MODULAR, SCALABLE AND INTERCHANGEABLE LEARNING OBJECTS, CONCEPTS, IMPACT AND REALISATION

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Abstract *¾ Innovative multimedia training systems become more and more important. The amount of available digital content is rising permanently. However, this material mainly exists in in proprietary formats and within heterogeneous solutions for wbt-courses. In this paper is shown that well structured educational material is not only of interest for creating and producing, exchanging and combining well formed courses, but may be also important for evaluating user interaction. Well-formatted material is an important factor for user evaluation and product improvements as it allows parsing content and matching the results with patterns of user interaction. Therefore efforts are made to evaluate the structure of learning objects and user interaction within given frameworks. The article emphasizes the importance of structure and behaviour for generating additional information of learning units.*

Terms ¾ educational content, standardization and user evaluation, XML-markup languages, parser

INTRODUCTION

Due to the fact thatcomputers integrated in networks are widely available in education, more and more digital material is created and used in the context of teaching and learning. However, the production of learning material is still orientated towards proprietary formats, non-interchangeable methods and non-standardized content. Some progress with respect fosoftware engineering and systematic instruction design has been made during the last years, but state-of-the-art technology still uses a craft men's way to implement practical modules (units of study). The opportunity to get out structure information from the content body – in contrast to meta standards - in a more general way to extract structure information is not yet exploited. For further creation and evaluation it is important to extract user interaction data for instruction models and improved learning courses. The following model offers these capabilities and supports producers and students by offering more objective results.

CONCEPT OF THE MODEL

Basicly two parts can be distinguished. The structure of the course modules – called structured information base (SIB) ,and the communication base (CB). The content material is combined and enriched with pedagogical information (like instructions etc.) and forms the didactical structured information (DIB). The material is embedded into the learning environment. Above these structures communication processes occur - the resulting data is called communication base -, when student access material in the learning process. Interaction processes between students and the objects within the wbt-system are monitored. Therefore, the learning environment [1] consists of the communication processes data and information which is transformed.
The basic concept consists of structured content objects. They are marked up thus allowing to separate structure of the content and surface information. Educational content is produced and stored in a production [2] environment which consists of either a file system or a database. The ready-to-publish modules are deployed for futher use. To determine the structure of the content some procedures are necessary.

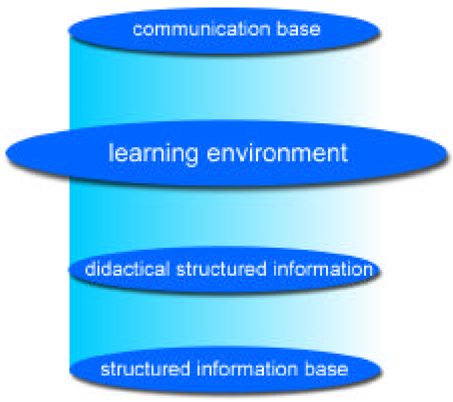

FIGURE. 1
INFORMATION FLOW AND COMPARISON BETWEEN CONTENT STRUCTURE AND USER INTERACTION

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Structure information is striped out by reading the semantic tags. Existing attributes of the material like frequency of characteristics (e.g. text characteristics), size (amount of ASCII-characters in the text), duration (time) or quality (kind of media type) are extracted and serve for later calculations. After finalyzing the static content is embedded after finalizing into the dynamic environment. Dynamic environments are typical learning plattforms[3] [3] [4] which allow to generate and store user data like working and testing results. Dynamically generated experiments and simulations [5] are linked to the particular environment, not necessarily and physically on the same location. They may be distributed on different spots. Users are personally logged into the learning environment, and through their interaction with the system they generate behavioural data. In the last step, the structure information is matched with the interaction information in order to locate the content and the action taking place on it.

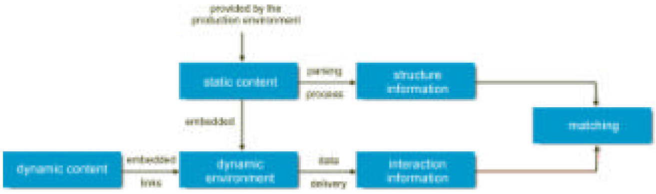

FIGURE. 2
INFORMATION FLOW AND COMPARISON BETWEEN CONTENT, STRUCTURE AND USER INTERACTION

Structuring content

In order to achieve usable results for evaluating learning material and later improvements of the learning system and the entire objects two factors are critical: Dermination of the content structure and its distinguishing characteristics on one hand and the result of the runtime environment on the other hand. Well formed static educational material is filled in a special production repository or an integrating publishing environment. In a first step the file containing the content and the structural data is parsed for the markup tags and the respective characters extracted. The results of this process are written preferably into a database for later access. The aim of this procedure is to detect different statistical and semantically relevant items the material consists of. The cours material is normally created according to assumptions and according the later use.of special interest are the basic nodes[4] of information – we call them presentation units or short pu's - and links which connect the nodes. The amount and the kind of links structure the module from a more linear to a hypertextual formation. The node has an id and is represented by an unambiguous number for storing into the data base. This allows to describe main aspects of the document structure.

The static material on the online learning environment is supplemented by dynamical data which is generated in real time and - depending on the configuration - partially weaved into the static content. Dynamic data like results of e.g. experiments of satellite bandwidth simulations are included into the static text based body and thus offer more flexibility for learning in this environment.

System activities and user interaction

Important for further calculations is the extraction of system activities and generating user data. Three components are of interest:

- **Learning platform:** Information from the server log-in data serves as a source for user activities. This leads to some problems. It has the disadvantage beeing not enought meaningful as asource for valid user data - because neither it can control client side activities nor time duration for user activities. Only frequencies of requested media data are not useful to evaluate learner activities on these modules. Due to technical delay there is a lack of permanent stream of system messages which lead to a couple of problems.
- **Experiment server:** For servers running special experiments protocols are written for students' access. These servers handle the simulations separated from the learning environment. Running experiments may be protocolled and the user driven results can be logged and evaluated later.
- **Client interaction**: Users' working profiles based on internet browser distance learning environments are screened on the user side. Time based information streams are buffered and transmitted to a central logging server. This offers the opportunity to create time based Information.

Matching structure and user interaction

The extracted structure of the static content is saved into a data base and the results of the user behaviour are compared in a matching process. This allows to compare the structure of the content with the user profiles generated within the server and client interaction.

The results are used for later calculation and comparison with other evaluation [6] sources like standardized questionnaires or results of communication processes.

The advantage of this method of proceeding is the fact that user data is separately stored from the structure information. User accumulated profiles deliver more general statistical data to match. Personal data can be protected against abuse, as collecting and storing on one hand and matching on the other can be done separately on different databases or even offline.

The raw matching result from the above mentioned comparisons are proceeded in conjunction with user model assumptions on a higher level. Didactic paradigms are

[3] platforms are subject of evaluations concerning several characteristics
[4] nodes are synonymously used to screen, frame or foil s, basic units of presentation

verified. The user and content model formulates expected coherences between the given structure and interaction results and the theoretical model. The system/user verification results serve as cues for future developments. in addition to the learning module[5] information is matched with results of usability [7], [8] studies[6] and questions. The results are stored for later post processing or are passed to online tools for real time calculation and output.

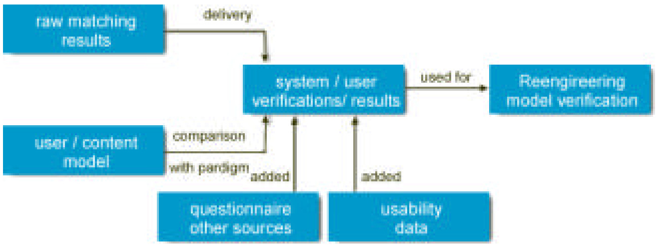

FIGURE. 3
MATCHING PROCESS OF EXTRACTED INFORMATION AND USER INTERACTION

The collected results serve for different purposes:

- **Learners** can enhance self-organized learning by using the calculation results as feedback mechanism
- **Teachers** get a tool to steer online courses more powerfully
- **Autors** and **producers** get structure information to match several didactic instruction models and have feedback information how their modules are really used
- **Modell verfication** enabels information if the model of learning and instruction within the context is adequate
- **Re-engineering** of the courses in the next life cycle enables improvements of material by obtaining more objective information

Modeling content and user interaction

The unambiguous identification of the content - the kind, amount and interactivity level just as the interaction profile of the user are stored into a database system for later calculations. The database has to be connected to the Internet, as the interaction data by the acting users is transmitted online and written into files. For the implementation availability of the system and performance is important. Time outs and connection delays have to be handled just as bandwidth problems and security aspects concerning personal user information. Technically the system has to collect statistical data from the server like browser information and frequency of access. Transmissions form the learning platform to the interaction server are necessary. Further dynamically generated information has to be passed from the experimental gateway server to the collecting server. The most critical information is served by the client of the modules. The students are working in the browser window. As standard browsers are widespread they are the most common interface for working in network related environments. Interaction patterns are generated by browsing the content within elements, for instance using scroll bars or following links. All this navigation and interaction results are monitored and structured in a way allow to save them to categories. This enables to watch navigation within the content as well as locally as superordinate objects, e.g. global indices or glossaries . Learners access different objects like practicing within calculation exercises watching videos or animations. They navigate 3D objects or perform special tasks. Multiple choice tests [9] or dialogues running on a server allow picking results and writing them into the database. Very important is the collection and filtering of relevant time information of the data stream.

[5] module is used as sysnonym for unit of study, self-contained learning material

[6] laboratory studies, made seperatly according to scientific methods of the social sciences

TECHNICAL REALISATION

For the technical realisation of the mode described above different technologies and methods are in use. They cover all aspects of the system's architecture and have to fulfill following demands:

- The system must be internet based. WBT training modules must collect, transmit and store data in realtime over networks via TCP/IP
- The system has to use open standards to allow flexibility by using e.g. w3 [10] standards
- The system has to be robust with respect to connection problems and delays

Structuring content

In oder to generate content with the opportunity to scale and measure characteristics it's desirable to select methods of content tagging in a general, widely known and standardized format. The Extensible Markup Language (XML) [11] offers language structures to model educational content in a parseble and open way, and is a good choice to deliver additional information besides the original content. Some languages with focus oneducuational processes are already available. In contrast to the meta information, the Learning Material Markup Language (LMML) [12] [13] serves as a framework to integrate educational oriented material with the intention to include didactical concepts. The TeachML [14], [15], [16] serves as a quite close idea to include different material in order to structure an output for various purposes. Simple structures are available within the milca-project [17] and the ilias-server [18], which allows easy exchange. All these languages have in common the mark up of mainly text based content. The EML [19] is another powerful language separating content and methods and to distinguish between roles, activities and environments. Further they offer the opportunity to incorporate other standards like SVG [20] for scalable vector graphics and animations or e.g. MathML [21] or Xforms [22] to create formulars or VRML for 3d scenes [23]. Some specifications cover different aspects of learning like questioning and test like the Tutorial Markup Language (TML) [24] description, Question Mark-Up Language (QML) [25] or the IMS specification [26]. As the main information model is text based, most of the body and links can be analysed.

The following fibure shows the wwr-specification[7], which is developed within the wwr-project [27]. The following figure shows the the tags of the wwr markup language for structuring content in an didactic way, which differs from the typically logical orientation.

```
<?xml version="1.0" encoding="UTF-8"?>
<module   xmlns="WWR-CONTENT"
          xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
          xsi:schemaLocation="WWR-CONTENT ../wwr-content.xsd"
          intensity="all" target="all" device="all"
          id="MOD0001" title="Include-Demo">
   <author>
      <firstname>Denny</firstname>
      <surname>Voigt</surname>
   </author>
   <paragraph id="PAR0001" include="chap1.xml#PAR0011" title="XML Einf
   <paragraph id="PAR0002" include="chap2.xml#PAR0012" title="DTD vs. S
   <paragraph id="PAR0003" include="PAR0001" title="Einführung in XML",
</module>
```

```
<?xml version="1.0" encoding="UTF-8"?>
<paragraph   xmlns="WWR-CONTENT"
             xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
             xsi:schemaLocation="WWR-CONTENT ../wwr-content.xsd"
             id="PAR0011" title="Eine kurze Einführung zu XML">
   ...
</paragraph>
```

FIGURE. 3
STRUCTURED INFORMATION BASE BEFORE ASSEMBLED TO DIDACTICALYL STRUCTURED UNITS

Content modules are consisting of paragraphs for structuring the chapers in smaller units. The basic tags own several attributes. (The language will not be discussed further)

[7] currently only as draft version available

Parsing structure information

As a second step, the structure information according to the scheme [34] is parsed and extracted after the implementation of the database in XML (and less the meta data [28] –[33] it's appearances).. Hereby the information nodes called presentations unit, e.g. text with embeded formulas and graphics are detected . Links and their describing qualities - like their kind e.g. link to index or glossary – are of interest. After finishing the content, didactical information according to instructional models is added and forms the final XML-document. Structures are transformed in several steps before the parsing process is perforemd. First references are striped out and the document is transformed to meet several demands. The parsing process take place within the production environment as a result of the authoring and transformation processes [35] [36]. A single application extracts content information offline or works as a sepertate network service, which allows to detect the significant characteristics.

```
<?xml version="1.0" encoding="UTF-8"?>
<module   xmlns="WWR-DIDACTIC"
          xmlns:wc="WWR-CONTENT"
          xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
          xsi:schemaLocation="WWR-DIDACTIC ../wwr-didactic.xsd"
          id="MOD0001">
   <organisers>
      <!--
         allgemeine didaktische Infos zum Modul
      -->
   </organisers>
   <lesson>
      <organisers>
         <!--
            speziellere didaktische Infos zur Lektion
         -->
      </organisers>
      <introduction>
         <wc:pu id="PU0011" include="chap1.xml#PU0001"/>
         <wc:pu id="PU0012" include="chap1.xml#PU0002"/>
         <!--
            ...
         -->
      </introduction>
      <step>
         <wc:pu id="PU0021" include="chap2.xml#PU0001"/>
         <wc:pu id="PU0022" include="chap2.xml#PU0002"/>
         <!--
            ...
         -->
      </step>
      <conclusion>
         <wc:pu id="PU0081" include="chap8.xml#PU0001"/>
         <wc:pu id="PU0082" include="chap8.xml#PU0002"/>
         <!--
            ...
         -->
      </conclusion>
      <training>
         <wc:pu id="PU0091" include="chap9.xml#PU0001"/>
         <wc:pu id="PU0092" include="chap9.xml#PU0002"/>
         <!--
            ...
         -->
      </training>
   </lesson>
   <!--
      weitere Lektionen
   -->
</module>
```

FIGURE. 4
SOURCE CODE STRUCTURING PRESENTATION UNITS, WHICH CONTAINS PRESENTATION UNITS TO EXTRACT

The concrete implementation for the wwr-markup parser is realized in Java to resolve the namespaces and different tags with their attributes. Embedded elements can be detected and partially analyzed. Thy table I shows the most important data types selected and recognized for the data base.

TABLE I
Typically supported multimedia objects within the wwr-language description

Element	Type
image	"gif", "jpg", "png"
animation	"flash", "svg"
video	"avi", "mpg"
sound	"mp3", "wav"
applet	"class", "jar"
scene3d	"vrml"

Generating behaviour pattern information

The information derived from the behaviour pattern is the result of the comparison of the students' activities according to didactical and psychological learning models. In the first step, the matching of content and activities is generated by the data base system. Later other factors are compared and stored for online and offline statistical calculations.

IMPACT OF THE MODEL

The advantage of the model is the high degree of flexibility. The information body which can be freely formed as far as it remains conform to the corresponding doctype definitions (DTD) or X Schema and the interaction in the browser window and it's extensions. Therefore the appearence of the content and semantic structre are seperated from each otherand may be analyzed by the tools developed [27] independently, as far as the structure of one content node remains almost the same. The matching results gives multiple cues and uses the whole bandwidth of the XML-family.

CONCLUSION

More and more attempts are made to use XML as markup system of content description. The significance rises within authoring systems, course management systems and learning platforms. With the appearance of real XML enabled internet browser, a high degree of availability will be guaranteed. Thus content has to be structured according to establishing standards such that this powerful technology can show it's full capacity. Tools parsing XML-based language constructions will be of great importance in the future and their lack still hinders faster development. The model helps in very concrete way everybody benfits from the advance of XML. Seperating content and behaviour for didactical structuring is new according to this model.

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