

MODULARIZED LEARNING DOCUMENTS FOR PRODUCT DEVELOPMENT IN EDUCATION AT THE DARMSTADT UNIVERSITY OF TECHNOLOGY

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1. Introduction

At the department product development and machine elements (*pmd*) of the Darmstadt University of Technology, a specific modularization of teaching materials is currently being carried out for the product development course. This is suitable for graduate students with a technical focus in their studies. The course runs for two semesters. Regarding the content, the focus is set on early phase of product development. Costs, safety engineering, QFD and design for environment are also discussed. An accompanying exercise puts into practice the theoretical material learned. This work has two aims: firstly, the revision of all materials used (adjustment to the newest research, solid structure, didactically strong preparation) and secondly, the evaluation of a modularization approach. This approach has been conceived in the *thekey*-project [Albers et al. 2001] [Birkhofer et al. 2002] and enhanced at the department *pmd* [Berger et al. 2002] [Birkhofer et al. 2002]. Modularization results in uniform and conclusive structured documents and an integration of general examples to illustrate and explain theoretical content. This paper deals with the construction and revision of teaching materials. The traditional procedure is compared with the modularization approach. Important aspects, such as benefits, effort, consistency and effects on the target group, are discussed.

2. State of the Art

A modularization approach takes objects apart, eliminating duplicates and puts the rest together again in a well-structured way. Thus, documents become more consistent in structure (e.g. motivation, learning target, explanation, example) and content (e.g. terms, definitions) more methodical. Basic structures are common in all derived documents. This results in documents with a high consistency and recognition value concerning their terminology. An easily remembered and didactically expedient structure is immanent in all documents so derived.

The work presented in this paper is based on the so-called EMC-Model (3-Level-Model), which in turn is based on elements (e.g. text and picture fragments). From these, modules and containers are derived (e.g. explanations, examples, chapters). The modularization approach [Berger et al. 2002] is not explained explicitly in this paper.

The current course “product development I+II” is based on a 350-page script plus 180 pages of exercise material. The lecture is comprised of up to 900 Power Point screens. For the summer semester 2003, two hours of lecture including an exercise have been implemented. The topic of these new units is variant management. As regards the content, the course teaches both customer individual configuration of products and standardization. The modularization approach mentioned before is used

to derive essential teaching documents. The main problem is the modularization process itself. There has been no guideline which describes the modularization process until now. Therefore, a first step in overcoming these difficulties must be found. To accomplish this, a competence team of 5 people was formed.

This paper describes the problem and the use of the modularization approach, the results and the feedback of students after the course. The results are reflected critically.

3. Learning Documents

Until now, the preparation of new teaching units (lecture, exercise and required material) was executed on the basis of a traditional attempt. The new way uses modularization to prepare the material. To explain this, the traditional procedure is described briefly here. Then, the modular way is explained.

3.1 Traditional procedure

A clear demarcation of the content is a prerequisite to the creation of new units. Usually, not all potential content is ready to be processed. In some cases, potential content is not even determined. Therefore, the acquisition of content dominates this stage. In this context, the term “content” means the real content plus accompanying examples and additional material. The acquisition of content is primarily made by enquiry in the literature and in the internet. Material already available has been included. At the end of the acquisition phase there are extensive materials about the defined topic.

In a further step, the content is selected. Content which shall expand into the new material becomes isolated. The remainder is put back (backup material). This selection is largely based on experience. It is not formalized and varies intersubjectively. The preparation of documents, such as scripts or slides, also depends on the location and individual preferences of the lecturer (this is a main problem if one would use modularization by different authors sharing documents). A further step is the (re-) structuring of selected contents. By structuring, the different content types are taken to an expedient order. Here, didactical aspects are predominant. This is done intuitively and based on experience.

The result is that there is then a structured representation of canvassed and selected contents. And these are ready to be processed electronically. The traditional procedure is summarized in figure 1.

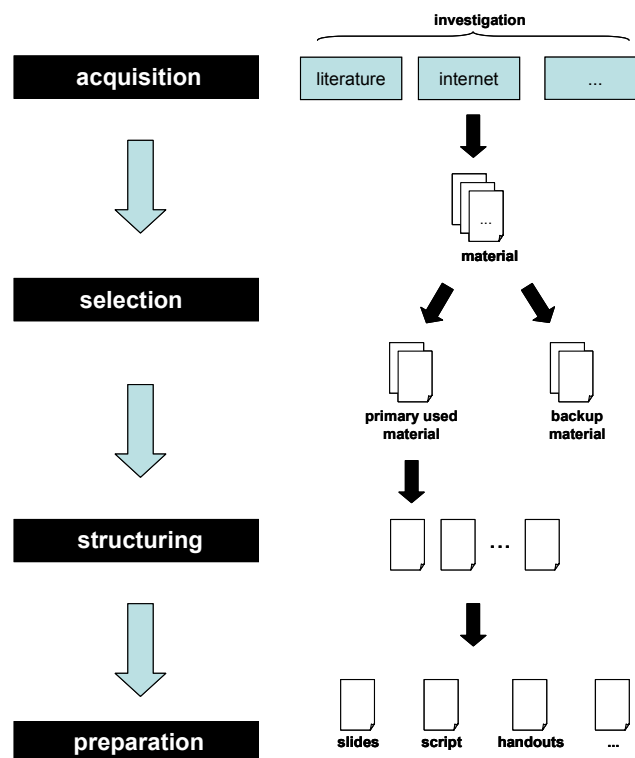


Figure 1. Traditional way from acquisition to documents

3.2 Modularized procedure

The procedure “modular construction of documents” differs from the traditional way. In the following, the modular proceeding is described briefly as “modularization”. It is based on the approach mentioned above. Modularization can be characterized as a method in the preliminary stage. Intuitive styling and discursive derivation of content are dominant. Here, the processing is largely methodical, but there have been no recommendations for practice until now.

In a first step, a time schedule was made, and milestones (work steps) and further sessions were defined. Milestones are: a first rough structure of the desired content, the acquisition of content, the selection and structuring of content, the transformation of content into modular fragments, and the derivation of documents.

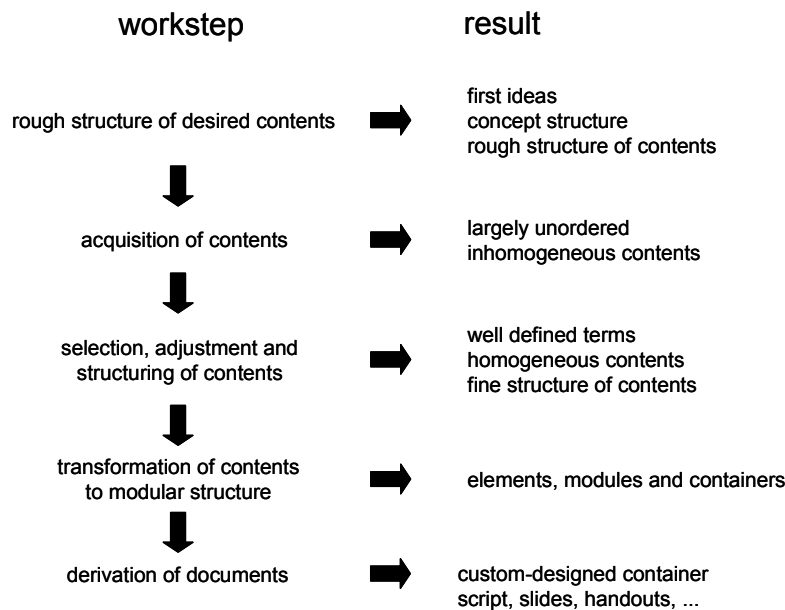


Figure 2. Work steps and results of the modular procedure

The work steps represented in Figure 2 and the results are explained below.

The common goal was explicitly defined in a first session: ‘modular construction of the chapter "variant management" for the lecture product development II’. Parallel to the discussions, ideas concerning potential content, their arrangement and examples were collected. An essential factor concerning modularization is a well-defined concept structure. All used concepts must be treated uniformly (among other things for purposes of definition, consistency and recognition). The concept structure defines the kind of information coupled to a concept *and* its sequence. It is defined as follows:

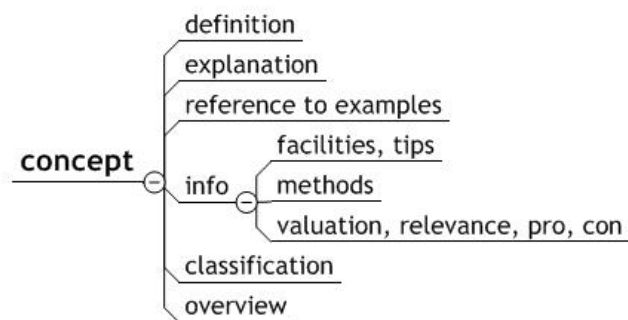


Figure 3. Concept structure

At first, each concept is defined and provided with an explanation, examples and additional information (figure 3). Every concept contains a classification (upwardly) and an overview (downwardly) when required. Definition and explanation have to be indicated for every concept. Examples and additional information are nice to have. If required, a classification and an overview are indicated.

Beyond the concept structure a first rough content structure was worked out (figure 4).

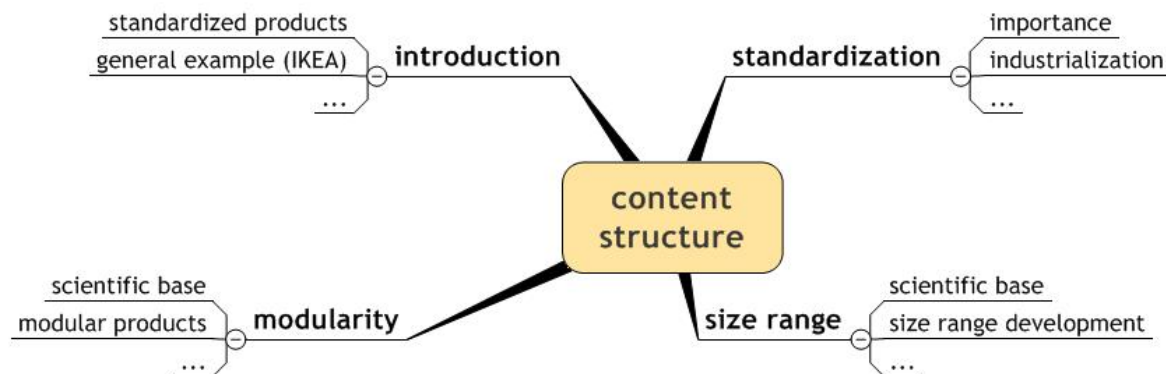


Figure 4. First content structure

This structure was iteratively enhanced in the session. Specific literature enquiries were made, e.g. in works of [Franke et al. 2002] [Schuh et al. 2001]. The insight gained was journalized and central concepts were isolated. Literature was canvassed by the criteria “name recognition of the author“ and “publication date”. It is important to note that the selection of literature did not turn out single-sided. Usually, the announcements of some definite experts dominate in a very special field of knowledge. An partial overlapping of content occurs. If one leaves this narrow circle of experts, one frequently finds in the literature the same content again in an easily modified form. So the accession of additional information quickly converges towards a saturation line. Largely, the canvassed contents are disordered and unhomogeneous at this stage. However, some authors define partly equal concepts differently. This is a problem in the modularization process since this requires a strict definition of all concepts. Authors were often found with various opinions on questions of detail. These differences were worked out, discussed in the team and transformed into a uniform statement in the end (if possible). At the end of the enquiry, the gained content structure served as a basis for the structure of the lecture, as well as for the modularization. Therefore, all contents followed a logical sequence. All concepts used were worked out solidly according to the concept structure from Figure 3.

The contents processed must now be modularized. Modularization aims at the multiple use of contents. Therefore, the contents must be independent of the complete context. Content components gained in this way can be used for other purposes. Cross-references or terms such as “see above” or “as already mentioned ” must not occur. In a further step, canvassed contents are cleared up around such relations. Repeatedly usable parts get isolated. These are, among others, definitions, headings, images and references. This is a labor-intensive step resulting in a variety of elements and modules. These are described according to the 3-Level-Modell [Berger et al. 2002].

According to modularization, duplicates must be distinguished from redundancies. Duplicates are documents having the same content and character (e.g. multiple definitions of specific concepts by the same author). Redundancies are documents with the same content but different character (e.g. customized presentation) [Berger et al. 2002] [Weiss et al. 2003]. Redundancies are necessary because of individual customization concerning different application scenarios. Examples of redundancies are short and long forms of explanations. Particularly, the configuration of a script requires different content as the content for arranging slides. Thus, duplicates must be avoided while redundancies are necessary.

From this, custom-designed containers can be derived in a further step. These containers serve a special application purpose such as scripts, exercise documents or handouts. According to concepts, an inner chapter structure was declared: motivation, learning objective, initiation, summary, technical chapter, result. This simple structure is easier for future readers to understand. On this basis a custom-designed container “script” was derived. The practical derivative of the documents is carried out with the help of a tool developed by the authors [Weiss et al. 2003]. At first, an editor provides the definition of elements. From this, modules can be defined using the drag & drop tool. Here, a configurable graphic work space serves as basis on which elements and modules filed in a data base can be arbitrarily placed, formatted and configured as containers.

4. Discussion of Benefits and Problems

As result can be noticed that by modularization materials (such as script, exercise documents, handouts, foils) can be derived. These documents are derived with high-quality and low time expenditure. This is valid if an extensive knowledge base already exists. However, the creation of this underlying knowledge base requires considerable time to create. Initially, the overhead to build up the knowledge base is very high. But it converges with further progress asymptotically towards a saturation line; a clearly defined and delimited topic is presupposed. However, a time economy contrasts with this time expenditure at the derivation and modification of contents.

A high quality of modularized contents already arises from the compulsion to very clear definitions and structures required for the modularization process. Particularly, the acquisition phase is dominated by collisions of concepts. This takes time. Extensive discussions and various views determine the final decision and the further procedure here. The modularization approach forces the decision: either several concepts are summarized in one or every concept is defined separately.

The structure of derived modules and containers is based on a formalized approach. Dependencies are immanent in the structure. A modification at the element level immediately leads to modifications in derived modules and containers. Therefore, the correction overhead, if required, is very low .

The modularization approach avoids duplicates. In the absolute sense this can not be guaranteed. But a far-reaching duplicate exemption must be striven toward. If the same contents must be presented differently, then redundancies are generated. These redundancies imply that an extensive spectrum of application scenarios can be satisfied. In principle, derived materials are built up from already existing fragments. This leads, in conjunction with redundancy and no duplicates, to solid results.

Various custom-designed containers (such as scripts or foils) are derived from a knowledge base uniformly defined. Therefore, the recognition value is high between different documents, e.g., concerning courses between scripts, exercise documents and lecture slides or concerning industry seminars between slides and handouts.

After the event with two double period lectures and two proper exercises, the feedback from the students was very positive. The clear structuring, definition and clearness of the offered materials, as well as the cohesion between event obtained documents, were praised. The wish to release more documents of this kind is very great. In this sense, a strong rise in quality can be explicitly identified.

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