Proceedings of DET2011
7th International Conference on Digital Enterprise Technology
Athens, Greece
28-30 September 2011

RECOMMENDING ENGINEERING KNOWLEDGE IN THE PRODUCT DEVELOPMENT PROCESS WITH SHAPE MEMORY TECHNOLOGY

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ABSTRACT

Shape Memory Technology (SMT) opens up new approaches to actuators and sensors but a broad application of SMT is hindered by two major issues: First, industrial users lack the necessary knowledge to apply SMT in their products. Second, there is a lack of simplified tools for scientists to make their research findings available to industrial users more easily. Therefore, SMT-specific engineering knowledge has been collected in the "Knowledge and Method base for Shape Memory Alloys" (KandMSMA). An assistance system has been integrated into the KandMSMA which supports scientists on publishing of new content and industrial users on finding relevant content. The article at hand presents an analysis of the initial situation, which led to development of the assistance system and a description of the assistance system itself. Based on this, the article concludes with an evaluation of the usability of the assistance system and an outlook for an enhanced SMT-based product development process.

KEYWORDS

Shape Memory Technology, Product Development, Recommender System, Methodical Support

1. INTRODUCTION

SMT represents an innovative, but heretofore sparsely used approach to developing novel actuators and sensors. In this way Shape Memory Alloys (SMA) are, for instance, employed in unlocking actuators as described in (Sadek et al, 2010). However, there are two crucial problems to a broader employment in diverse products. For one thing, the material properties and effects entail higher demands as to the skills of the product developers. For another thing, developers lack exactly the knowledge that is necessary for a useful integration of SMT into their products. As described in (Langbein, 2009), the required knowledge comprises information on effects and material properties of different SMA and especially information that supports the SMT-specific product development process as described methodically in (Sadek et al, 2010) and (Breidert and Welp, 2002). Within the interdisciplinary SFB459, various research findings in the field of materials science and a methodology for the development of SMT-based products have been generated. These research findings were then edited for industrial transfer and were made available online in the wiki-based KandMSMA. The acquired research results stem from diverse fields of materials science, mechanical science and product development.

In order to face the issue of the lack of information and to enable an optimal transfer of the research results in industry, an approach for an improved information provision has to pursue two goals: The first goal consists in the development of a recommendation-based assistance system for the support of scientific authors and industrial users,

Table 1 – Different content domains within the KandMSMA

Basic knowledge of SMT	Guidelines for product development	Manufacturing and processing of SMA

▪ Effects
▪ Material characteristics
  ▪ Alloys
  ▪ Polymers
▪ Characteristics in use
  ▪ Corrosion
  ▪ Wear
  ▪ …
	▪ Process model for SMT
	▪ Methods for
	  ▪ Dimensioning
	  ▪ Standardisation
	  ▪ …
	▪ Application samples
	▪ …
		▪ Processing
		  ▪ Master forming
		  ▪ Forming
		  ▪ Finishing
		  ▪ …
		▪ Processing tools
		  ▪ Laser melting
		  ▪ …

which will enable a simplified documentation of research results and their provision in the KandMSMA. Here, easy to operate and supportive software tools keep the effort for the insertion of and search for information low, so that an improved exchange of information between industrial users, especially product developers and scientists is facilitated. The second goal is to integrate methodical support which is oriented on existing process models for methodical product development into the assistance system to be developed. This methodical support has to provide information adapted to the developers' progress in the product development process.

2. INITIAL SITUATION

In the course of the research in SFB459, the wiki-based KandMSMA has been implemented in several iteration stages (cf. (Welp and Breidert, 2001)). The KandMSMA already includes a major part of the research findings in the form of articles on different groups of themes. Therefore, the KandMSMA is a central tool for the documentation and provision of interdisciplinary research findings and for the support of the development process of SMT-based products. The contents of the KandMSMA essentially stem from three topic areas as shown in Table-1: Basic knowledge of SMT, methodical guideline for product development with SMT as well as manufacturing and processing of SMA pre-products and SMA components.

The first area comprises basic knowledge on shape memory materials and effects. The information included in this area describes the material properties of SMA as well the corresponding experiments. The micro structural composition of SMA and the characteristic of the phase transformation stages are elaborated on in particular. The second area comprises information on a methodical guideline for product development with SMT.

Here the individual steps and the methods used in them are described for a product development process that is adapted to the development of SMT-based products. Furthermore, examples of the employment of SMT in diverse products are to be found in this area. The third area finally deals with aspects of the manufacturing and processing of shape memory alloys. On the one hand, information on SMA and their components come up under this area. On the other hand, there is also information on the manufacturing and processing of SMA.

A major task of the KandMSMA that has already been accomplished to date is the collection and provision of the information on SMT generated in SFB459. In contrast to conventional databases and wiki systems and due to the future implementation of an assistance system, the efficient and targeted provision of the contents stored in the KandMSMA is to be to the fore. The usage of the KandMSMA and the integrated assistance system supports developers in the development of SMT-based products along the entire product development process and allows them to access the required information faster. The focal point of the information contained in the KandMSMA is the support of a developer in the early phases of product development, i.e. planning, conception and design.

An intended further task of the assistance system in the KandMSMA is the support of developers on the qualitative inspection of the results generated in the product engineering process with appropriate tools. Besides classic check lists or to do lists, which a developer can use in individual steps during product development, simple interactive tools, e.g. for dimensioning are supposed to be available, too. In addition to this, the user is to be enabled through appropriate contents to use other supportive tools for the development with SMT, for instance in the way described in (Breidert and Welp, 2003). Thereby the use of the KandMSMA leads to a considerable reduction of the iteration loops and thereby of the development effort.

2.1. TARGET GROUP FOR SUPPORT VIA AN ASSISTANCE SYSTEM

The support via the assistance system primarily addresses industrial users. However, it is also necessary to address the circle of scientific authors with this support. The profiles and goals in the addressed groups of people from research and industry are heterogeneous. They differ in their way of usage as well as in their standard of knowledge. Both in industry and in research the knowledge standard on SMT appears to be very differently distinctive, so that differently experienced users or user groups have to be considered for the development of the assistance system as shown in Table-2. Since the KandMSMA and the assistance system are available online, the differing experience of the users with online media and online publications also has to be considered. The essential user groups can therefore be characterized by means of the following criteria: knowledge standard in the domain of SMT, experience with publication in and use of online media, manner of use of the KandMSMA, frequency of usage of the KandMSMA and demand for support on the use of the KandMSMA and on SMT. The following reference groups and implication scenarios are therefore taken as a basis for the development of the assistance system:

Science (I): SMT-experienced material scientists who are sufficiently experienced in dealing with online media and who are planning to publish their research findings in the KandMSMA. It is expected that theses users have sufficient experience in their area of studies. Still, due to the scope and complexity of the information in the KandMSMA, they are not able to integrate their research findings sufficiently well into the structure of the KandMSMA. These users are to be supported primarily in the integration of these contents into the KandMSMA.

Science (II): SMT-experienced material scientists who want to inform themselves of the latest research findings on different SMA and to integrate their own findings into the KandMSMA. Just as user group Science (I), they have sufficient experience in their own area of studies. By contrast, they have only inadequate experience in dealing with online media. Due to the scope and complexity of the information in the KandMSMA, they are also unable to integrate their research findings sufficiently well into the structure of the KandMSMA. On the one hand, the user group is to be assisted in integrating their research findings into the existing contents of the KandMSMA at a lesser effort. On the other hand, they are to be enabled to navigate to the contents that are interesting to them by means of simple and intuitive tools.

Industry (I): Product developers who want to implement SMT in their products and therefore need information on the development of SMT-based products. The developers lack the necessary basic knowledge and methodical knowledge for the development of SMT-based products. Consequently, support for the developers has to be given in two ways. For one thing, the developers are to be lead through the development process methodically. For another thing, they are to receive the information necessary for their current step in the development process.

Industry (II): SMT-inexperienced prospective customers, who want to inform themselves essentially of SMT and its uses. This exemplary user group is particularly interested in sample applications and information on the different effects that are presented to them in a targeted fashion.

The emphases in the development of the assistance system are on developers (Industry I) and scientific authors (Science I and II).

Table 2 – User properties

	Science (I)	Science (II)	Industry (I)	Industry (II)
Knowledge on SMT	high	high	low	low
Experience with online media	high	low	medium	low
Intention of use	transfer of research results	transfer of research results	application of SMT in products	collecting information
Type of use	active, publishing	active, publishing	passive (assisted), consuming	passive (assisted), consuming
Frequency of use	medium - high	seldom	medium	seldom
Required assistance for publishing	low - medium	high	- (high)	- (high)
Required assistance for using KandMSMA	low	low	medium	high

2.2. CHALLENGES DURING THE PROVISION OF INFORMATION IN THE KANDMSMA

In the existing KandMSMA, groups of themes and articles come under an evolved hierarchical structure as depicted as a section in Figure-1. This structure leads to difficulties with the integration and finding of information in the KandMSMA, both for the scientific authors and for the industrial users. This deficit is now to be remedied by the assistance system which is integrated into the KandMSMA.

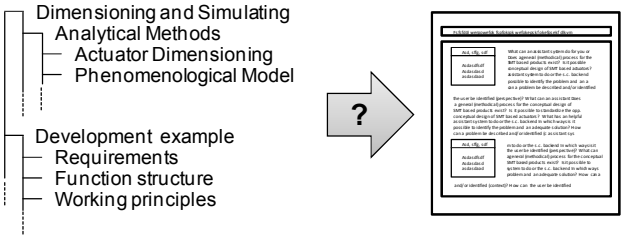

Figure 1 –Section of the content structure used in the KandMSMA with article example

Two essential problems with the integration and finding of contents emerge from the present wiki system of the KandMSMA: The first problem consists in the basic possibility to assign articles to several groups of themes and thereby to different positions in the hierarchical structure. For example, it is possible to class an article on the manufacturing of an SMA both with the area of manufacturing and with the area of SMA. This problem can be further subdivided into three sub problems:

1. While articles are integrated, the structure can be complemented with user-individual substructures, mostly without using existing suitable substructures. This leads to several thematically identical parallel structures within the KandMSMA.
2. New articles are integrated into inappropriate substructures, which lead to an intermingling of different groups of themes and exacerbate the subsequent location of contents.
3. New articles are not classed within the hierarchy profoundly enough and thereby not unambiguously, so that articles on different groups of themes are located at the same place in the hierarchy. Owing to the low hierarchy level, these articles are indeed correctly classed, but are insufficiently easy to find within the bulk of articles located in this place.

This situation emphasizes a second problem. Due to their varying standards of knowledge, users of the KandMSMA can only with difficulty class articles in the complex and scientifically oriented hierarchical structure of the KandMSMA. Furthermore, the structure of the articles allows for different interpretations by users from diverse disciplines and with various standards of knowledge. As a consequence, less adept users, who do not know this structure sufficiently will have difficulty finding articles they are looking for. This aspect is especially applicable to industrial development engineers who want to inform themselves of SMT and integrate it into their products. In addition to this, the existing system is characterized by an only static provision of information to the user and by a requirement of substantial human resources for changing and annotating articles.

3. APPROACH TO RECOMMENDATION-BASED ASSISTANCE

In order to meet the problems in the existing KandMSMA, a new approach has been developed to assisted users with a sophisticated assistance system. The approach is based on two basic functions as described in the two following subchapters. On the one hand, recommendations are made for the annotation of contents, so that these can be integrated into the KandMSMA in a most simple way. On the other hand, suitable recommendations of contents are generated in a personalized way, based on these annotations, for individual users, in particular product developers. Here the users are offered two kinds of recommendations. The first kind comprises recommendations that are similar or contextually related to the contents viewed by the user. The second kind of recommendation is a series of articles, in which the individual contents are ordered in a sequence suitable for reading and processing. This second kind of recommendation is especially suitable for the stepwise support of a product development process. The implementation of these two functions facilitates a detailed and more efficient provision of information, so that published research findings can be made available to the developers in an easy fashion. By means of this, a reduction of the time that a user needs for finding information in the KandMSMA is also to be achieved by means of a personalized provision of information.

3.1 RECOMMENDATION OF ANNOTATIONS FOR NEWLY-ADDED CONTENTS

A new approach to solution, the basis of which is a semi-automated annotation of articles, has been developed for the publishing of new contents in articles. In this context, the term semi-automated refers to the fact that the assistance system recommends seemingly suitable annotations by means of a combination of content-based and rule-based methods. Users can accept, alter and also reject these annotations for their articles. In this

approach, the complex hierarchical arrangement of articles in the KandMSMA is replaced by a list of acceptable key words and categories, from which the annotations and thereby the relations between articles are created. Contrary to the solution in being, articles are thus available in a non-hierarchical structure and are therefore non-redundant in the hierarchy. Individual users who want to integrate and annotate new articles are not necessarily meant to know the entire amount of available key words and categories, but can confine themselves to the subareas that are relevant to them. Moreover, by recommending possible annotations, users are to be induced to rather use existing keywords and categories than to integrate keywords and categories of their own. Finally, the semi-automated annotation is supposed to minimize the formation of parallel content structures and competing annotations, which exacerbates the subsequent location of contents. In this way, the time and the number of actions required to insert new contents into the structure of the KandMSMA is reduced through the semi-automated annotation of the contents.

3.2 PERSONALIZED RECOMMENDATION OF INFORMATION

As the second basic function of the assistance system, by means of the recommender system (Klahold, 2009), users are recommended a subset of the contents of the KandMSMA that is relevant in a context, e.g. the information necessary for development. The context comprises the user profile, the totality of the contents of the KandMSMA and the situation in which the user is situated together with the assistance system. The user profile itself is composed of various explicit, i.e. indicated by the user, and implicit properties, which were deduced from the user behavior. Examples of explicit information are contact data and personal data as well as information on the industrial or scientific background of the users, their research fields or professions. There is also the option for a user to state preferences for different topics which the assistance system considers for recommendations. Topic preferences are also deduced from the users' behavior as implicit properties. Since the assistance system is to accomplish an accompanying support of the developers along the development process, the progress in the development process has to be recorded additionally in the user profile. After all, a situation describes further influencing variables, which can be considered by the system during the generation of a recommendation. Examples of this are the system deployed by the user or the protocol of the current browser session. During the development of the assistance system, the consideration of the situation only plays a minor part.

On the whole, the information used by the assistance system can be subdivided into three main categories (Burke and Ramezani, 2011). In the first category, information on the user for whom the recommendation is generated is collected. This information is contained in the user profile as mentioned above. The second category describes information that can be deduced from the collective behavior of all users. The contents, for example that have been searched and viewed successively as well as the annotations assigned by the individual users are especially part of this behavior. Furthermore, evaluations and opinions can also be included in the recommendation generation. The third and therefore last group observe information in the articles of the KandMSMA, themselves. The properties, for example annotations, of these articles serve as a primary basis for this.

Content-based and collaborative approaches as well as combinations of these are used for processing the available information. At the same time, further supportive approaches such as e.g. editorially created rule –based systems can be deployed. There is a variety of approaches as illustrated e.g. in (Burke and Ramezani, 2011) and (Manning et al, 2008). Content-based approaches determine recommendations on the basis of the similarity of contents. In this way, contents are compared e.g. by reference to the occurring terms or the annotations used for them. This means that contents which are similar to the contents that have already been viewed or defined as preferences are recommended in the user profile. Collaborative approaches by contrast neglect the actual contents and their properties. Instead, they use statistics on the behavior of users during the employment of the KandMSMA and search for similarities in the user behavior. Here sequences and coherences in which the contents of the KandMSMA are called and employed by users are of particular interest. Both content-based and collaborative approaches make use of mathematical algorithms such as e.g. Term Frequency-Inverse Document Frequency (TF-IDF, cf. (Burke and Ramezani, 2011) and (Manning et al, 2008)), Latent Semantic Analysis (LSA, as in (Landauer et al, 1998) or (Guillermo and Jose, 2010)) or Latent Dirichlet Allocation (LDA, (Blei et al, 2003) and (Krestel et al, 2009)) in order to determine the relevance of a recommended content. A more detailed explanation of these algorithms is not to be a subject of this paper.

3.3 CHALLENGES IN RECOMMENDATION GENERATION

Two significant problems have emerged especially in the realization of the semi-automated annotation. The first one consists in the finding of appropriate approaches that are suitable for a support of the annotation of new contents. As already described, these are based on user-individual or social/collaborative information or on the contents to be annotated. Even though all of these approaches would be generally suitable to recommend annotations, in this special case of publishing new contents they are utilizable only under specific conditions. Thus if the author is not the only one who has access to these contents, collaborative approaches are utilizable after the publication of the contents in the KandMSMA only. Therefore, they are not suitable for recommending annotations for new content.

Contrary to this, annotations for new contents can already be recommended when using content-based and user-individual approaches. The second crucial problem with semi-automated annotation consists in the fact that these approaches have to draw on a sufficiently large reference corpus in order to be able to recommend appropriate annotations for new contents. By contrast with the recommender systems and databases applied elsewhere, only a rather small text corpus is available to the present KandMSMA (cf. e.g. (Burke and Ramezani, 2011) and (Manning et al, 2008)). Hence a concept for an assistance system that solves all of the problems mentioned above by a combination of the different approaches has been developed specifically for SMT as described in the following.

4. APPROACH TO RECOMMENDATION-BASED ASSISTANCE

The development is aiming at the creation of an assistance system that is integrated into the already existing KandMSMA, which on the one hand effectively provides the user with personalized information from the KandMSMA and on the other hand enables a simplified publication of new information. Figure-3 shows the basic sub approaches and their interaction in order to facilitate the recommendation of annotations and articles.

4.1 RECOMMENDING ANNOTATIONS FOR NEWLY INTEGRATED CONTENT

On the one hand, the contents to be newly integrated are analyzed by individual methodical components of the assistance system, so that a recommendation for an annotation can be generated. In this process, the aforementioned content-based approaches are employed in combination with editorially generated rules. Editorial parts are of particular importance to the recommendation of annotations. In this manner, e.g. in the text corpus of the KandMSMA at hand, improvements in the annotation could be achieved and recommended series of articles could be generated by using editorial rules.

For the recommendation of articles from the KandMSMA on the other hand, collaborative methods are used in addition to the content-based and editorial defined rules. In order to recommend annotations on new contents, the author first integrates the content into the KandMSMA.

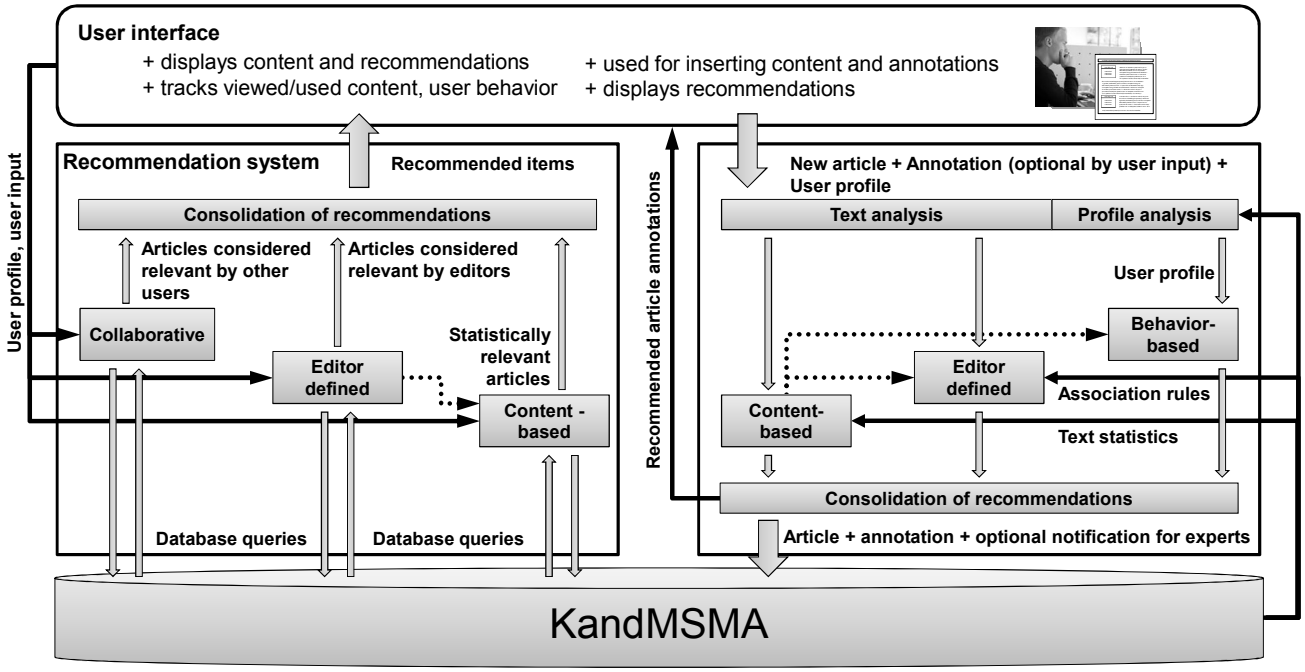

Figure 3 – Overall concept for the assistance system

The content which is thus forwarded to the assistance system is then examined along with the user profile via a text and profile analysis. In a second step, a comparison between the new content and the existing content is drawn. By means of this, it is to be rendered possible e.g. to class a new article with the topic requirement determination in the planning phase according to the terms used in it. Editorially created association rules utilize the terms used in an article in order to recommend additional annotations. In the profile analysis, interests and actions that are saved in the user profile are matched with the new contents. It is then determined in how far a user has already been active in a subject area. This allows for e.g. the information of experts in this subject area on new contents in cases of no accordance. The individual annotation recommendations from these sub-approaches are subsequently arranged in a general annotation, so the user can now accept or alter the suggested annotations.

4.2 APPROACH TO RECOMMEND CONTENT FROM THE KANDMSMA

On the analogy of the recommendation of annotations on new contents, user profiles and actions are used as a basis for the recommendation of existing contents. For this, the user is observed by the assistance system when he makes use of the KandMSMA. This observation is to determine especially his interests and context, which can be deduced from e.g. the annotations of the articles read. These annotations are employed by three groups of methods for recommendation generation. In the behavior-based group, the user profile is matched with the profiles of other users and contents that other users have viewed in the same context or with the same interest are selected. The editorially rule-based recommendation group deduces further recommendations for potentially relevant contents and series of articles from the viewed articles. Content-based methods are finally used as last group, which generates a recommendation of articles that are similar in content to the articles viewed. With adaptations, the described mathematical algorithms for the recommendation of annotations can also be used. On the analogy of the recommendation of annotations, the individual recommendations are finally merged with a control system to a general recommendation.

4.3 PRESENTING RECOMMENDATIONS TO THE USER

Starting from a support during the conceptual development of SMT-based products, developers are to be supported on the design of their products and on the realization of a prototype.

Developers are to be offered check lists, catalogues and examples as methods of support. These methods are to be complemented with tools, e.g. ones that support developers on their calculations. An example of a tool of that kind is depicted in Figure-4 (German is used as the main language in the KandMSMA). This tool enables the conduction of a coarse dimensioning of wire actuators. The tool itself is embedded into an article which describes the fundamental principles and calculations for dimensioning an SMA wire actuator.

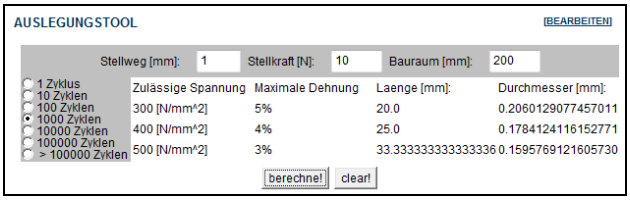

Figure 4 – Screenshot section of an embedded tool for dimensioning SMA wire actuators

Functions and interfaces for presenting recommendations are grouped into the following 4 groups: Search, portals, Lists (e.g. tag clouds) and graphs, which are used to provide the recommendations to the user. Especially the search, portals and lists are commonly known by most of users because of the wide range of use in the internet. The recommendations are integrated into these functions. For example the search results and the content presented in portals are filtered and ordered based on the user preferences. Lists in form of tag clouds also suggest relevant annotations to the user. The support of the developers occurs via a targeted provision of the information and tools contained in the KandMSMA and is guided by the assistance system. As a result, the assistance system is to gradually lead developers from the information provided in the articles through the development process and also to instruct them to proceed in a methodical way. This support is given by a recommendation of the KandMSMA articles relevant to the respective developer on the basis of the personalized user profiles and statistics on the use of the KandMSMA by other users.

To this end, user profiles which describe the interests and focus areas as well as the usage history of a user are generated by the system. This means that the system can attempt to classify developers into a phase of the product development according to the articles they have viewed. In consequence of this classification, the assistance system then recommends suitable contents and series to the developers. Figure-5 illustrates the function for the

recommendation of series relevant to the progress in the development process that is provided by the assistance system. Here, the recommended contents are depicted in the form of a graph.

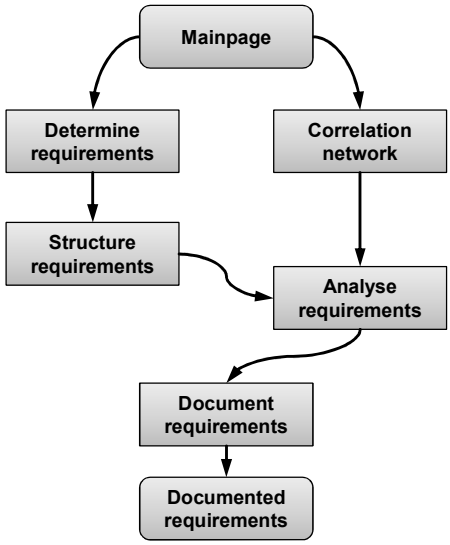

Figure 5 – Example of the recommendation of an article series for determining requirements

5. USABILITY OF THE APPOACH

To evaluation of the implemented assistance system, the system consists of several test series beginning with a simple questioning and ending with an evaluation project. At the current state of the project a first set of acceptance and usability tests was conducted, using a questioning, whose summarized results are presented in the following section.

The questioning was targeted on determining the acceptance and usability of the supporting functionality and interfaces provided by the assistance system. It is important to determine the acceptance by the user to improve these functionality and interfaces for a faster and more simplified access in the further development of the assistance system. This can include changes of existing function or even the removal of a non accepted functionality. It has to be noted, that the usability of the assistance system is in focus.

The determination of the usability is based on the analysis of the benefit for solving given tasks with the functionality provided by the assistance system. For this reason, users have to answer five SMT-specific questions with an increasing level of difficulty. The level of difficulty of a question is defined by the complexity of the actions, which are necessary to answer this question. For example, easier questions can be answered by searching specific articles in the KandMSMA. In opposition to this, questions with a higher level of difficulty require to read and understand a series of articles.

The analysis of the acceptance is based on the frequency of use of different functions and interfaces for answering the questions. In addition to this, users are asked to estimate the popularity of the provided interfaces and their knowledge in the domain of SMT. Functions and interfaces are grouped into the following 4 groups: Search, portals, Lists (e.g. tag clouds) and graphs, which are used to provide the recommendations to the user.

In the course of the experiment, users have to answer the questions first without the help of the assistance system and then with.

5.1 EXPERIMENT SETUP AND EXECUTION

Based on the described targets a questionnaire with three parts has been generated. The first part of the questionnaire consists of a self assessment and an estimation of the popularity of different interfaces and functionalities. The second part contains the SMT-specific questions, which have to be answered with respectively without the assistance system. Finally, the third part asks the user for the use of the functions and interfaces to find information in the KandMSMA.

Questions for self assessment and popularity are based on rating scales with values from 1 to 5. All other questions are open. The answers to the SMT-specific questions are checked for correctness. The experiment was conducted with 17 students from engineering science, sales engineering, medical science and business administration, which represent the targeted user groups. Each user answers a questionnaire under observation. The observer ensures the solely use of the KandMSMA and documents its use. In addition to this, the users are allowed to ask the observer in cases of comprehending the questionnaire or the experiment.

5.2 RESULTS

The following two diagrams illustrate the influence of the assistance system on the answering of the SMT-specific questions and the acceptance of the provided functions and interfaces. The first diagram (Figure-6) shows the answering of the 5 SMT-specific questions (Q1-Q5) without and with the use of the assistance system. The questioning of 17 users with 5 SMT-specific questions results $17 \cdot 5 = 85$ answers in two rounds. Without the assistance system the users have given 28 correct answers in sum or 33% of the possible answers. It has to be noted that more questions with a low level of difficulty has been answered correctly. With use of the assistance system the number of correct answers increases to 64, which represents 75% of the possible answers. Also an increase of answers for more difficult questions is notable.

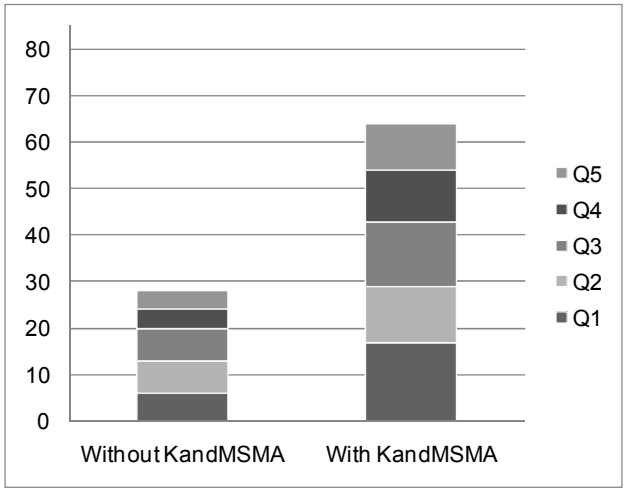

Figure 6 – Number of correct answered questions (y-axis) with and without the assistance system

The second diagram (Figure-7) shows the use of interface for finding information within the KandMSMA. Especially interface, which are known by the user from common internet sides, are used. Unknown or sophisticated functions like graphs are used only by a few users.

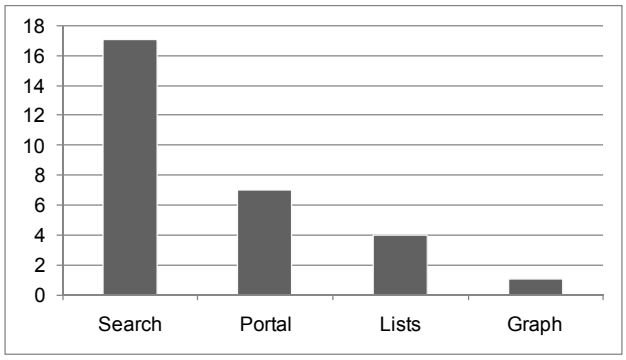

Figure 7 – Used interfaces and functions (y-axis: number of users)

Users have noted that more sophisticated functions or interfaces are not obvious and not familiar enough to use them effectively. As a conclusion of this experiment it has to be stated, that especially the interfaces have to be improved to provide a better access to the functionality of the assistance system.

6. DEVELOPMENT PROCESS OF SMT-BASED PRODUCTS

The assistance system described in the previous chapters has the central task of supporting the product developer in various tasks along the product development process. For example, if a user reads an article on requirement determination, the assistance system will recommend further articles on the group of themes on "requirement". As already mentioned in the introduction, the recommendation of series of articles, which lead users to their self-defined goals, constitutes a crucial functionality of the assistance system. Figure-8 illustrates the process model that was taken as a basis for the development process.

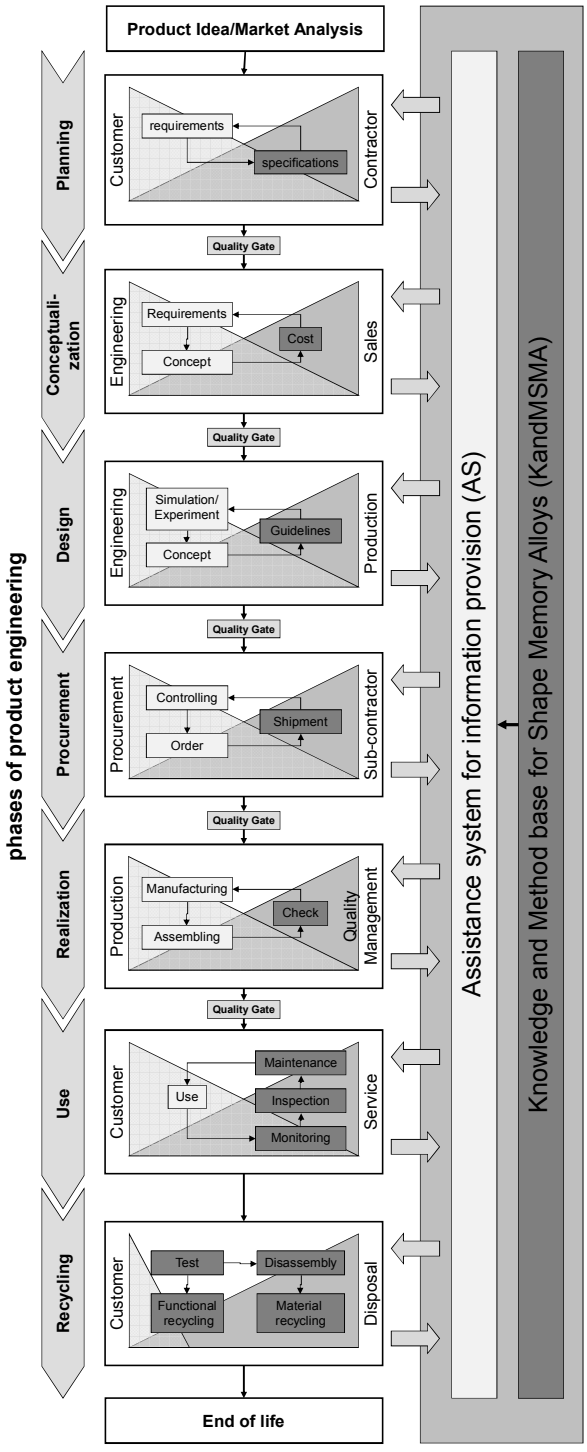

Figure 8 – Process model for the development of SMT-based products

Initially, steps similar to those in other process models are gone through, e.g. VDI2221. After the first two phases of planning and conception, the phases of design, acquisition and realization follow, which cater particularly to the specifics of the SMT-

oriented process model. The steps that are to be processed during the succession of the phases are depicted in detail in the assistance system. Methods and tools, for instance are to be elucidated and made available in the corresponding articles as early as during the planning phase.

7. SUMMARY AND OUTLOOK

The introduced approach has to support the developers in diverse tasks along the product development process and to instruct the developers to proceed in a methodical way. Depending on the identified user context, contents of the KandMSMA are compiled as personalized recommendations and are then presented to the user. In addition to that, the assistance system has to offer support on the publication of new contents by enabling a semi-automated integration of these contents into the KandMSMA on the basis of recommendation of suitable annotations. The assistance system which provides support along the product development process makes use of the existing KandMSMA and is directly integrated along with the available interfaces into its web frontend. Moreover, this enables the use of the assistance system by every web-enabled computer with a standard browser.

With advancing development, the functionality of the assistance system has to be evaluated. For this purpose, objective evaluation criteria and scenarios, which depict the expected users of the KandMSMA representatively in their respective contexts have to be developed systematically.

The presented results of the experiment indicate to focus further developments efforts into the representation of the functions of the assistance system. Therefore, the interface design and integration of the functions into the web frontend have to be improved and evaluated in further tests.

ACKNOWLEDGMENTS

We thank German Research Foundation (DFG, www.dfg.de) for funding our research within the project Special Research Project SFB459 “Shape Memory Technology” (www.rub.de/sfb459/). The presented results and findings would not have been possible without this funding.

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