AICC, SCORM, OKI). The overall goal of these approaches is to improve the interchangeability of learning resources. Concurrently, information systems (IS) research on system integration has gained momentum. In the IS field mediators are defined as systems that exploit encoded knowledge about certain sets or subsets of data to create information for higher layer applications (Wiederhold, 1992). From an educators’ point of view, these mediators enable their users to reuse and compile distributed units of knowledge to construct some entities of larger granularity that are pedagogically coherent and relevant. In a similar direction goes the vision of the semantic web, which aims to have distributed data and services defined and linked in such a way that they can be used by machines not just for display purposes, but for automation, integration and reuse of data and services across various applications (Berners-Lee, Hendler, & Lassila, 2001).

Integrated educational systems based on these ideas are herein referred to as educational mediators, other terms used are electronic markets for learning (Hämäläinen, Whinston, & Vishik, 1996), knowledge pools (Duval et al., 2001), learning media (Guth, Neumann, & Simon, 2001), or e-markets for education (Pawlowski & Adelsberger, 2002). In this paper we offer the following definition of educational mediators: Educational mediators are network-based information systems, which integrate educational artefacts from dispersed sources in order to provide a higher layer application serving a particular need in the educational domain. A higher layer application goes beyond, for example, the simple up- and download of educational material to a repository. Educational mediators can be perceived as enhanced digital libraries (Bieber et al., 2002), which include computer-mediated communications, community process support and/or marketplace functionality. Table 1 provides an overview of the kind of services educational mediators can provide. These use cases of educational mediators typically support educational community tasks such as curricula design, developing and distributing educational material, delivering courses, advising and mentoring, assessing learners and instructors, etc. Educational mediators focus on different kinds of educational artefacts (see Table 1). These artefacts are available via legacy systems. As a consequence, educational mediators are required to provide interfaces to learning management systems, local repositories of educational material, human resources management systems, course catalogue management systems, assessment tools, etc.

According to the above definition, the following examples of educational mediators can be identified Ariadne’s knowledge pool system (http://www.ariadne-eu.org/), Cuber (http://www.cuber.net/), the Edna Portal (http://www.edna.edu.au), the Gateway to Educational Material (GEM, http://www.thegateway.org/), or Merlot (http://www.merlot.org/). Collecting educational material and educational activities is the service these inter-organizational systems provide. Edna, Merlot and GEM integrate educational artefacts published on dispersed web servers via hyperlinks. ARIADNE adopted a more tightly coupled architecture in which metadata and documents are all stored in a replicated knowledge pool (Duval et al., 2001). CUBER (Lamminaho & Magerkurth, 2001) aims at providing students and local administrators with information on courses of various higher education institutions in order to support student exchange and course accreditation.

<table>
<thead>
<tr>
<th>Use Cases</th>
<th>Educational Artefacts</th>
<th>System Interfaces required to</th>
</tr>
</thead>
</table>

In this paper two types of services are presented (Simon & Quemada, 2002):

- Exchange of educational material and
- Mediation of cross-institutional educational activities

The exchange of educational material supports instructors preparing their courses. Educational material such as electronic textbooks, lecture notes, exercises, case studies, etc. is already widely available at web-enabled repositories or learning management systems (LMS). Exchange platforms for educational material integrate with repositories and LMS and make their content available via one virtual node. The idea behind such educational mediators is to support the reuse of educational material and the collaborative development of it. Additionally, these systems provide means for managing usage rights.
The mediation of cross-institutional educational activities allows educators to deliver courses and other educational activities to a distributed audience. Cross-institutional educational activities rely on virtual meeting places realized via Computer-Supported Collaborative Work (CSCW) tools so that an educational event can take place simultaneously at dispersed locations. Exchange platforms for cross-institutional educational activities integrate course administration information, which, for example, provides basic data on time and location, registered students and instructors involved. Based on this data, which is usually available in legacy systems or human resources management systems, the delivery of learning is organized. According to a specific schedule, cross-institutional educational activities take place at a virtual meeting room and are usually accompanied by educational material. Mediators for cross-institutional educational activities provide means to link educational material to them.

**Literature Review**

Metadata for learning resources have become a widely discussed research topic in the field of IT-mediated education (Richards, 2002; Duval et al., 2002; Symytsya, 2003; Duval & Hodgins, 2003). However, the concept is still too loosely defined to provide guidelines for its use (Nilsson, Palmér, & Naeve, 2002).

In general, metadata refers to data about data. In our specific case, metadata is used to describe learning resources. As any data model, metadata for learning resources can serve multiple purposes. Hence, learning resource metadata vary depending on its intended use and the context within which they are developed.

Metadata models can be differentiated between models for designing and controlling learning processes, on the one hand, and models for exchanging learning resources, on the other. Metadata models for designing and controlling learning processes describe learning resources, so that they can be manually or (semi-)automatically combined/aggregated in order to support learner-centred knowledge acquisition processes via an electronic learning environment (Paquette & Rosca, 2002; Allert, Dhraief, & Nejdl, 2002; El Saddik, Fischer, & Steinmetz, 2001). Here, metadata is primarily used by (instructional) designers of these electronic learning environments. A model for designing learning processes tends to be fairly complex, because the model needs a vocabulary that is rich enough to describe all kinds of learning objects and their dependencies. Additionally, concepts are needed to describe and control the learning process itself. These must be flexible enough to serve different learning theories and instructional approaches.

The Educational Modelling Language (Hermans et al., 2000) is an example of a metadata model developed for the purpose of designing learning processes. By January 2003 the Educational Modelling Language has evolved to an official IMS specification called Learning Design Information Model (Koper, Olivier, & Anderson, 2003). The Learning Design Information Model aims to provide a common language, which consists of a comprehensive notational system that allows the codification of — what is called — “units of study”. The model allows specifying environments for the delivery of learning, for example, defined by communication objects, which can either be based on asynchronous communication media (e.g. news groups, e-mail) or on synchronous communication media (e.g. chat room, videoconference).

This paper focuses on the development of a metadata model developed for the purpose of exchanging learning resources. Models describing the artefacts subject to exchange play a crucial role when it comes to the design of educational mediators (Sutton, 1998; Nejdl et al., 2002). Such models provide means for labelling artefacts with descriptors in order to facilitate exchange. The concepts introduced must be easily comprehensible by educators, since they are most likely the ones who are asked to describe learning resources and make reuse decisions (Friesen, Roberts, & Fisher, 2002; Hatala & Richards, 2002).

The Dublin Core Metadata Initiative (DC, 2002) and the IEEE Learning Object Metadata (LOM) Standard (IEEE, 2002) provide pre-defined sets of descriptors for learning resources, which are relevant for both application scenarios of metadata models (For a comprehensive overview on metadata models provided by the various standardization bodies please refer to Anido et al., 2002). Other standardization initiatives such as SCORM and IMS base their recommendations on these standards.

However, the generic models provided by the standardization bodies do not serve the requirement of providing an effective set of comprehensible metadata elements for the purpose of exchanging learning resources (Hatala & Richards, 2002; Garrido, 2003). A particular drawback of LOM is the lack of unambiguous concepts (Farance, 2003). When it comes to the metadata model design of educational mediators, for example, one needs to
consider that educators need to know whether they are confronted with a full educational service such as an educational activity or material that they can reuse for their own lectures.

LOM suggests the learning resource type attribute for the purpose of classifying learning resources (the attentive reader might note that although LOM is based on the notion “learning object”, the educational type classification attribute is called “learning resource” type while no further explanation on the difference between those two notions is provided in the document). For learning resource type a vocabulary of 15 values has been defined, which has the following weaknesses when applying it in the context of educational mediators:

1. While some of the meanings of the attribute values overlap (Friesen, Roberts, & Fisher, 2002), e.g. diagram, figure, graph, the value space can be perceived as a subjective selection from a large set of potential values. This impression is reinforced when looking at the variety of learning resource types used by some of the platforms mentioned above (A survey on learning resource type values is available at http://nm.wu-wien.ac.at/e-learning/lr-types.htm).

2. LOM’s value space for learning resource type mixes up media type, educational activity type and educational material type, but without providing a sufficiently rich set of attribute values for any of those attributes (Simon & Quemada, 2002; Friesen, Roberts, & Fisher, 2002). For example, diagram, graph and figure refer to a media type; exercise, lecture and self assessment to an educational activity type; table, slide, and narrative text to an educational material type. This particular problem is caused by LOM’s broad definition of the term learning object (Wiley, 2001; Ip, Morrison, & Currie, 2001). This paper aims at reducing the ambiguity of the learning object notion in the context of educational mediators.

**Educational Activities and Educational Material — A Taxonomy-Based Definition of Learning resources**

Educational mediators support the exchange of learning resources or, as they are called according to LOM, learning objects. Other terms used for learning resources are (Barritt & Lewis, 2000; Brantner et al., 2001): educational objects, content objects, reusable (learning) objects, learning resources, and training components. LOM defines learning objects as any entity, digital or non-digital, that may be used for learning, education, and training. Wiley challenged the usefulness of this definition that can be interpreted as the universal set of all things (Wiley, 2001).

Based on the different use cases as described in Section II it is argued that it is important to remark the difference between two different types of learning resources: "educational material" and "educational activities".

The term "educational material" is used to denote all units of content that can be stored and transferred in digital or non-digital form. These content units are somehow static in the sense that they are produced to be (re-)used by persons who rely on this type of learning resources in order to deliver education. Arguing along the lines of Wiley (2001) and Suthers (2001), we propose a narrower definition of educational material similar to theirs, which emphasizes the role of educational material in supporting learning. Extending their definitions a step further, we underscore the exclusion of human as a requirement for distributing information. The "educational material" category includes not only books and other reading material, but also courses or lectures recorded on video tapes, learning management systems or multimedia CD-ROMs, because they are used by educators to support their instructional activities. The term "educational activity" is used to denote events where educators and learners work on the enhancement of knowledge or skills. Hence, an educational activity is a service that is provided in order to support the accomplishment of a specific educational objective. This is achieved by creating a learning environment consisting of educators, educational material, communication infrastructure, meeting places, etc.

For the sake of brevity, we will use in the paper the acronyms EM and EA for "educational material" and for "educational activities", respectively.

The widespread deployment of communication infrastructure, and especially of the Internet, has introduced new ways of accessing educational material and of delivering educational activities. In the past the delivery of learning was primarily based on the realisation of educational activities in specially configured rooms, such as lecture rooms, laboratories, tutoring rooms, libraries, etc. Nowadays, physical libraries are being substituted by virtual libraries, blackboards had first been complemented and were later substituted by video projectors to a large extent, some lectures are being delivered via videoconferencing sessions, etc.
The taxonomy (see Figure 1) represents a mixture of learning resource types, a phenomenon observed especially after the advent of the Internet. Today, traditional educational activities are supported, enhanced or substituted by learning resources offered via the Internet. Traditional and Internet EMs and EAs are two extreme cases where all the elements thereof exclusively belong to the traditional and Internet category, respectively. Nevertheless, hybrid EMs and EAs, which constitute a mixture of traditional and Internet elements, become increasingly predominant.

Books, videotapes, lecture notes, etc. are and will be used for a long time together with electronic material accessible on the Internet. In many cases there will even exist paper and electronic versions of the same book or material, which are used indistinctly. A similar tendency can be observed in educational activities, where traditional courses are more and more complemented with the new services offered by the Internet (Simon, Haghirian, & Schlegelmilch, 2002), such as web-based tutoring via learning management systems, videoconferencing-based, multicultural lectures or simply via e-mail.

The ways to reference a traditional EM or EA and an Internet EM or EA are also different. Traditional EMs or EAs are referenced using techniques that are designed to reference physical elements and are substantially different from the referencing techniques used for the Internet. A URI (Universal Resource Identifier) is the standard means of accessing resources in the Internet. The most common form of a URI is the Uniform Resource Locator (URL). Another form of a URI is the Universal Resource Name (URN), which is not in wide use today. Proposals for usage of a URN — to reference book ISBNs, any-cast services, etc. — do already exist. However, there is no wide consensus about it. We will use in this paper the common form of referencing traditional educational materials and activities, for example, a book will be referenced with: title, author, publisher, year and ISBN. Internet resources will be referenced by means of a URI.

**Modelling Learning Resources**

The model proposed in this paper tries to cover the richness of educational scenarios that the present technology can deliver. It allows a precise description of EAs, which should serve for describing educational offers in a form that is machine and human readable. The definitions are usable for electronic publishing, negotiations, exchange, analysis, etc. The development of this model has been motivated by the need to precisely define mediation of Educational Activities between providers and consumers over an educational mediator, called EducaNext, which is being developed in the UNIVERSAL Project (Brantner et al., 2001).
The model considers the following elements as core components of educational activities:

- **Name**: an identifier
- **Educators**: persons who play a provider role in the educational activity, such as coordinators, lectures, tutors, instructors, etc.
- **Educational objective**: defines the educational goals and scope of the activity.
- **Schedule**: the time periods in which the educational activity takes place.
- **Delivery Platform**: the virtual or physical place, where communication between educators and learners takes place. Examples of delivery platforms are:
  - A lecture room where lectures are given locally
  - A videoconferencing platform connecting several classrooms
  - A TV channel for broadcasting lectures
  - A chat room for text message exchanges
  - An audio conferencing system
  - Forum or email discussions
  - Web applications for communication between educators and learners, for example for collecting exercises or exams on the Internet
  - Others
- **EM**: any piece of information that can be used as a supporting material for an EA.

The definition of the model is made by means of a simple language where the syntactic constructs correspond to the components (or groupings of components) of an EA or an EM. This approach leads to abstract, simple and readable definitions, whose primary purpose is the identification of the components and composition rules of an EA and an EM. The model could have been expressed in the eXtensible Markup Language (XML) or the Resource Description Framework (RDF), but it would have led to lengthier and less readable representations, which are more appropriate for machine processing than for an abstract representation.

The language is defined with a semi-mathematical model of EAs and EMs. The syntax of the language for describing EAs is given in a Backus-Naur Form (BNF) and the semantics is given informally. The BNF notation used is given in the following table.

**Table 2. Backus-Naur Form**

| SCN ::= ……… | defines a new syntactic category of name "SCN"
| [……] | composition of alternative definitions
| [...] | delimits an optional syntactic construct
| "..." | symbols, literals and reserved words are double quoted
| <...> | reused external elements, such as URLs, names, etc

A graphical description of the model is shown in Figure 2, which depicts the structure of an EA and an EM. This description provides a graphical representation of the BNF definitions given in the next section. Sequential composition of components is represented graphically as a vertical pile of components linked with a continuous line. For example, an EA (educational activity) is formed by the sequential composition of an ANAME (activity name), an OBJECTIVE, EDUCATORS, an EM (educational material) and a DSEQ (delivery sequence). On the other hand, choice and/or repetition of components is represented with dotted lines. For example, an EMSEQ (EM sequence) is formed by one or more sequential compositions of any of the following choices: an IEM (Internet EM) or a TEM (traditional EM). Or an EM (educational material) is formed by one or more sequential compositions of any of the following choices: a MNAME (EM name) followed by an EMSEQ (EM sequence) or a MSEQ or a MNAME.
A Model for Educational Activities

Educational activities denote educational events with properly defined educational objectives, which identify educator(s) involved and take place at a dedicated (virtual) meeting place according to a specific schedule. Cross-institutional educational activities rely on virtual meeting places realized via videoconferencing systems, chat rooms, etc. so that an educational event can take place simultaneously at dispersed locations. The language for describing an EA is defined by the following syntactical rules:

Table 3. Language for describing educational activities

| EA := "EA" ANAME "=" "{" OBJECTIVE EDUCATORS EM DSEQ "}"
| DSEQ := DTYPE DNAME "=" "{" DELIVERY "}" [DSEQ] ANAME ";" [DSEQ]
| DELIVERY := EDUCATORS ";" SCHEDULE ";" PLATFORM ";" EM"
| DTYPE := "LECTURE" | "SELFSTUDY" | "SIMULATION" | "EXAM" | "..."
| ANAME := <Educational Activity name>
| DNAME := <Delivery name>
| OBJECTIVE := "EDUCATIONAL_OBJECTIVE" "=" <Goals and scope> ";";
| EDUCATORS := ETYPE ";" <person identification> ";" [EDUCATORS]
| ETYPE := "COORDINATOR" | "LECTURER" | "TUTOR" | "INSTRUCTOR" | "..."
| SCHEDULE := "SCHEDULE" "=" <time frame scheduled for EA>
| PLATFORM := "PLATFORM" "=" <delivery platform>

The definition of educational activities includes optional parts in the syntactic definition, but this does not mean that those elements should not be defined in a well-formed EA definition. The rule to be followed for constructing well-formed EA definitions is that each EA must contain only deliveries which always have a properly defined objective, educator, schedule, and platform, either explicitly or inherited from a definition at a higher level. The only optional element is EM, because it is conceivable to have an EA without EM, but it does not make sense to have a “DELIVERY” which has no “OBJECTIVE”, no “EDUCATOR”, no “SCHEDULE” or no “PLATFORM”.

Two very simple taxonomies for “DTYPE” and “ETYPE” are introduced because of the need to render these taxonomies explicit. The taxonomies are not further defined because the fundamental goal of this paper is the
definition of the basic constituents of an EA, as well as the composition rules to define an EA. Just a couple of
types have been given in both taxonomies that will be used in the examples.

In the EA model no clear separation is made between a traditional EA and Internet EA. Not even the optional
“URI” of the “PLATFORM” definition is an indicator of an Internet EA, because the URI can be just a pointer to
a web page that defines the assignment of classrooms or other traditional delivery platforms.

A Model for Educational Material

An EM is any supporting material that can be used in an educational activity. Examples of EMs are: a
presentation, a set of viewgraphs generated out of a presentation, a text book on paper, a text book in PDF, a text
book in HTML, a web server, a video tape, a video in a streaming video server, a CD-ROM, etc. The model
given below has been designed to be able to reference a large variety of existing educational material that may be
used in educational activities. EM is therefore any unit of content that can be accessed or acquired through a
reference by an educator or by a learner.

In the past, the information was stored on paper, videotapes, CD-ROMs and other technologies that required a
physical action to access them, such as fetching or buying a book or a DVD. The Internet has made virtual
library a reality. As digital repositories can store nearly any kind of information, a virtual library connected to
the Internet can provide seamless access from any place in the world to any information. The model uses a
simple taxonomy that differentiates two categories of EMs, which will be equivalent in many cases, but
referenced differently:

- Traditional Educational Material (TEM): requires a physical action to be retrieved. For example: books,
  notes, CD-ROMs, video tape, etc.. A "traditional EM" is also represented as a "TEM".
- Internet Educational Material (IEM): can be retrieved in electronic format on the Internet. All the previous
  TEMs can be transformed into IEMs if they are made available on the Internet in digital format. An
  “Internet EM” is also represented as an “IEM”.

The first category, TEMs, should be referenced using the standard referencing procedures such as, names,
authors, publisher, ISBN, ISSN, etc. The second category, IEMs, should be referenced using standard
referencing schemes for the Internet, such as URLs or more generically URIs. MIME typing is a standard
mechanism for typing digital information in the Internet and should be used to type IEMs.

The language for describing an EM is defined by the following syntactical rules:

<table>
<thead>
<tr>
<th>Table 4. Language for describing educational material</th>
</tr>
</thead>
<tbody>
<tr>
<td>( EM := EMSEQ \mid MNAME = &quot;&quot; { EMSEQ } &quot; \mid MNAME ; &quot; )</td>
</tr>
<tr>
<td>( EMSEQ := IEM EMSEQ \mid TEM EMSEQ \mid IEM \mid TEM )</td>
</tr>
<tr>
<td>( IEM := MNAME = &quot;&quot; &lt;URIs as defined in the IETF RFC2396&gt; &quot; ; &quot; )</td>
</tr>
<tr>
<td>( TEM := MNAME = &quot;&quot; &lt;A traditional EM reference&gt; &quot; ; &quot; )</td>
</tr>
<tr>
<td>( MNAME := &lt;Educational Material name&gt; )</td>
</tr>
</tbody>
</table>

The definition of an EM accepts as the minimal EM any material that can be referenced by some means, either
with an URI or by traditional means. The model allows grouping and naming EMs as needed in a given
definition. Additionally, the model allows the reuse of EM definitions by other EMs as well as hierarchical
definitions.

Examples of EM and EA Definitions

The following examples show the usage of the model to represent a variety of types of EMs and EAs. The next
eexample depicts an EM definition, named PresentialMathsMaterial, to be used typically in a presentential course on
Calculus:
Example 1: Educational material for a presential course

The “PresentialMathsMaterial” of Example 1 groups and names the various support materials used in a typical presential Maths course. It includes the following elements:

- The “CourseGuidelines” is offered over the web in Example 1. But this material can also be presented on paper as it was usually done when the Internet was not available.
- The “ClassViewgraphs” is offered in electronic format (PDF) for download so that the learners can have a printed copy to facilitate the work in the classroom.
- The “CourseBook” is the textbook for the course which can be acquired in bookstores or lent in a university library. Here the traditional book reference is used.
- Finally, the “CourseExercises” is offered over the web for self-evaluation by students.

The second example depicts an EM definition, DistanceLearningMathsMaterial, to be used typically in a distance learning mathematics course.

Example 2: Educational material for a distance learning course

The “DistanceLearningMathsMaterial” of Example 2 groups the various supporting materials for a similar Maths course which is delivered in a distance learning Maths course. It includes the following elements:

- The “CourseGuidelines” is offered to the students over the web as in the presential case, but it can be available on paper and sent by normal mail as it was usually done when the Internet was not available.
- The “SelfStudyMaterial” is offered to the students over the web. This material usually includes theory description, complementary exercises, questionnaires and measures of progress achieved by remote students.

The third example depicts an EM definition, TheMathematicsMaterial, which groups the two previous definitions together.

Example 3: Educational material grouping the material of Examples 1 and 2

The purpose of the above three examples is to show how educational materials may be grouped together. The granularity is defined by the references used. The user of the model can choose the granularity he would like to have in his definition. For example, if books are referenced, the granularity will be established at the book level. However, it can be established at the chapter or even exercise or section level by using the proper references.

To illustrate the diversity of activities that can be represented with this model, some examples are given below, which include a variety of component types. The educational activities chosen range from traditional courses in the classroom to courses over videoconferencing or over learning management systems.

Example 4 describes a course held in a classroom. There is an overall coordinator, and each lecture is delivered by a different lecturer. The definition of Example 4 is structured as follows:

- The first three definitions are at the highest level and define therefore the overall course elements: the educational objective, the overall coordinator of the course, and the overall course documentation, including guidelines, a book and exercises. The guidelines and the exercises are IEMs and are accessible over the web. The book is a TEM.
Next, the deliveries are defined, comprising all types of lectures in this example course. All the lectures have the delivery dates specified in the schedule and are delivered in a classroom (A138 of ETSIT at UPM). Each delivery has a different set of viewgraphs to be used in the lectures. The deliveries are named according to the topics covered, for example, the first one is “LECTURE IntroductionToTheInternet” and the last one is “LECTURE SecureApplications”.

The last delivery is the presential examination that the learners must pass so as to obtain the credits or title associated with the course.

EA PresentialCourse = { 
   EDUCATIONAL_OBJECTIVE = Mandatory for year 3 of TE Level 1 Title; 
   COORDINATOR = Juan Quemada <jquemada@dit.upm.es>; 
   CourseGuidelines = http://CSDcourse.myuniversity.edu/Guidelines.html; 
   CourseBook = Java Network Programming, Elliot R. Harold, O.Reilly, 2000; 
   CourseExcercises = http://mathcourse.myuniversity.edu/exercises.html; 
   LECTURE IntroductionToTheInternet = { 
      LECTURER = Juan Quemada <jquemada@dit.upm.es>; 
      SCHEDULE = 12h-13h 5/3/02, 7/3/02, 12/3/02; 
      PLATFORM = presential lecture in room A138 of ETSIT at UPM; 
      ITTISlides = http://CSDcourse.myuniversity.edu/P1Viewgraphes.pdf; 
   } 
   LECTURE: ……. = { 
      ………. 
   } 
   LECTURE SecureApplications = { 
      LECTURER = Bernd Simon <Bernd.Simon@wu-wien.ac.at>; 
      SCHEDULE = 12h-13h 8/5/02, 9/5/02, 15/5/02, 16/5/02; 
      PLATFORM = presential lecture in A138 of ETSIT at UPM; 
      SASlides = http://CSDcourse.myuniversity.edu/P1Viewgraphes.pdf; 
   } 
   EXAM FinalExam = { 
      SCHEDULE = 12h-13h 30/5/02; 
      PLATFORM = presential exam in A138 of ETSIT at UPM; 
   } 
}

Example 4: Educational Activity — Presential Course

The same course can be offered via videoconferencing. Assuming that only the delivery platform changes and that the course has exactly the same EMs, the same coordinator, the same lectures and is scheduled on the same dates. The definition of the new course can be obtained by changing just the platform definition and the revised version is as follows:

EA VideoconferenceCourse = { 
   EDUCATIONAL_OBJECTIVE = To learn about the network architecture of the Internet; 
   COORDINATOR = Juan Quemada <jquemada@dit.upm.es>; 
   CourseGuidelines = http://CSDcourse.myuniversity.edu/Guidelines.html; 
   CourseBook = Java Network Programming, Elliot R. Harold, O.Reilly, 2000; 
   CourseExcercises = http://CSDcourse.myuniversity.edu/exercises.html; 
   LECTURE IntroductionToTheInternet = { 
      LECTURER = Juan Quemada <jquemada@dit.upm.es>; 
      SCHEDULE = 12h-13h 5/3/02, 7/3/02, 12/3/02; 
      PLATFORM = H320 Videoconferencing, connect to MCU at +34915771655; 
      ITTISlides = http://CSDcourse.myuniversity.edu/P1Viewgraphes.pdf; 
   } 
   LECTURE: ……. = { 
      ………. 
   } 
   LECTURE SecureApplications = { 
      LECTURER = Bernd Simon <Bernd.Simon@wu-wien.ac.at>; 
      SCHEDULE = 12h-13h 8/5/02, 9/5/02, 15/5/02, 16/5/02; 

Example 5: Educational Activity — Distance Course

The attendees, instead of going to the classroom, will connect a videoconferencing system to the Multipoint Control Unit (MCU) to follow the course from the distance with a computer at home or a workstation in a university computer laboratory. Another variation of this set up can be performed by attending the course in lecture rooms in different universities that are connected via a videoconferencing platform. In this case the platform should specify the MCU and also the lecture rooms connected.

Instantiating the Model at the EducaNext Portal

The EducaNext portal (EducaNext, 2003), addresses the new trends in higher education by providing a web-based tool for the sharing of learning resources. EducaNext is an educational mediator based on the technology of the Universal Brokerage Platform, which implements the metadata model presented above.

On EducaNext, educators are able to provide learning resources to their peers and specify offer conditions on which interested consumers are required to agree before accessing the learning resources. Based on general educational metadata and target-audience specific offer information (e.g. commercial offer, open content-like license agreement, etc.), learning resources are advertised through a catalogue and interest-specific mailing lists. Based on this information, educators can choose and access learning resources from dispersed delivery systems such as video conferencing applications, learning management systems, streaming media servers and standard web servers after agreeing on the terms specified. The process of agreeing on the offer terms is referred to as booking and constitutes an important means for creating awareness about intellectual property rights issues. The complete exchange process is illustrated in the Figure 3.

![Figure 3. Exchange Process supported by the EducaNext portal](image)

A necessary prerequisite for the exchange of learning resources is a common language and understanding on both machine-level and human-level. Hence, defining a common syntax and semantics is a crucial activity when it comes to learning resource exchange. The model presented in the previous sections has significantly contributed to this process. Learning resources have to be described with structured metadata in order to enable an effective access to the learning resource repository. Structured metadata provides an information base that can be used for facilitating an open interface between a brokerage platform and content-providing delivery systems.
such as the ones mentioned above. Figure 4 shows the Learning Resource Provision area of the EducaNext Portal, where providers can choose between providing an educational material and an educational activity.

On the EducaNext portal, learning resource metadata contain attributes describing the learning resource and providing hints on its usage. The general attributes of our model such as title, description, language, etc. are mapped into those prescribed by Dublin Core (and Dublin Core Qualifiers), which is the most widely spread metadata standard available (Synytsya, 2003). Some education-specific attributes such as typical learning time are taken from the LOM. In addition to standard-based attributes, EducaNext introduces its own, proprietary learning resource attributes such as educational objective and builds upon the taxonomy of learning resource types as presented above.

The design methodology followed along the principles of contextual design (Beyer & Holtzblatt, 1999). As opposed to more expertise-oriented approaches used for developing metadata models for standards, contextual design suggests that system development should follow a deep understanding of the users’ tasks.

Throughout the development of the portal, EducaNext users have constantly assessed the metadata model presented herein. At the beginning of the project — when no reference implementation was available — the proposed model was assessed by means of electronic forms, potential users were asked to fill in to virtually announce their learning resources. Already this early measure revealed that the LOM model was neither sufficient nor could the attributes be instantaneously understood by the users (The latter is an important requirement for a tool, which cannot rely on extensive user training). As a result of these early findings, the metadata model emerged more and more towards the model presented in this paper. Important milestones in this process were two brokerage trials, where users were able to actually use and provide feedback on the implementation of the metadata model.

In September 2003 the EducaNext portal had about 1,000 registered users and held more than 400 learning resources described according to the model presented above. According to our user trials the model has substantially improved the ease-of-use of the platform, especially compared with a solely LOM-based model. However, with this new expressiveness additional efforts have to be undertaken when connecting delivery systems with the portal (Simon & Brantner, 2003; Simon, Retalis, & Brantner, 2003), since the delivery systems need not only to send LOM-compliant learning resources descriptions, but are for example also required to reuse the taxonomy of this model in the learning resource type field.
Conclusion and Future Work

This paper proposes a new taxonomy for learning resources that differentiates “educational activities” from “educational material” and a model that provides a precise definition of “educational activities”. This model serves as a vehicle for defining educational offers which should be acquired or consumed by third parties with the help of educational mediators. The model can represent a variety of educational offers available since the dawn of the Internet, ranging from traditional courses in the classroom to courses via videoconferencing or via learning management systems.

The term "educational activities" is used to refer to events of which the primary goal is to educate and train persons within a comprehensive learning environment, whereas “educational material” is used to refer to units of content that support educational activities. A clear differentiation between these two categories of learning resources seems necessary for deriving proper exchange models for educational mediators. Besides, we support the argument that educational activities as a special type of learning resource are not sufficiently covered by the IEEE LOM.

The model proposed is still extensible. We consider this an important property of our model, since standards can only provide a global framework, which — especially in fields like education — requires local adaptation. Hence, the proposed model includes the most relevant aspects for differentiating an “educational activity” from “educational material”. However, it does not cover a language for expressing intellectual property rights and usage conditions, which goes beyond the scope of this paper.

To develop this work further, it may be necessary to push such models towards an ontology-based construction of learning-related concepts as it is for example investigated in the ELENA project (Simon et al., 2003). Standardized ontologies may make the open exchange of learning resources possible without requiring closed world instantiations of the presented model. An open ontology for learning resources can have two consequences: On the one hand, standardization processes would become more concept-focused requiring semantically rich definitions of attributes and their associated attribute values (a lack of both in the case of LOM and the model presented herein). An ontology-based design would also require specifying the relationships among the terms introduced at a higher level of detail (e.g. a case study guide accompanies a case study which is used in a marketing course unit). On the other hand, such an approach would make localized, educational concepts easier to integrate in existing standards, especially when they are also ontology-based. One can envision a hierarchy of concepts within which the top-level concepts such as title and description are defined by widely accepted standards such as Dublin Core, and bodies such as the IEEE LTSC provide mid-level, educational domain-specific concepts. Local-level concepts described by local stakeholders of educational mediators can then provide use-case and context specific concepts. By doing so, a new level of flexibility would be gained, which would make it easier to adapt metadata models for educational mediators.

Acknowledgements

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References


This book has the worst title ever. The title is not only too literal but it really does nothing to indicate the book’s true value. The book is really about something much more engaging than the title implies, and academics, researchers and teachers (especially teachers already working in online environments – which is in fact, the perspective of this reviewer), will find much of what is written here of value.

So what is the book about? It is about social spaces and social interactions on the Internet. The editors seek to chart the development and the study of these spaces, ranging from their earliest context (Usenet), and ending with a technical phenomenon they recognise as ‘CoWebs’ or ‘Wiki webs’ (one might reasonably ask where this ridiculous terminology comes from). Most of us have heard a good deal about Usenet, as the embodiment of much of what the early Internet was all about — asynchronous communications organised around tens of thousands of topically organised forums or newsgroups, all of which are replicated across multiple servers and networks. But few, I believe, are familiar with CoWebs, or ‘Collaborative Webs’.

CoWebs are really one representation of constructionists’ (rather than constructivists’) influences in the Web, and might be better characterised in terms of what Stephen Heppell of Ultralab (http://www.ultralab.net) has called the ‘participative web’. Back in the mid 90s, the technology necessary to enable distributed users to collaboratively build, maintain and adapt web content (as social and educational spaces) without requiring programming skills in HTML or XML, was still very new. These days, it is commonplace. In fact, during the writing of this review, my 10 year old stepson, Rolando, was working on his own collaborative web site with other children he has never met, and almost certainly never will, face-to-face, to look after and ‘sell’ his adopted collection of ‘Neopets’ (http://www.neopets.com). But perhaps the biggest collaborative web presence, or educational one at least, is embodied in SchoolNet Global (www.schoolnetglobal.com). The SchoolNet Global project, started in 1998 in the UK, has over actively involved over 500,000 young people, aged 4 to 18 in collaboratively building and maintaining a series of curriculum focused web pages. They have worked in groups to record their thoughts and feelings about life in the 21st Century, on over 54,000 web pages detailing their own lives, homes, interests, wild ideas, hopes and dreams and how they will make the world a better place. In 2000 this project entered the Guinness Book of Records as the biggest educational Web project of all time.

But back to this book. As with all such edited collections, the range of chapters are partially dependent on the interests and work of individual researchers. The editors appear to have done well to organise the full range of contributions into 3 coherent sections: Introduction to Online Studies and Usenet; Studying Spaces; and, Enhancing Spaces. All the chapters find an appropriate home within this categorisation.

So, we find we have the very interesting historical/political analysis of Usenet’s origins from Pfaffenberger; a more straightforward yet still intriguing ‘social accounting’ of Usenet by Marc Smith; and an analysis of Usenet postings in terms of demographics, conversational strategy and interactivity from Whittaker, et al. Conclusions reached by the latter authors are really very stimulating for anyone committed to the use of asynchronous communication tools in education (for example, the greater the diversity of the online population, the more likely it is one will find stilted and unsustained conversations in postings). Another chapter focuses on the difficulties of understanding ‘lurking’ more completely (Nonnecke and Preece), in which the authors offer an insightful perspective on the practices associated with non-contributory approaches to mailing lists, Usenet groups and the
like. Of course, few suggest that lurking is a permanent condition of online participation, but most accept the practice is widespread. However, I wonder if lurking is really worthy of such lengthy consideration — lurking is, in the final analysis, surely just another characteristic of online discursive behaviour.

For me, the most interesting yet in some ways the more frustrating chapters, among a preponderance of interesting chapters, are those grouped together in the final section of the book (part 3). These chapters are all focused on enhancing social spaces on the Internet, through the application of technology innovations (for example, enabling the distributed and collaborative management of web content); and through the adoption of processes such as data mining – that is, filtering large amounts of data so as to make predictions of individual behaviours, for example (Amazon.com use data mining processes to make book recommendations to individual and new users of their online services). I say interesting, because these chapters provide insights into current and future embodiments of social spaces on the Internet; and frustrating since they perhaps don’t go far enough in these insights. For example, much is made of the attributes of online spaces and what a better understanding of these might hold for studying and creating such spaces; but nothing is spoken of the effects of innovations such as the ‘adaptive web’ – web sites that automatically improve their organization and presentation by learning from user access patterns – on the appearance of these spaces. In fact, for me the latter part of this book loses direction somewhat and fails to build on earlier chapters concerned with the behaviour of both individuals and groups in web spaces.

Overall, however, this book is a valuable read and I’d recommend it to anyone with a practical or research driven interest in the design, development and implementation of online spaces for social interactions.
Designing Information Spaces: The Social Navigation Approach
(Book Review)

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Textbook Details:
Designing Information Spaces: The Social Navigation Approach
Kristina Hook, Bavid Benyon, Alan J. Munro (Eds.)
2003, Springer-Verlag Berlin
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There seems to be an infinite capacity for more and more sophisticated functionality in today's digital technologies. We have long surpassed lowly word processing, financial tracking and forecasting, synchronous and asynchronous communication, health and medical diagnoses, gaming, VRML, and so on. Newer generation machines and software have progressed to tracking world stock markets, launching military smart bombs with microscopic accuracy, fully equipped smart homes, and even entertainment (witness the magnificently generated Golum in Lord of the Rings). There seems to be no foreseeable limit to growth.

And yet it is a sobering reminder that as sophisticated as these new digital systems may have become, they are at best only inferior approximations of the human capacity for socialization and information processing that we as a species have naturally shared long before computers were ever even imagined. In this sense even our best computing programs have "dumbed down" the sophisticated nuances that occur between two or more people in the same room or in a shared physical space. This dumbing down has been neither deliberate nor accidental; rather, it seems to be the inevitable consequence of any design process. Our designs are always less than the sum of who we are and what we know. Thus while it may be true that human beings need to adapt to computers, it is also true that our interface designs need to adopt to us by being more realistic and faithful to the good old-fashioned face-to-face human experience. Achieving this fidelity is much more difficult than one might suspect, but well worth the effort. Designing Information Spaces goes a long way in surveying the landscape and showing us where we are and where we should consider going.

"Social Navigation" is many things: it is a theory, a philosophy, an analytical approach (a kind of methodology) and a design approach that recognizes the human experience in social space as the real center of interface design. The idea is that as we move (navigate) through physical or informational space, we are always looking for clues and hints from other human beings who are around us in the here and now, or for clues from human beings who were here before us. Research and design in these new areas are surely sunrise industries. These authors are (rightly) insistent that their notion of social navigation is new because it emphasizes movement "within" information space rather than conventionally seeing the user/designer as someone trying to "bridge the 'gulfs' between themselves and information" (5). The idea of real and metaphorical immersion in recognizable and habitable space is at the core of this new line of thinking.

Designing Information Spaces is an anthology of seventeen collaboratively-written essays by thirty-two very creative minds, and it surveys and re-interprets a wide range of innovative interface design research. My own academic and career history is a mixture of architecture, literature, and HCI. I always felt awkward when I tried to explain to people how that was a natural progression and not the random shifts of an undisciplined mind. I am now delightfully surprised to see that these very same elements are at the core of this book. The authors, and the experimentors they engage, all want us to imagine interfaces that metaphorically and symbolically reproduce the intangible and abstract social bonding between human beings. Through the language and metaphor of architecture, urban topographies, variously positioned avatars and other visuals, it is possible to design interfaces that reflect in a very dynamic way, the many nuances of social interaction. The keynote of the book is the idea of "footprints in the snow" (1) and it begins with a reminder that we rely on others and take are behavioural and navigational cues from those around us. This reliance on others should not be confused with passivity, but rather it is a very active and engaging process by which we seek connections with other human beings in order to get what (and where) we want. There's not one weak chapter in the book, but perhaps a few examples will help.
make the key point that I want to make, namely that using social navigation as a design approach can be very effective, but is also still at frustratingly limiting stage of development.

The idea of the anthology is that each chapter looks at a different area of HCI innovation and then proceeds to summarize, analyze, and theorize much of the HCI research done in the last ten years, and to show how different kinds of experimentation can be understood (or in some cases re-interpreted) in the light of social navigation. For this reason alone the book is extremely valuable, but there is much more.

The core research activity from which emerge the other satellite activities described in this book, is the Footprints Project itself. The experiment was an attempt to create and comprehend interfaces that could visually express the "interaction history" (226) of social activity. There are six parameters that shape interaction: proxemic/distemic (closeness of people), active/passive (whether signs of our presence are left deliberately or inadvertently), rate/form of change (how historical data is saved and purged), degree of permeation (how rich or lean the symbolism is that records our presence), personal/social (group versus individual records) and kind of information (what, who, why, and how) (226-231). These parameters allow designers to measure, and consequently visualize in the interface, the entrance and exit of individuals or groups from social space, narrative experiences, storefront experiences, message experiences, and so on.

The lecture proxy is one example of an experimental attempt to produce an interface that visualizes the social dynamics of what happens in a typical lecture or conference call where a main speaker addresses a relatively large audience and questions can be asked and answered. The aim of this visual metaphor (they call it a "proxy" (26)) is "to provide a visible representation of the interaction that foregrounds the … expectations that define" the experience (26). The interface itself is a dynamically updatable a pie wedge on its side with the point of the pie on the left and the wider circumference of the outside of the pie on the right. The speaker is represented as a simple avatar (a small colored marble) nearest to the point of the pie. A long as that person is the main speaker and no questions are asked, the speaker's marble remains apart from the other color marbles, each of which represents another person involved in the interaction. If someone asks a question their marble moves closer to the front and hence the speaker, and by implication, the avatars of people who do not interact with the speaker fade further away from the speaker to the outside of the pie. The key point here is that "proxies can … make interactive expectations visible" (27). As compelling as this model is (and I would very much like to see it in use) the fact remains that the proxy is still disturbingly naïve about what constitutes social interactivity. For example, in real life situations audience members could interact with a speaker's delivery by passing notes or talking to each other, or even by scribbling notes down for themselves later on. So what are we really measuring except the most external of interactive parameters? And from the user's perspective, receding marbles might easily be misinterpreted to mean that the audience is not interacting at all, when in fact they might be spellbound by the speaker and silently processing information in very active ways with each other, or even through body language. Still, the idea holds great promise.

I was particularly fascinated by Joseph A. Konstan and John Riedl's article (chapter 2) entitled "Collaborative Filtering: Supporting Social Navigation in Large, Crowded Infospaces" (43). They define collaborative filtering as a system of "signposts" that are not the same for all users, but are "dedicated to presenting each user with the most individually relevant information" (44). There are many challenges in setting up and maintaining intelligent CF systems that either "push," "pull," or "automate" advice about purchases, choices, or tastes of other like-minded individuals. CF can be a very effective way of managing the massive amounts of information that all of us are challenged to sort through. They provide many compelling examples (the authors call them "motivating" examples) of successful and potentially successful interfaces that visualize not just what the recommendations are, but also show how close our own preferences match those like-minded people. The most interesting work here is that done by Herlocker et al (2000) that links choices to the preferences of a whole group of demographic called "neighbours." The idea here is to make recommendations to known users rather than unknown ones (81).

CF has very powerful implications for marketers because it actively tries to link preferences with a socially definable group. Throughout all of this, however, I am still ambivalent. When it comes to purchasing a car, I would very much like to know if a group of users in my income range found it difficult to keep up with (say) the high cost of imported parts, but when it comes to the value of taking a course in Greek rather than in marketing, I worry that any form of CF will make a recommendation on quantitative criteria rather than qualitative. Some of the best music I ever listened to originates from the back tracks of a record or CD and not from what everyone heard on radio and TV. How low a consumer or user profile can you have before you drop off the significant list? What does this imply about the pervasiveness and hegemony of user opinion and taste, and would CF contribute to that homogeneity? Would such a contribution be good thing or a bad thing?
The article by Andrew McGrath and Alan Munro (chapter 7) entitled “Footsteps from the Garden: Arcadian Knowledge Spaces” (175) is another interesting chapter for me. The idea here is that information gathering is very much a social process (182) and that visualizing both the search process and the results can be visually and metaphorically expressed as organic process (and even product), hence the idea of the garden. Designs that rely on the garden metaphor to visualize knowledge need to take into account the idea of inherent, inevitable and unpredictable growth, as well as the ongoing need to prune that which is irrelevant, and to keep re-organizing that which is. The metaphor of the tree or plant also affords itself as a good representation of how various bits and pieces of knowledge are related (trunk and branches) and how they are related to each other (positioning in the garden).

There is much to be learned from this very fine book. It describes, synthesizes, theorizes and provokes the imagination. It excites the mind with new possibilities and encourages thinking "outside the box." It provides a comprehensive overview of the more exciting and compelling new directions in interface design and it does so in a language that is refreshingly free of the tyranny of academic jargon. Don't be fooled by the simplicity and clarity of language here. The words on the page may be simple, and the metaphors used to describe the ideas (ex: "footprints in the snow") may be simple, but the ideas most certainly are not. I found that the index is not very helpful, but this is a very small blemish on an otherwise excellent overview and re-assessment of the current state of HCI thinking in interface design. Well done indeed!
From a village in rural Ghana, Dr. John Afele has studied in Belgium, Japan and Canada. He has traveled further on development missions and for conferences, for instance as a Board member of Global Knowledge for Development. Serving as a North-South bridge person in worldwide knowledge networks through the Internet also qualifies him for the book’s theme. His focus is on innovative ways to bridge the global digital divide and to empower local economies with global knowledge. He pursues every possible way that the least fortunate could be assisted more effectively by development grants, intellectualizing indigenous knowledge, mobilizing Africans of the Diaspora and others concerned with development. The reader can see issues through indigenous eyes where actual conditions, needs and possible solutions can be more clearly assessed than through the intermediation of international development agencies. A social dimension of the book is evident in having extensive Acknowledgements near the beginning of the book, plus an emphasis on networks and partnerships as well as ideas and technologies.

Content-wise, the book is classified as economic aspects of knowledge management, IT and telecommunication for developing countries. Dr. Afele also details agricultural issues, indigenous practices both ingenious and inefficient, along with scientific suggestions based on his Doctoral training. His attitude is that Africans in particular need food but also IT, as knowledge is urgently needed for self-sufficiency and economic development. Drawing from his experiences with international development organizations, his critiques are understated in keeping with his humanistic ethics. Although not mentioned in the book, he remains constructive despite many of his own ideas having been adopted without reward or attribution by prominent international projects. Thus it is important that the non-Western author’s knowledge, sometimes his only wealth, is not siphoned off. In any event the value of this book is not in sound-bite conclusions but rather in the stance and detailed prescriptions for greater effectiveness of development initiatives.

That being said, the following brief account of the chapters will include some quotations to convey the author’s approach. Each chapter has numerous references, often available online with URLs provided. In the Preface, Dr. Afele writes that “[b]uilding a knowledge community necessitates that talents and ideas are identified; creativity is nourished, capitalized, and translated into tangible services and products for the primary impact zone” (p. viii). This is in contrast, as he explains later, with local talents serving as cheap labor for products made only for export. In Chapter I, Introduction, he argues “for customized IT systems that are realistic, given the infrastructure, social, and inherent intellectual capital of the impact communities” (p. 16), which he details in the following chapters.

Chapter II. Standards of Knowledge Communities briefly establishes the terrain of current events and debates in the development field, and the expectations that global standards could be applied to transitional and developing countries. Chapter III, Nurturing Knowledge Communities uses the African corn industry as an example and addresses some of the daunting problems of the region such as HIV/AIDS from a scientific viewpoint. While he advocates expert systems, his focus is on empowering people for self-help, local talents and facilitators thereof. He acknowledges ingenuity gaps which unjustly importing state-of-the-art technologies from IT-rich countries, but tailored to the indigenous social system by local facilitators. Development projects are usually dispensed through governments and trickle down if at all through elite classes. Dr. Afele would have all local families record their life details and changes for online knowledge systems designed to assist them better with their input.
Chapter IV. Splicing Modern Knowledge and Ancestral Wisdom aims to preserve and capitalize upon indigenous cultural traditions in adopting new technologies. Since the colonial era, educational systems in Africa have not incorporated local knowledge, engendering technical and intellectual dependency rather than self-reliance. The continent has been subject to predations of cultural goods as well as diminution of traditions. So while readers may wish to hear more of what or how ancestral wisdom remains, Dr. Afele seems more intent on finding every way that the well-being of the poorest humans could be enhanced by modern knowledge without attendant sacrifice of cultural identity.

Chapter V. Digital Bridges and Digital Opportunities for Developing Nations is the longest chapter and does treat developing regions besides Africa, such as Southeast Asia. Taking the global digital divide largely as a given, the chapter is full of ideas on how state-of-the-art technologies could be applied to specific needs. Dr. Afele cites current events and actual activities of development-related networks, both of which should be familiar to many readers of this review, to exhibit problems and limitations of mostly top-down approaches. His prescriptions are wide-ranging and refreshing in treating local realities with bottom-up solutions. He shows acute concern for changing brain drain to brain gain, for education and HRD, for the plight of women whose talents could enhance national development, for health and security, for youth groups and governance. To the rather accusing question of food or IT for Africa, he wants both but calmly shows how IT could assist in enhancing local ingenuity, how modern knowledge could lead to greater agricultural self-sufficiency.

Chapter VI. Globalization and Frameworks for Digital Opportunities looks for ways to improve the functioning of international development institutions, mobilizing public opinion, and spreading awareness of global issues. Chapter VII. Capitalizing the Knowledge Economy of Developing Nations focuses on the need for fund-raising to help break the cycle of poverty. He also points out how, in many developing countries, national budgets are skewed to military spending, often to defend a corrupt regime, so more benevolent democratic leadership could free local budgets to be allocated more constructively. He often tries to include Africans of the Diaspora abroad, even African-Americans, in the search for solutions by joining people together. A deeper leitmotif of the book is that such people, to which readers might see the author as a leader, are the most salient bridges to connect global knowledge to local needs.

Chapter VIII. Preservation of Cultural Identity and Preventing Piracy of Indigenous Intellectual Properties is the briefest of the main chapters. In keeping with Dr. Afele’s focus on the positive, he holds problems with piracy of his own ideas in abeyance and mainly appeals for more awareness, inasmuch as intellectual leaders of developing countries are already at a disadvantage in actualizing their visions. He does caution that even digital bridges could “encourage external agents to siphon off valuable knowledge from the poor communities, just as natural resources such as minerals and forest products, and local arts and crafts were subjected to” (p. 194). He focuses more attention, however, on specific remedies such as Websites in local languages to help bring about the best of both worlds.

In Chapter IX. Postlude, Dr. Afele concludes that “digital opportunities could be deduced from the information and knowledge needs of these economies, such as the need for better access to telecommunication infrastructure, tools, knowledge networks and communities of practice, expertise, and opportunities to build on local knowledge (p. 198). Connectivity should enable people to learn, solve problems, produce more efficiently, preserve natural systems, and foster peace among communities and nations.”

As can be seen from the quotations, the book is rather dense and perhaps better read little by little. Another round of editing to make especially the earlier sections more readable might have made this an award-winning book. The value of the book lies in extracting the details, both the indigenous viewpoint and the innovative ideas.

Dr. Afele is currently maintaining the International Program for Africa that he started as an agricultural faculty member at the University of Guelph. For further online reading, see: http://www.waoe.org/africanknowledge/.
Implementing Collaboration Technologies in Industry - Case Examples and Lessons Learned

(Book Review)

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The book, of operative nature, identifies a taxonomy of factors that affect implementation of collaborative technology and provides a series of practical advices for successfully realiseing such implementation. Collaborative technology is intended in a broad sense, that is as all the types of information and collaboration technologies that have a potential to support collaboration and the corresponding infrastructure technologies. Attention is mainly focused on the adoption problems due to the attitude and feel of users and to the organisational context.

Factors affecting implementation and their taxonomy are discussed on the basis of previous research in the field, in particular experimental. Advices are derived mainly by the analysis and the comparison – guided by the taxonomy - of a number of case studies, that refer to the experience of a number of big companies.

The content is organised into three parts, each one including several chapters, and three appendices. Bibliographical references and an analytical index complete the book.

Part 1 (including 4 chapters) is introductory with respect to collaborative technology, frames the context and the main problems. Chapter 1 shows the book plan (this choice is a bit confusing). Chapter 2, after a very brief historical overview, defines collaboration technology, presenting a classification framework that comprises five categories: communication technologies, shared information systems, meeting support tools, coordination technologies and integrated products. These categories are presented mainly from the point of view of their functionalities and of the possible applications. In Chapter 3, research findings and experiences in industry, collected from academic publications, are analysed, with the attempt of identifying factors that affect implementation. On this basis, a taxonomy of these factors is constructed and presented in Chapter 4, aimed at guide the interpretation of the case studies presented in the following part.

Part 2, that includes 6 Chapters from a number of authors from academy and companies, presents a number of case studies of organisational implementations. This part aims to clarify key aspects which contributed to successful adaptation of collaborative technology in a number of big companies. Chapter 5 (by Munkvold and Tvedte) discusses the ten-years experience on the introduction and use of a variety of collaboration technology in Statoil, a Norwegian oil company. Chapter 6 (by Munkvold), reports the empirical findings deriving from the establishment of a collaborative infrastructure and its use to support collaborative projects in Kvaerner, a Norwegian engineering and construction group. Chapter 7 (by Poltrock and Mark) reports the problems related to the adoption of a data conference service in the Boeing Company. Chapter 8 (by Palen and Grudin) focuses on the use of collaborative calendaring applications. The factors that contribute to the current use of these applications are discussed, by comparing findings about experiences of the mid-1980s with the results of two interview studies carried out at Microsoft and Sun Microsystems (mid 1990s). Chapter 9, (by Evjemo, Akselsen
and Grav) outline some practical guidelines deriving from the 10-years experience carried out by Telenor, an ICT Norwegian company, in particular from projects a tele-radiology service employed in the health care sector, a collaborative solution to support local politicians interactions, a lotus note application aimed to support management, daily collaboration and team maintenance in case of a Telenor distributed teams, a technical and organisational structure for clusters of companies. Chapter 10, by Bostrom, Kadlec and Thomas refers to the experience gained through an e-learning project referring to an MBA programme developed by the University of Georgia Terry College of Business for a North American Consulting Group (PricewaterhouseCoopers). The findings are based on data derived from the actors involved in the overall process (teachers, students, implementation team, management).

Part 3 is organised into two chapters, 11 and 12. Chapter 11 revises the case studies of Part 2 trying to identify elements particularly influencing the implementation of collaborative technology, and discusses them at the light of the taxonomy presented in Part 1. On this basis, Chapter 12 presents a number of general recommendations aimed to guide the planning and implementation of collaborative technologies.

A number of Appendices complete the content: Links to collaboration technology forums and resources, links to the sites of examples of products (both quite limited) and the taxonomy (useful).

The book aims to address the research results about the complexity of the process involved in the implementation of collaborative technology towards their practical implications. In my opinion this is reached only indirectly, as the focus of the work is mainly on the practical side. However, researchers can find in the book very valuable hints and indications about the problems to be faced to transform research results into companies’ innovation. The book, which is easy readable, is full of practical indication deriving from experiences in real organisational contexts and covers a wide spectrum of collaboration technologies: thus, it is particularly interesting for practitioners, such as managers of enterprises who have to plan the introduction of collaborative technologies in big companies and people who has to realise this introduction.
AniCAM: Developing stream based teaching resources

(Software review)

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Product details:

Product Name & Version: AniCAM Lite (Version 1.0, build 0821)
Product Category: School/university multimedia, intranet and internet software
Producer Name: Nian-Shing Chen, Shin-Yi Huang, National Sun Yet-sen University
Product link: http://anicam.elearn.com.tw/
System Requirement:
- Windows ME, 2000, XP
- Pentium class 500MHz+
  For capture: Using Microsoft Video 1, at 2FPS and 1024*768, 10GB disk space is required to store 30hrs of film. This is then compressed to a WMV file. A version that captures direct to WMV file is being developed.

Snapshot review:

Ease of use: ****
Ease of navigation: ****
Documentation: NA
Price/value ratio: NA
Pedagogical foundation: ***
Instructional values: ****+
Interactivity: ****

Background and features

1. Introduction

In their paper “Applying Evolutionary Prototyping Model in Developing Stream-based Lecturing systems, Nian-Shing Chen and Shun-Yi Huang describe three models of course delivery. Synchronization mode, Browser capture mode and full screen capture mode.

In Synchronization mode four separate files are created by the lecturer (video stream, audio stream, teacher’s annotation and the associated html pages). Inconsistency in presentation on the student’s browser and special players for viewing are listed as some of the problems.

In the Browser capture mode the teacher captures the contents of the Browser into a streaming video file (e.g. WMV), records whatever is displayed in the browser space. The major drawback is that if the teacher wants to display say an application outside the area defined by the browser window it is not recorded.

2. AniCAM Features

AniCAM allows capturing of the entire screen, with teacher annotations to create one streaming video file that includes the images supplied by a web-cam and sounds recorded via a microphone. This is shown in Figure 1.
Figure 1. An Anicam streaming video displaying an annotation and web-cam. The tutorial is on the windows sound recorder.

A simple control window allows record/stop and customization options (Figure 2). The control window can be minimized while recording. Capturing is to an AVI file, then using an encoding wizard this is converted to the WMV streaming video format.

Figure 2. AniCAM control window

3. Installation and operation

Installation was straightforward, though on Windows 2000 the logged in user must have administrator privileges. A special English version was used as the development version was in Chinese.

Operation is via the control panel (Figure 2). This is enhanced during recording mode to add the annotation commands (Figure 3). Additionally the recording mode control can be hidden and function keys used to control operations such as pen drawing on/off, and Anicam recording off. Using this was straightforward and intuitive.

Figure 3. AniCAM – enhanced controls showing annotation commands

Recording sound via a head set microphone on my Pentium III 850 Laptop with a Hard Drive approaching full, proved unsatisfactory with the sound out of synch with the images, and of poor quality. Trying AniCAM on an AMD500 with a new and fast Hard Disk gave better results.

The AVI to WMV file encoder would only encode to a maximum of 800 x 600 so setting the screen properties to 800 x 600 created a better quality output. As with any sound/video capture the quality of the equipment has a major effect on the quality of the result.

A second version is currently being developed allowing for immediate capture to a WMV file.
Anicam Maker is also available that enables simple editing of captured AVI video. At present this version is in Chinese.

4. Critique

4.1. AniCAM in teaching and Learning

In a course that the reviewer was a participant in, a discussion was had regarding the suitability of systems such as AniCAM to teaching and learning. AniCAM was first demonstrated then discussed. A summary of this discussion follows. It should be noted that updated versions were made available subsequent to the discussion, so some comments have been modified and represent the current version.

4.1.1. Advantages

For pre-recorded sessions, the system would have benefits to Extra-mural students, as it would give a “live” feel to what are traditionally static content notes. For lessons that are recorded in real-time, then made available as a movie, the system would be useful to students as they can review the lecture including teacher comments and class interaction. In the case of timetabling clashes or absences students would be able to view the lecture they have missed. The video lesson was seen as an addition to normal teaching delivery. If the video lesson was constructed well it could be part of a repository of video lesson clips. It was thought that the video lessons would be most useful in practical subjects such as cooking. The inclusion of the video allows for the teacher’s personality to be included into the lesson.

It was believed that an important advantage would be that the lesson video could display reasoning behind a concept. For example, developing a graphical representation of a system is not just showing the final result (as would be the case in a static system), but the reasoning process that were used to create the diagram.

4.1.2. Disadvantages

Given that the lesson is a complete steaming video file the following observations were made. As the session is streamed, the video will be viewed sequentially until fully downloaded to the PC, this means that essentially it is asynchronous. As the lesson video file is created prior there is no interaction between the teacher and learner. If the lesson is captured in real time the student interruptions can break the flow of the lesson. (This is to be addressed with Anicam Maker – which was not available when the class discussion took place).

Concern was expressed as to the quality of the lesson video. Video production is a skilled process and production by amateurs can create poorly constructed, difficult to follow and inefficient files. For example, video compression can be improved by using white space effectively; the position of the web-cam can make a big difference to the linking of the teacher to the content. The suggestion that the video could be edited was discussed. Those who had edited video previously indicated that this was a significant task, and in many cases could take longer than the time it took to create the original video lesson.

Privacy, copyright and ethical issues were also discussed. There are many things that need to be considered in this area. Performance issues were also noted. In the demonstration the video was often out of sync with the sound. This created a disturbing effect for some in the group. A suggestion was made that lesson videos be created with a range of common frame rates.

Compatibility was discussed. If the files were created in WMV the student must have available a WMV player. At present this is available on modern Windows systems but not on many other platforms. This issue will probably resolve itself over time.

4.2. Application models

Possible applications that AniCam could be applied to include:

- Recording of an actual lesson. This is the model proposed by the authors.
- Prior recording of a technique. For example a complex graphic task can be illustrated, where the techniques can be discussed while they are being demonstrated.
Recording of a “brain-storming” concept map. Where a concept map is being developed the rational and reasoning behind the entries can be as important as the entries themselves.

For new software it can assist in evaluating the human-computer interaction. As the recording is in real-time and can include verbal input, system designers can track the movements of new users in their application. This will give a valuable insight into the usability of the software.

Help desk. When a user has a reproducible problem, they are able to record what was done to cause the problem. This would greatly assist a Help desk operator in identifying the causes of the problem.

Creating multimedia video elements. As the use of Anicam is straightforward, it could be used to create simple Internet and TV advertising. A video of a presenter could be captured along with product information.

Student assessments. Students could use Anicam to record the answer to an assessment item, for example dismantling a PC recorded via a web cam with typed notes and verbal comments included. This could be set up in such a way as to prove authenticity of the student with the assessment.

Annotating existing PC video. As a video is displayed on-screen, use of either voice or a notepad that can be captured with the video is possible. The PC video could be paused while the annotating is being made.

5. Observations in creating a sample session

In the first example, a short video that would illustrate a mail merge in Microsoft Access was to be created. For this no Camera was attached just a headset microphone. Setting up was reasonably straightforward. To highlight a button the drawing tool was used. Unfortunately in this version returning back to the standard cursor mode was not possible (There is a bug-fix that resolves this problem). By creating multiple short videos the task was completed. One of the main observations to come out of the first recording is that it is important to be able to do basic editing of the video. In recording you make false moves (for example opening the wrong window) or at the end hunting for the AniCAM off button? The video continues to record these. Anicam maker is actually an important tool and needs to be included with Anicam.

Playing the video produced its own challenges. As the video was saved at 800 x 600 (see earlier note), playing the video in Windows media player on a screen set to 1024 x 768 distorted the image, as the controls of media player meant the viewable area for the video was less than 600 pixels high. Attempting to run the video in full screen produced the alternative effect of stretching the video also creating an undesirable effect. Experimenting with different skins it is possible to choose one with minimal controls so that the full 600 depth can be displayed. Another alternative that was explored was to place the video in a web page and set the height and width properties to display the video correctly.

Recording techniques where a Web-Cam is included needs to be explored. Initial efforts with the reviewer included in a video window, actually distracted from what was being demonstrated.

5.1. Observations

It was thought that a video of an entire lesson would create attention and concentration problems for many students. A repository of video lessons could be considered where examples of best practice lessons are available to course builders. Also, in the repository associated case studies could be included, from say an expert or practitioner in the domain. The streaming video files could be hyper-linked by teachers into their own lessons. The availability of the lessons on CD or VCD should be considered in cases where there are slow bandwidth problems.

Anicam maker is an important and essential part of the application, as editing the video is important to edit out undesirable parts. This needs to be as simple as possible, as editing quality video is a time consuming and demanding task.

This innovative application will be applicable to a wide variety of teaching and learning situations.

6. Reference

Nian-Shing Chen and Shun-Yi Huang (2001), Applying Evolutionary Prototyping Model in Developing Stream-based Lecturing systems.