A Holistic Model for Integrating Usability Engineering and Software Engineering Enriched with Marketing Activities

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Abstract. To support the integration of usability engineering and software engineering this paper analyses corresponding international standards and introduces a model that consists of activities and artifacts highlighting dependencies, similarities and possible points for integration. In addition the model presents activities that serve as potential integration points for the third discipline of marketing. By using this model processes can be aligned easier on a common information base (e.g. activities, artifacts). Innovative thinking will be forced by considering the business perspective of marketing activities likewise.

Keywords: Integration, Usability Engineering, Software Engineering, Marketing, Marketing Research, Standards ISO 9241-210, ISO/TS 18152, ISO/IEC 12207 and ISO/IEC 15504.

1 Introduction

In todays industry usability has already been recognized as an important quality aspect of the software development process. However, the integration of usability engineering and software engineering still remains to be a challenge in practice [1], even though implications of good usability are obvious: End-users will be able to work more effectively and efficiently, but it is also beneficial for the developing organization in different aspects, e.g. in monetary form, such as the reduction of support- and training-costs. Thus, usability is not an exclusive attribute of the generated product; it is also a fundamental attribute for the development process itself. Furthermore the usability of the product will have major impact on its proposition on the market. According to the increasing competition and the variety of alternative solutions a product will only survive on the market if it is easy to use and if it supports the user's needs. A good example is Apple Inc. that provides products that are easy to use and well accepted by costumers and the market. Consequently it is assumed by the users that even 'any' future product will have the same benefits in terms of usability and therewith this will increase the market relevance of company's products. It can be said that usability is an important marketing aspect [2].

In this paper the authors present an approach that integrates usability engineering with software engineering and that identifies potential links for marketing, too. This

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includes an equal consideration of interests and aims for all these three disciplines. In order to do so, the authors analyzed existing integration approaches and identified the abstraction level of standards as a basis for the integration. Common activities have been identified; artifacts and their dependencies are worked out and extended by marketing perspective. As a result a holistic model for integration was created. This was evaluated based on the results of interviews with experts from usability.

2 Background

In order to create a common integration model of the three addressed disciplines usability engineering, software engineering and marketing it is important to create a common understanding.

Usability engineering (UE) is a discipline that involves user participation during the development of software and systems and ensures the effectiveness, efficiency and satisfaction of the product through the use of a usability specification and metrics [3]. Software engineering (SE) is a discipline that addresses the whole software lifecycle (from the phase of requirements specification up to the maintenance of a released product) in a systematic and predictable way adopting several engineering approaches [4, 5].

Both disciplines use process models to plan and systematically structure the activities and tasks to be performed during software creation. In general these models detail activities, the sequence in which these activities have to be performed as well as the resulting deliverables (in various levels of abstraction). The goal is to define a process where the project achievement does not depend on individual efforts of particular people or fortunate circumstances and aims to create good software. The essential attributes of good software are maintainability, dependability, security, efficiency and acceptability [5]. Even like in UE and SE especially the attribute of acceptability is an important marketing characteristic.

Marketing (and Marketing Research) (MM) is a discipline that offers market-oriented business strategies to satisfy customer needs and expectations [6, 7]. One important issue that needs to be considered is that the customer is not necessarily the end user. This discrepancy exists in current practice not only in marketing but also in software development: The customer is not (always) the user. However, the end user is a promising stakeholder for MM even like the customer, as the users needs will have a major impact on the success of the product. Benefits for SE appear in less maintenance and those for UE are obvious – the satisfaction of the users. Thus, this seems to be one common dominator of all three disciplines.

While looking on integration approaches a considerable amount can be found - at least for UE and SE - in theory and practice. The integration with MM is still an open issue, which will be addressed later on in this paper.

2.1 Existing Integration Approaches

While looking on existing approaches the authors investigated in those for UE and SE primarily. The reason is because SE is usually the driver in software development and the amount of existing integration activities with UE is remarkable. An investigation on these two disciplines should therefore serve as a basis to build on.

Most of the UE and SE integration approaches can be organized along four general categories [8, 9]: Approaches that a) concern the concrete implementation; b) present a common specification; c) address the definition of processes and process models; and d) focuses on abstract or generic approaches.

Those *concerning the concrete implementation* define activities and artifacts as well as links to existing SE activities. For example, Ferre [10] specified a set of 51 generic UE techniques that had been reviewed by experts following some criteria, e.g. how adaptable the techniques are to software development processes, how the applicability of the techniques is in general, how much it costs to perform the techniques and how the acceptance is in the field of human computer interaction. To ensure the relation of the techniques to SE activities the concepts and the terminology of SE have been adapted. A second group of integration approaches presents a *common specification*. For example, Juristo et al. [11] developed an approach concerning the measuring and evaluation of usability topics using architectural patterns embedded in the system architecture design. Therefore they identified several patterns of UE and adopted them to SE. Other integration approaches address the *definition of processes and process models distinguishing* between independent UE models and SE models with integrated UE activities. As an example, Düchting et al. [12] discuss existing agile process models (e.g. Scrum or eXtreme Programming [13]) for the implementation of UE activities and derived practise-oriented recommendations. A fourth group of integration approaches *focuses on abstract or generic approaches* specifying general conditions to be considered for the integration. As an example, Metzker and Reiterer [14] present an 'Evidence-Based Computer-Aided Usability Engineering Environment (CAUSE)' for the organizational level of an organization. They use the paradigm of a situation-based decision-making and developed a process meta-model supporting the selection of UE methods.

As the variety of UE and SE integration approaches show there is a lot of research going on. However, the discipline of marketing and its integration appears to be very sparse. Only few approaches can be found such as [15, 16]. They focus on user centered design processes and try to implement activities or results in the product innovation process. These can be mapped to the third category of defining processes and process models.

It can be said that most of the approaches for integration were applied in practice appear to be on an operational level, which results in very specific activities or customized methods. The challenge is that these approaches cannot be easily transferred to any other situation in practice. Therefore it seems to be promising to investigate in a more abstract view of integration.

2.2 Hierarchy of Integration Approaches

While looking on the different types and categories of integration approaches for UE and SE, Nebe [17] differentiates into three levels of abstractions: 'standards that define the overarching framework, process models that describe systematic and traceable approaches and the operational level in which the models are tailored to fit the specifics of an organization' (see Figure 1). This hierarchy exists in both disciplines software engineering and usability engineering and can be exploited for integration. At the level of standards general integration strategies can be defined that

are applicable to a large number of existing development processes. For the purpose of integration Nebe has focused on the SE standard ISO/IEC 12207 [18] and the UE standard ISO 13407 [19].

ISO/IEC 12207 addresses essential processes in the software development lifecycle (from acquisition to maintenance) and supports the development and management of a software product. ISO/IEC 15504 [20] aims at the evaluation of the maturity of a software development process in a specific organization and is also known as SPICE ('Software Process Improvement and Capability dEtermination').

ISO 13407 defines four activities of human-centered design that should take place during system development. In the meantime a revised version of the UE standard Nebe used has been published (ISO 9241-210 [21]). ISO 9241-210 focuses on human-centered design for interactive systems and is mainly structured in four parts: 'understand and specify the context of use','specify the user requirements', 'produce design solutions','evaluate the design against requirements' [21]. ISO/TS 18152 [22] is based on the ISO 9241-210 and specifies issues for an assessment of human-systems.

Nebe compared standards and defined compliancy and key requirements for the integration of the disciplines. These requirements can be used in addition to existing base practices (based on ISO/TS 18152) to access existing processes in an organization and to specify concrete activities to be performed. This work shows that even when looking on the abstract level of standards concrete strategies on an operational process level can be perceived. Thus, as mentioned before the level of standards seems also to be promising for integration of UE, SE and MM. The idea in behind is, that no process-specific or organizational-details would being an obstacle and the common information exchange would succeed.

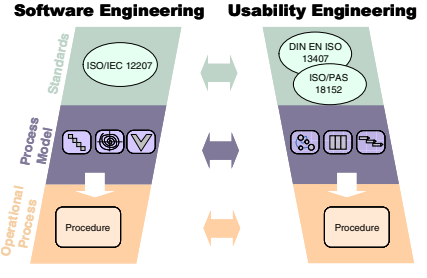

Fig. 1. Similar hierarchies in the two disciplines SE and UE: standards, process models and operational processes [13]

3 Proceedings

Looking forward to create a common integration model the authors have analyzed specific standards for UE and SE. The aim was to create a concrete basis of activities and artifacts for further investigations. In addition, dependencies of those activities and artifacts have been examined to show the flow of information between the activities of each discipline. After that, interdisciplinary dependencies between UE and SE have been analyzed to show the information exchange and the correlation

between activities of both perspectives. Then, the authors verified the activities and identified potential gaps according to assessment standards.

Then, the authors analyzed literature to search MM activities, which show commonalities in the outcomes regarding to the artifacts of UE and SE. By doing this, potential integration points are being identified, where MM can enrich the overall development process. Having analyzed and listed the activities and artifacts of all three disciplines the authors visualized them in a holistic model highlighting while showing all the commonalities and interconnections. The goal was to create a clearly laid out and comprehensible picture of the complexity. Finally, the authors evaluated the model in two ways (with the focus on UE). First they compared the activities with the compliancy and key requirements from Nebe [8] to verify the list and to incorporate changes according to revised UE standard ISO 9241-210 (formerly ISO 13407). Second, the authors proved the completeness, the relevance to practice, as well as the correlations between UE and SE artifacts of the UE activities- and artifacts-list by interviewing UE experts.

As a result, the model was partially approved and seems to have potential for the integration of UE, SE and MM. The detailed proceedings will be described as follows.

3.1 Common Activities and Artifacts

As mentioned previously, standards seemed to be a reasonable basis for the development of a holistic model. Starting with the integration of UE and SE, the two standards ISO 9241-210 and ISO/IEC 12207 have been analyzed in detail. Therefore the specification documents have been examined. The goal was to operationalize these standards in terms of defining lists of activities and artifacts that can be used as a basis for an integrated model. While having this in mind, the authors scanned the documentations and looked for ‘verbs’ that represent potential activities and added them to a list. In addition, potential inputs and outputs as well as dependencies of those activities are identified and added to the list, too. This was done for the UE as well as for the SE standard likewise. As a result, two independent lists were created highlighting all activities and artifacts for the corresponding standard and discipline.

Next, the flow of information was analyzed, as communication is crucial for different disciplines to work together. By doing this, textual correlations of activities and artifacts between the two lists are identified and documented.

Having listed activities from the UE and SE the authors verified them by comparing with Base Practices of the corresponding assessment standards (ISO/TR 18152 for UE; and ISO 15504 for SE). Each base practice has been compared to the list of activities while seeking for semantic relationships between the base practices and an activity. By doing this, the activities- and artifacts-lists’ completeness could be verified. By doing this, gaps in the list of base practices have also been noticed but these appeared to be irrelevant for the model. However, as a result of the verification gaps in the fundamental standards (ISO 9241-210 and ISO/IEC 12207) have also been identified. In the process, this has not been further investigated until now. However, it is expected that this originates either from the incompleteness to their corresponding assessment standard or the missing activities have not been identified during the author’s analysis of the standards.

An excerpt of the resulting list is shown in Table 1. The activities are listed with a number for identification (e.g. 'AKT.UE.12' – means: activity from UE + increasing identifier), the reference to their textual position in the origin standard (chapter/ paragraph) and the reference to their correlated base practices (existing reference number).

Table 1. Examples of identified activities for the perspectives of UE and SE based on the analysis of standards

Reference	Activity	Origin	Base Practice
AKT.UE.12	Identify the characteristics of the users or group of users.	9241-210:6.2.2.b	HS.3.1.BP3
AKT.UE.18	Identify user and other stakeholder needs.	9241-210:6.3.2	HS.1.1.BP5 HS.1.2.BP5 HS.2.3.BP1
AKT.UE.33	Allocate tasks and sub-tasks to the user and to other parts of the system.	9241-210:6.4.2.2	HS.2.7.BP2 HS.3.3.BP1
AKT.SE.8	Specify functions and capabilities of the system.	12207:5.3.2	ENG.1.1.BP1 ENG.1.1.BP2
AKT.SE.36	Develop and document a top-level design for the interfaces external to the software item and between the software components of the software item.	12207:5.3.5.2	ENG.1.3.BP2
AKT.SE.51	Test each software unit and database ensuring that it satisfies its requirements.	12207:5.3.7.2	ENG.1.4.BP3 ENG.1.5.BP4 ENG.1.5.BP6

3.2 Integration of Marketing

In order to add MM details to the approach, basic literature of the discipline has been analyzed [23] in order to identify activities, which have commonalities to the content of the artifacts-lists of UE and SE. Therefore the literature was scanned for 'verbs' that gave hints to similar activities or outcomes. The overall aim was to highlight potential points for integration where results from marketing can enrich the overall development process. The perspective how marketing can obtain was recently not in the focus of investigation. However, there are potential benefits for marketing as considering the users' needs will certainly improve the quality of innovative products.

Having the focus in mind, the authors looked for conductive integration points to an overall process. Examples are the tasks of synchronizing 'the identification of user characteristics' (UE) with the 'analysis of the consumer behavior' (MM) or 'the identification of the system environment' (UE) with the 'analysis of the macro-economic environment' (MM), which both can influence and increase the quality of the context of use description. A complete list of MM activities can be found in [24].

Those similarities have been visualized in the overall diagram of the model, which is exemplarily shown in the next section.

3.3 Visual Model of Integration

In order to present the complex results of investigation the authors created a concrete visualization: the holistic model. This includes the lists of activities, artifacts and their

correlations as well as the disciplinary and interdisciplinary dependencies of UE, SE and MM.

Therefore different visual representations were chosen. Activities are presented using squares and artifacts are presented using pentagons. To highlight dependencies between activities and artifacts the authors use arrows. The distance between two or more objects represents interdisciplinary correlations – the closer they are the higher the correlation is. Objects were colorized according to the corresponding discipline (performing the activity or creating the artifact): green = UE, blue = SE, and magenta = MM. An excerpt of the visualized model is shown in Figure 2.

Fig. 2. Examples of the holistic model focusing on integration points for MM (left)

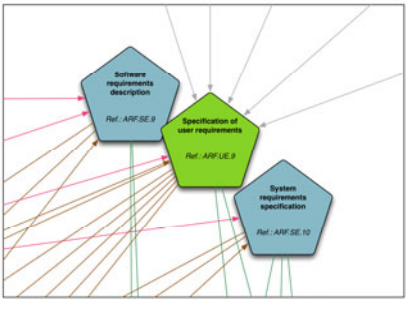

Fig. 3. The requirements specifications as a central artifact (right)

The illustrated model gives an overview of all activities, which have to be performed, and all artifacts, which have to be delivered. Similarities and dependencies are highlighted according to their visual closeness. The flow of information can easily be understood following the directed arrows (shown in Figure 3). The range of the activities to be carried out can be perceived and an approximately timeline of the activities is visualized. In addition the model enables organizations to easily compare and discuss their process along the model and as a result helps to identify integration aspects between UE and SE. The model can also be used to specify new and to enhance or evaluate existing process models.

3.4 Evaluation from UE Perspective

In the first step of evaluation the authors compared the lists of activities with the earlier mentioned compliancy and key requirements according to Nebe [8]. Therefore the textual and semantic existence of each requirement had been checked against the lists of activities. Any not confirmed requirement has been formulated as an activity and has been included in the list. By doing this, the authors wanted to verify the conformance of the list to the integration approach of Nebe and to incorporate changes considering the revised UE standard (ISO 9241-210). The result was an extended list of activities.

In addition the authors performed an evaluation focused on the UE perspective. Therefore they carried out interviews with experts in the field of UE who work in ISO committees as well. At first a guideline for the interviews had been created to

operationalize the topics to be questioned. Then the questions had been developed and validated according to their precision, uniqueness and comprehensibility. Further on the lists of UE activities and artifacts had been extended with a five point Likert scale. The aim was to get answers considering the relevance of the model in the current work practice of the experts, the completeness of the lists according to the experts and the prioritization of the activities in regard to their importance in the development process. An additional aim was to review the textual dependencies of artifacts between UE and SE. Finally the experts were interviewed.

As a result the experts confirmed the completeness of the lists of activities and artifacts and prioritized them. They acknowledged that an analysis of the context of use at the beginning of the development process can create an overview of the expected users, their characteristics and the tasks they want to solve. All participating disciplines in a software developing process have specific requirements that can be merged and reviewed in a shared requirements specification (compare Figure 3). In addition design solutions of a UE process should be compared with technical solutions of the SE perspective to discuss possibilities and constraints. The results are primary related to the UE perspective. With regard to the SE perspective no further statements can be made and with regard to the MM perspective no statements can be made. Therefore additional evaluations have to be realized, which the authors plan to do.

4 Summary and Outlook

This paper presents a holistic model for the integration of Usability Engineering (UE) and Software Engineering (SE) as well as Marketing and Marketing Research (MM), which is created, based on standards in UE and SE. Therefore it basically consists of fundamental activities and artifacts from UE and SE, flavored with contributions from MM. Activities are linked with artifacts showing dependencies and relationships. Similarities between the disciplines are highlighted.

The beneficial use of the model is manifold. Hence, the model enables organizations to easily compare and discuss their process along the model and as a result helps to identify integration aspects between UE and SE. The model can also be used to specify new and to enhance or evaluate existing process models. It also shows activities that may serve as potential integration points for a third discipline: marketing and marketing research. Thus, UE and SE can profit from MM activities even as MM can, based on UE. An early involvement of users in the process as well as the extensive analysis of their environment can create innovative ideas with business perspective, too. Existing processes of development may be extended with a MM perspective and also MM may be enriched with innovative ideas resulting from a user centered design process.

Currently the authors plan further validations with experts in the field of SE and MM in order to reflect the integration of all perspectives likewise. Additional perspectives are currently being analyzed to increase the quality of the final product. For example accessibility should be an issue considering that existing software products often lack of access for disabled people.

Further on the authors identified the need of a common understanding of requirements from different perspectives. When creating software, various participating parties specify their own requirements from their individual perspective and speak different domain specific languages. Extended requirements and redundant

requirements are formulated as well as contrary requirements. Thus in future the authors want to analyze how requirements are specified and communicated in an understandable manner reducing the addressed problems. Therefore a framework will be developed to share, understand, resolve conflicting and prioritize requirements in a common way.

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