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A Requirements Analysis of Adaptations of Re-Usable (E-Learning) Content

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Abstract: Re-using E-Learning content is a topic addressed in several actual papers. This paper presents requirements on adaptations of re-usable (E-Learning) content. Adaptations are needed to make a re-used learning resource suited for its new context. To analyze those adaptations we did a theoretical approach to find out which adaptations might occur. We verified our outcomes with a user survey. In addition we collected the requirements of possible end users with the user survey. Based on the survey we created the foundation for a tool that supports end users in executing content adaptations.

1 Introduction

Creating appropriate E-Learning content is a time and cost consuming task. One possibility to make the production of E-Learning content less expensive is to re-use existing content. Very often re-using content means that teachers or learners re-use the same content in more than one learning scenario. But this often fails as the existing content does not completely match for the new context. Therefore a procedure that allows authors to adapt the content to new contexts would be desirable. We call this Re-Purposing (Rensing et al. 05). In (Bergsträßer et al. 05) we examined Re-Purposing in detail. In this paper we will focus on one major aspect of Re-Purposing: the adaptation.

Our aim is to support users in re-purposing existing E-Learning content by a tool, which gives hints how to handle several adaptations or - if possible - takes over the adaptations in an automated way. Our work is situated within a project called "Content Sharing" (ContentSharing 05), funded by the German Ministry of Economics and Labor. The overall project goal is to develop a marketplace for the exchange of re-usable E-Learning content.

In this paper we give a survey of requirements on adaptations of re-usable (E-Learning) content. We present a tool concept that supports users in performing adaptations. In chapter 2 we define adaptations as part of the Re-Purposing process. In chapter 3 we present an analysis of requirements on adaptations. Chapter 4 explains the structure of adaptations and gives an overview on how an automated support of adaptations can be done. In addition we present how our tool will look like. Chapter 5 contains a summary and an outlook to the future.

2 Adaptation as part of the Re-Purposing process

2.1 Examples and definitions

Adaptation is a part of Re-Purposing. Re-Purposing consists of modularization, adaptation and aggregation. We define Re-Purposing and adaptation as follows:

> *"**Re-Purposing** is the transformation of a Learning Resource to suit a new learning or teaching context. This means especially that the Learning Resource is transformed to suit a new learning objective or a new target group, which is different from the learning objective or target group the Learning Resource was created for."* (Rensing et al. 05)

An example for Re-Purposing is: parts of a course "introduction to stochastic" are transformed to be used in a new course "Stochastik für Betriebswirte", which is a course in German about stochastic for business economists.

> *"**Adaptation** means changing a Learning Resource with regard to one dimension to make it fit to a new context of use. Dimensions are for example language, layout or terminology. To perform an adaptation an **adaptation process** is executed."* (Rensing et al. 05)

Adaptations are needed to make the re-purposed content suited for new needs. It might be necessary to perform several adaptations to adapt content to a new context. For example: in addition to changing the terminology it may be necessary to translate the course "introduction to stochastic" to transform it to the new course "Stochastik für Betriebswirte". Adaptations occur in the areas of layout (e.g. corporate design), content and technology (e.g. transformation to another format). Content changes comprise changes of the language (e.g. translation, terminology) and didactical changes (e.g. learning objective, learning strategy).

Further definitions on Re-Use, Re-Authoring and Re-Purposing can be found in (Rensing et al. 05).

2.2 Related Work

There are some other projects dealing with Re-Use and/or Re-Purposing of existing Learning Resources. But most of these approaches do not take into account that existing Learning Resources often do not fit exactly to the new scenario of usage and have to be adapted to be made suitable.

The ALOCoM framework (Verbert et al. 05) is used to re-purpose Learning Resource components. It uses an ontology as a generic content model. Based on the ontology learning objects are disaggregated into their components. These components can be aggregated to new learning objects "on-the-fly". ALOCoM only focuses on decomposing and aggregating learning content. But it does not consider adapting the content to changed scenarios.

Obrenovic et al. (Obrenovic et al. 04) deal with the Re-Purposing of multimedia-documents. They provide an XML based abstract intermediate format into which they transform multimedia formats and from which documents can be mapped back to specific multimedia formats. They use an ontology to model Re-Purposing. The work gives a good starting point for Re-Purposing, but at the moment it does not provide a concrete Re-Purposing tool.

The System for Courseware Reuse (SCORE) (Klein et al. 03) allows the generation of a repository for modularized learning content. The content can be re-used to generate new learning content. The approach deals with Re-Use of content that was especially designed for Re-Use. It does not provide a way to adapt other content to new needs.

The Resource Center (Hörmann et al. 05) is a Learning Object Repository combined with a tool set for authoring of SCORM-compliant E-Learning courses. It supports Re-Use of E-Learning content via Authoring by Aggregation. Authoring by Aggregation is the creation of new learning content by combining existing and new learning resources. The approach considers the need for adaptation, but adaptations have to be done manually.

The tools and concepts already available to adapt content are always restricted to special adaptation types and some selected formats. For example SYSTRAN (SYSTRAN 05) provides a tool that can be used in office applications for translations from one language into other ones. At the moment there seems to be no approach that offers support for all kinds of adaptations and for different document formats.

(Bultermann 01) describes the XML based "Synchronized Multimedia Integration Language" (SMIL). In addition to other features SMIL can be used to create content whose presentation is adaptable to new purposes or presentation devices. But SMIL does not deal with adaptation in general. In addition it is only able to handle SMIL content.

3 Adaptation of (E-Learning) Content: A Requirements Analysis

3.1 Theoretical Investigation

In addition to the related work we examined LOM (Learning Object Metadata) (IEEE 02) and ISO/IEC 19796-1:2005 (ISO 05). LOM describes learning content by using standardized metadata. ISO/IEC 19796-1:2005 offers an approach to how to achieve quality in learning, education and training. We analyzed both standards with the focus on which aspects in creation of E-Learning content and which metadata fields demand for an adaptation if they are changed. We found 15 adaptations:

- Adaptation to a changed learning objective
- Adaptation to a changed duration of the course
- Adaptation to a changed difficulty of the course
- Adaptation to a changed learning strategy of the course participants
- Adaptation to another language (translation)
- Adaptation to a special terminology
- Adaptation to several screen resolutions
- Adaptation to end devices (PC, PDA, mobile...)
- Adaptation to different bandwidths (modem, ISDN, DSL ...)
- Adaptation to a good printability
- Adaptation to another degree of interaction (of the course participants)
- Adaptation to another semantic density
- Adaptation to enable the transformation into several formats (HTML, PDF, ...)
- Adaptation to (corporate) design
- Adaptation regarding accessibility

3.2 User survey

To confirm the results of our theoretical analysis we performed a user survey. By this means we wanted to determine which file formats are in use and how often each adaptation is executed. We checked if our list of adaptations is complete. We wanted to get an overview on how experts proceed in performing adaptations. In addition we presented the interviewees a tool concept. We asked them to judge if such a tool would be useful in their daily work and to tell us how to improve the concept.

During our theoretical investigation of adaptations we found that at least some of the adaptations can be done as well on other content than E-Learning content. To prove this we decided to ask not only experts in the area of creating E-Learning content and classroom training material but also experts in the area of creating documentations and reports. We questioned 15 experts from eight companies that are working in at least one of the four areas. We organized the user survey in two parts:

1. A questionnaire sent out in advance containing four questions that had to be filled in by the interviewees.
2. A telephone interview which was carried out based on the answers we got to the questionnaire. In the interview the interviewees had to answer a couple of questions that were handed out to them in advance.

3.2.1 Questionnaire

The questionnaire contained the following questions:

1. Which is the format of your content on hand? Which formats that you are currently not using do you plan to use in the future?
2. Which tools do you use to create content?
3. How often are the following adaptations occurring in your work? Do you miss an adaptation in the list above?

4. For which adaptation would you like an automated or semi - automated support. (Please also take into account adaptations that due to lack of support you are currently not or only seldom performing.)

Questions 3 and 4 were referring to a table with the fifteen adaptation processes we identified.

For the first question we found that text-containing formats like DOC or PDF are used by almost all companies. The same holds for PowerPoint. HTML is also used very often followed by XML-based formats, Flash and audio files. Other animations or videos are used by less than half of the interviewees. There are some other formats that are used occasionally like Excel or SAP Script. Nearly all companies that do not use XML or HTML at the moment, plan to use them for the future.

Conclusion: As all formats are used quite often, a tool to be used for adaptation should be able to handle all of them.

We asked which tools are used to create content. We got a lot of different answers. There are some specific tools only used by a few companies, like SAP Tutor or Articulate Presenter. Other tools are used quite often, like MS Office (PowerPoint, Word etc.) or Macromedia Flash.

Conclusion: As a lot of different tools are used to create content it is desirable that an adaptation tool is able to adapt content without the need of installing the original creation tool. For example if users want to adapt HTML content they would not need to install an HTML editor if the tool would be able to perform the adaptation. In addition quite often Learning Resources contain more then one format. Hence the tool should take care on handling the different formats so that users can concentrate on the adaptation they want to perform.

We got very different answers to the question how often each adaptation is performed. The number of statements on the frequency (often, seldom or never) by which an adaptation is performed mostly was differing only by one or two. Therefore the answers can only be used as a vague trend indicator (see table 1). Adaptation to a changed learning objective, translation, and adaptation to (corporate) design are executed most often. Adaptation to end devices and adaptation regarding accessibility are executed least of all. But this might change in the future as both aspects are becoming more and more important.

No one of the interviewees mentioned an additional adaptation not listed.

Conclusion: There is no adaptation that could be neglected as it is almost never performed. But on the other hand there is also no adaptation performed so often that it is the most important adaptation needed by everyone. Therefore all adaptations have to be taken into account.

As no one missed an adaptation our list of adaptations is regarded complete by the experts of our target group.

	never	**seldom**	**often**
Adaptation to a changed learning objective	3	5	7
Adaptation to a changed duration of the course	8	6	1
Adaptation to a changed difficulty of the course	7	7	1
Adaptation to a changed learning strategy of the course participants	6	8	1
Adaptation to another language (translation)	3	3	9
Adaptation to special terminology	5	7	3
Adaptation to several screen resolutions	7	7	1
Adaptation to end devices (PC, PDA, mobile…)	9	6	0
Adaptation to different bandwidths (modem, ISDN, DSL …)	11	3	1
Adaptation to a good printability	5	7	3
Adaptation to another degree of interaction (of the course participants)	7	5	3
Adaptation to another semantic density	8	4	3
Adaptation to enable the transformation into several formats (HTML, PDF, …)	4	7	4
Adaptation to (corporate) design	2	6	7
Adaptation regarding accessibility	6	9	0

Table 1: Frequency of use of the adaptations

Considering the need for tools supporting the adaptations listed above the answers varied even more. For each kind of adaptation at least one quarter of the experts stated that tool support would be very important.

Conclusion: The need for tools seems to be very subjective. But there was no kind of adaptation for which not at least one quarter of the experts wanted a tool support. Therefore all adaptations have to be taken into account in an adaptation tool.

3.2.2 Interview

The interview focused on finding out how adaptations are done and how a tool support for the adaptation processes should look like. Therefore we asked the interviewees to describe us how they proceed in creating and adapting content. We wanted to get at least one description on each adaptation process. The detailed evaluation of these descriptions will be subject of further investigation. In this paper we give a general overview of the outcome.

One result of the survey was that there are some adaptations being performed by all participants in a similar, structured, rule based way. For other adaptations we found no common proceeding. Those adaptations are very often performed on the basis of experience and intuition. There are no or only few rules to be followed.

Based on these findings we created two categories (Tab. 2): The first one consists of adaptation processes that are done similar by most of the interviewees and that are based on certain proceeding rules. Further on we call them *structured, rule based adaptations*. They can be supported in a completely or partially automated way. The second category consists of adaptation processes that are performed differently by almost everyone, there is no common way how to perform them. They are based on experience and intuition. Therefore it is hard to integrate them into an automated tool. At most they can be supported in a partially automated way. We call them *unstructured, experience based adaptations*. In chapter 4 we will explain how to deal with both kinds of adaptation processes.

structured, rule based adaptations	***unstructured, experience based adaptations***
Adaptation to another language (translation)	Adaptation to a changed learning objective
Adaptation to special terminology	Adaptation to a changed duration of the course
Adaptation to several screen resolutions	Adaptation to a changed difficulty of the course
Adaptation to end devices	Adaptation to a changed learning strategy
Adaptation to different bandwidths	Adaptation to another semantic density
Adaptation to a good printability	Adaptation to another degree of interaction
Adaptation to enable the transformation into several formats	
Adaptation to (corporate) design	
Adaptation regarding accessibility	

Table 2: Categories of adaptation processes

In addition we presented the interviewees a tool concept (see chapter 4.2) and asked them for a rating of the usefulness of a tool based on this concept. We got the following answers: six persons rated the concept as very useful, six rated it as useful, one rated the concept as less useful and one rated it as not useful. One person was not sure on how to rate the tool.

Conclusion: The outcome shows that our approach is considered as helpful by possible users.

Then we asked the interviewees to give us their advice on how to improve the tool. The tool concept to be proposed in chapter 4 is based on the concept we presented the interviewees supplemented with their advice.

As mentioned before by means of the user survey we also wanted to find out if all or at least some of the adaptations can be performed on other content than E-Learning content. Therefore we asked not only persons creating E-Learning content but also persons creating other content. We found that adaptations on E-Learning content are performed for other kinds of content as well. Adapting E-Learning content is a special case of adapting content.

In order to transfer the adaptations on learning content to content in general sometimes the naming of the adaptations has to be slightly changed. In most of the cases the adaptations are completely the same. For example in E-Learning you need an adaptation to the learning objective: for general content you call this an adaptation to a changed target. Layout adaptations in contrast are performed in exactly the same way and with the same terminology for E-Learning content as well as for general content. In the project "Content Sharing" we only deal with adaptations of E-Learning content. But as this is only a special case of content adaptations our work can be used as well to adapt content in general after some slight modifications (mainly changes of the terminology).

4 Analysis, Structure, and Support of Adaptation Processes

4.1 Analysis of Adaptation processes

During our theoretical evaluation we found that adaptations are performed by executing what we call adaptation processes. Each adaptation process consists of - what we call - process fragments which consist of functions. The results of the interviews confirm this.

The following example gives an overview of the structure of the adaptation process for (corporate) design (Fig. 1):

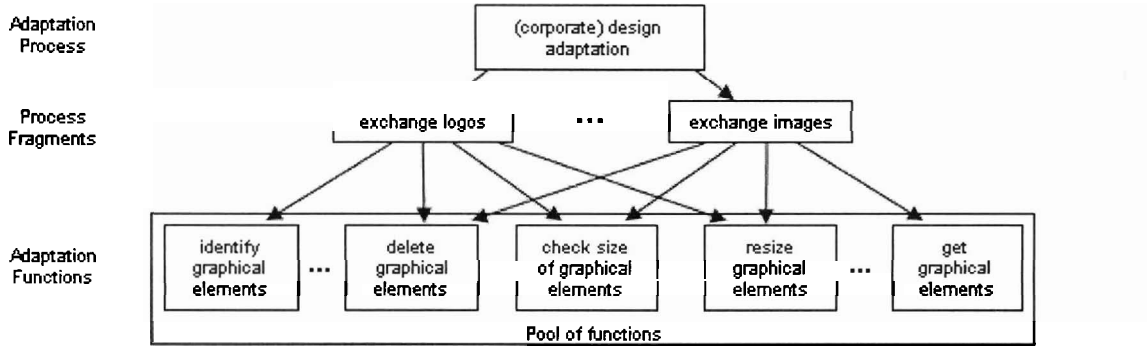

Figure 1: Overview of the Structure of Adaptation Processes

The design adaptation process consists of several process fragments: "exchange logos", "exchange images", "change fonts" etc. To achieve a design adaptation some or all of the process fragments have to be executed. In the example there is only one mandatory process fragment that has to be executed: at the end of the adaptation process it has to be checked if all elements are sized and placed correctly. The other process fragments are optional. In the example the order of the fragments is mostly not of relevance. Only the mandatory fragment has to be executed last.

In general all adaptation processes can be split up into process fragments. Some of these process fragments have a fixed position in the execution chain; others do not have such a fixed position. In addition some process fragments are mandatory in execution and others are optional.

The process fragments are composed of functions: "exchange logos" for example consists of the functions "identify graphical elements (logo)", "get graphical elements (new logo)", "delete graphical elements (logo)", "check size of graphical elements (new logo)", etc. Mostly all functions have to be performed in a fixed order to execute a process fragment. For example it is not possible to check the size of a new logo before getting it. However it might be possible to add the new logo without checking the size. But if the size of the new logo does not match the available space the new logo again has to be replaced by a second new logo with a corrected size. This additional effort will not occur if the size is checked before replacing the logo.

In general all process fragments consist of functions. The order of the functions is mostly fixed. Some functions are mandatory others are optional. Some functions are used in more then one process fragment. For example the function "delete graphical elements" is also used to delete images in the process fragment "exchange images".

4.2 Support of Adaptation Processes, Concept of our Adaptation Tool

As described in chapter 3 there are two kinds of adaptation processes: structured, rule based adaptation processes, and unstructured, experience based adaptation processes. In this chapter we will discuss how our tool based support for both kinds of adaptation processes will look like.

The first kind of adaptation processes can be supported (partially) automated. This means that at least some of the process fragments contained in the adaptation process can be done by the tool. For those process fragments that cannot (reasonably) be supported an explanation is offered how to execute the process fragment manually.

As stated before there is no common way how users perform the second kind of adaptation processes. Therefore we cannot completely support them in a structured way. We even can hardly support those adaptation processes being at least partially automated. But by talking to the users we found that an explanation on the particularities of those adaptation processes would help the users. Therefore we decided to offer the users guidelines how they can do the adaptations manually. For example a judgment of the semantic density of content requires expertise in the topic of the content as well as knowledge of how to achieve a certain semantic density. This can hardly be done by a tool. But the guideline could contain explanations of what lower and higher semantic density means and it could offer tips on how to achieve it. In addition it is possible to help the users in supporting them in finding appropriate content that they can adapt manually. For instance to change content with a low semantic density you have to find parts of the content that can be left out to achieve a higher density. We can offer users support in finding parts of content that can be left out. Or if users want to change the learning objective of some content we can support them in finding content that deals with the new learning objective. But in both cases the adaptation of the existing content to semantic density or to the new learning objective has do be done manually.

The tool concept we presented to the interviewees as mentioned in chapter 3 followed those general ideas. We asked the interviewees to give us advice on how to improve the concept. In the following we present a tool concept based on our first approach supplemented by the advice we got in the interviews.

The content is available in its entirety or as smaller units (so-called modules). All content is composed of various modules, which can be adapted separately or in a bigger unit. Users proceed as follows:

1. They select the content or the modules they want to adapt.

2. They select the adaptation processes they want to perform from a list of several adaptation processes (e.g. translation, (corporate) design adaptation, etc).

3. The tool checks whether the chosen adaptation processes are supported for the formats of files that are contained in the selected content. This enables the system to tell the user directly after selecting an adaptation process if this process is supported completely automated, partially automated or if it has to be done manually:
   If *no automated support* is offered, users can get instructions how to perform the adaptation manually.

   If the adaptation is *partly supported*, users get information which process fragments are supported automated and which process fragments have to be performed manually. Users can choose which of the supported process fragments should be performed automated. For those a dialog starts that guides through the adaptation process step-by-step, means process fragment by process fragment. For every process fragment the results are presented. For example all identified logos are presented in the process fragment "exchange logos". Users can accept or discard the results. Individual process fragments can be skipped totally if desired.

   If an *automated support* is possible for the whole adaptation process, a dialog starts which guides through the adaptation process. Users can choose which of the process fragments should be performed. The adaptation process done process fragment by process fragment. In any case the results are presented and users can decide if they want to accept or discard the results.

In all cases it is possible to get instructions on how to perform the adaptation manually.

During the execution of the adaptation a dialog guides through the process. Users have to enter the required information e.g. which elements are to be changed for a design adaptation. The dialog can vary for experts or freshmen, as the latter ones need more detailed information. Experts on the other hand do not need detailed explanation but want a dialog allowing for fast work. The dialog gives the possibility to quit the adaptation at all times during execution. Changes executed so far can be saved or discarded. After execution of the adaptation users have access to a log of all changes performed. In addition users get instructions on what remains for manual change.

5 Summary and Future Prospects

As the outcome of the interview has shown, there is need for a tool that supports users in adapting content. With our work we address this need. At the moment we are working on implementing an architecture that puts such a tool in practice. However it is difficult to develop a tool that supports all adaptation processes in a way that it will be accepted by potential users. This also became clear in the interview. But the interviewees also mentioned that a guidance through adaptation processes and instructions on how to execute adaptation processes manually would also be a great support in their daily work. Therefore we will implement a tool that guides users through the adaptation processes, providing guidelines where no automated support is possible or desired. Thereby the actual context of the user should be taken into account: Which adaptation processes have been chosen? Which formats are contained in the content? What has been done up to now? Is the user an expert or a freshman?

To achieve this we plan to build a system that uses a model (e.g. patterns or UML) to represent the adaptation processes. Based on this model the system will guide users through the adaptation process. In addition we plan to take our patterns as a basis to generate guidelines and additional information given to users if they need help. Which modeling formalism is suited to reach this goal is topic of future research.

6 References

Bergsträßer, S., Zimmermann, B., Meyer, M., Rensing, C., Faatz, A., Hildebrandt, T., Steinmetz, R. (2005): Re-Purposing: Motivation, Related Work, and Building Blocks. Technical Report KOM-TR-2005-03, Darmstadt University of Technology

Bulterman, D. C. A. (2001): SMIL 2.0: Repurposing Broadcast Content for the Web. *EBU Technical Review*, No. 287.

Content Sharing (2005). http://www.contentsharing.com. (Last accessed on 16.12.2005)

Hoermann, S., Hildebrandt, T., Rensing, C., Steinmetz, R. (2005): ResourceCenter - A Digital Learning Object Repository with an Integrated Authoring Tool Set. *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications ED-MEDIA 2005*, Montreal, 3453-3460

ISO/IEC 19796-1:2005 (2005): Information technology -- Learning, education and training -- Quality management, assurance and metrics -- Part 1: General approach

Klein, M., Ateyeh, K., König-Ries, B., Müller, J. (2003): Creating, Filling, and Using a Repository of Reusable Objects for Database Courses. *Workshop "Datenbanken und E-Learning"* within the GI-Fachtagung "Datenbanksysteme für Business, Technologie und Web (BTW 2003)", Leipzig, Germany

IEEE LTSC (2002): Draft Standard for Learning Object Metadata

Obrenovic, Z., Starcevic, D., Selic, B. (2004): A Model-Driven Approach to Content Repurposing. *IEEE MultiMedia*, 11 (1), 62-71

Rensing, C., Bergsträßer, S. Hildebrandt, T., Meyer, M., Zimmermann, B., Faatz, A., Lehmann, L., Steinmetz, R. (2005): Re-Use, Re-Authoring, and Re-Purposing of Learning Resources - Definitions and Examples. Technical Report KOM-TR-2005-02, Darmstadt University of Technology

SYSTRAN WebServer (2005). http://www.systransoft.com/products/client-server/webserver.html. (Last accessed on 16.12.2005)

Verbert, K., Jovanovic, J., Duval, E., Gaševic, D., Meire, M. (2005): Ontology-based Learning Content Repurposing: the ALOCoM Framework. *PROLEARN-iClass thematic workshop on "Learning Objects in Context"*, Leuven, Belgium