NordDesign 2014
August 27 – 29, 2014
Espoo, Finland / Melbourne, Australia

Situation-appropriate method selection in product development process – empirical study of method application

A. Albers[1], N. Reiß[1], N. Bursac[1], J. Urbanec[2] & R. Lüdcke[3]

[1]*IPEK – Institute of Product* Engineering,
Karlsruhe Institute of Technology (KIT), Germany
{Albert.Albers; Nicolas.Reiss; Nikola.Bursac}@kit.edu

[2]*IPRI – International Performance Research Institute gGmbH*
jurbanec@ipri-institute.com

[3]*Innovation and Concept Development*
Dr. Ing. h.c. F. Porsche AG, Germany
Robert.Luedcke@porsche.de

Abstract
Although numerous methods exist for the product development process they are not regularly used in practice. One reason is that there is often not enough know-how available regarding the integration of the methods in product development processes. In this contribution, results of an open online survey are presented. Major findings of this study reveal that applied methods are usually used with a certain focus, although all method categories can be found throughout the entire product development process. Furthermore, the research results show that the variance in the evaluation of the suitability of individual methods within a category was remarkably low. Simultaneously the number of used methods within the corresponding category was spread out since there are many seldom-applied methods that are evaluated as successful, so the purpose of the methods' research should be the provision of situation-appropriate methods to developers.
Keywords: method application, empirical study, activities in product development

1 Introduction

The success of companies in the globalized markets of our time is largely determined by the development of new products. To assist the companies in the innovative development of new products the Federal Ministry of Education and Research initiated the project "IN ² - from INformation to INnovation" in 2012. The aim of the project is the encouragement of the systematic development of innovations through an intelligent management of methods. Although numerous product development methods exist and their utility is demonstrated in the appropriate context, they are of a limited use in practice [1], [2]. One reason for this is missing knowledge of how organizational practices can be effectively integrated into the product development process (PDP) [3]. In order to face this problem, an application for mobile devices

will be developed. This app, named „InnoFox", recommends situation appropriate methods. The input for this purpose was gathered analyzing processes of industry partners, the relevant literature and results of an empirical study. This paper will present the major findings of the empirical survey.

2 State of the Art

In the following Chapter the state of the art about (1) method application and (2) acceptance as well as (3) the activities of product development is presented.

2.1 Method application

Due to increasing complexity of technical systems, shorter life-cycles of knowledge and a constantly increasing time pressure in development projects, methods are of great importance in product development processes. Methods describe a goal-oriented procedure. They have a descriptive character and represent the generalized background of certain application cases. They should serve as assistance for the attainment of a goal to the user. The outcome of the application of a method is open [4]. Lindemann [5] understands as well as Ehrlenspiel [6] that the term "method" means the description of a rule-based and planned action to perform certain activities according to its specification. Thus, methods always have an instructional character. They provide a step by step proceeding to solve a specific problem. A method can include the use of different tools in order to achieve the goal. They can comprise guidelines which tools should be used as well as the order in which they should be applied. Due to the varied work in product development, numerous methods such as FMEA, QFD or morphological boxes have been developed. These methods are used to enable the recourse on the experiences of others at repeated problem patterns [4]. The design methodology refers to this general definition and relates the term methods to product development and their environment. According to state-of-the-art, the design methodology has thereby transgressed the limit of pure support of the engineers and the management [7]. Furthermore the matters of facilitating organization, planning and concept development are addressed [6], [8].

2.2 Acceptance of methods

Methods of product development intend to support the developer effectively in his tasks. Despite the wide range of methods and process models at different abstraction and granularity, these methods have so far been insufficiently integrated into daily development practice and even in this context only rarely fully exploited in their potential [9]. Franke et al. [10] find that successful firms use more frequently methods during PDP, especially analysis methods. These methods are not only used in the idea phase but also during the concept development and later stages of the PDP. Yeh et al. [11] show that methods appear to be effective although engineers use them rarely in praxis.

Although numerous methods exist and their use has been verified, in practice however they are not regularly used [1], [6]. One reason for this is that often there is not enough available expertise about how methods can be appropriately integrated in the PDP [12]. In spite of large number of available methods, only a few of them are accepted. Recent research has therefore dealt with the investigation and description of the reasons for the lack of acceptance of methods. In this context, for example Jänsch [2] and Bender [13] conclude that science is often too far away from reality. The individual needs and abilities of every single human as well as the individual working and thinking styles have been taken into insufficient consideration. In addition, the verifiability of improved results and decreased development effort due to the method approach can be revealed to a limited extend, meaning under specific conditions. The integration of operation cycles and the consideration of company goals are also rather rarely regarded. Another mentioned reason for criticism is that methods are often only theoretically

depicted and cannot be adjusted to the actual situation. The selection and editing of methods are in most cases not user-friendly. The sum of the listed points of criticism results in a lack of acceptance of methods being put into practice. However, the availability of knowledge and acceptance represents a major basis for a successful introduction and deployment of methods [14]. Therefore the methodological research should provide, with respect to the situation, also new and suitable methods to the developer. Consequently, the distribution of new and efficient methods enables to broaden the developer's horizon which can reinforce an efficient product development as well.

2.3 Activities in product development

Many common process models often do not account sufficiently the importance of iterations within the development process [1], [15]. Wynn [1] criticizes a narrow focus and a high degree of abstraction. Methods and process models contain too little recommendations on how they should be applied. In order to increase acceptance of methods in companies, it is crucial to introduce the right methods at the right point in PDP [16]. For this purpose methods and processes should be considered together [3]. Beyond that it should be taken into account that every development process is unique and individual [17]. In order to ensure comparability of method approaches of different companies throughout the PDPs, a generic view on the product engineering process is necessary. One model, which allows this, is the integrated product-engineering model (iPeM) [18], [19]. The iPeM, shown in Figure 1, is particularly well suited as a framework for the allocation of methods [20]. On the one hand the blue (a) marked activities of product engineering represent the relevant fields of action of the product developers [21]. This means that these fields represent search regions which can supply the necessary information. In the metamodel iPeM, the orange (b) marked SPALTEN problem-solving process is used to specify the activities [22]. Spalten is a German acronym which means "to split" and it stands for a cycle of problem-solving activities in a specific structure or sequence; situation analysis (S), problem containment (P), detection of alternative solutions (A), selection of solutions (L), analysis of consequences (T), deciding and implementing (E) and recapitulation and learning (N).

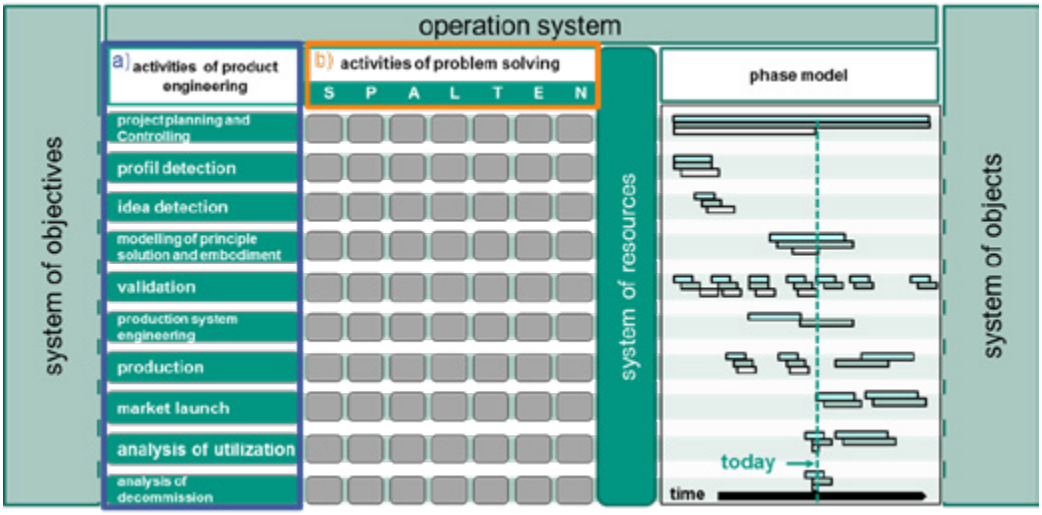

Figure 1: integrated product-engineering model (iPeM) with a) activities of product engineering (blue) and b) activities of problem solving (orange) [18]

3 Research Questions

Considering the state of the art, it can be determined that PDPs are insufficiently supported by method application. One reason for this is the lack of transparency in situation-appropriate method selection in the PDP. The aim of the project IN² is to improve this by addressing the following working hypothesis.

By a situation- and needs-based recommendation of methods, the developer can be supported which can lead to an increase in the acceptance of methods.

The aforementioned discussion leads to the research question:

Which method can support developers situation-appropriate during the product development process?

The research question will be studied in long-term. However, this paper provides a contribution by answering the following questions:

1. Which method categories are used in practice?
2. Which method categories are suitable for the individual activities in product engineering?
3. Which are the preferred methods in the respective activities and are they adequate?

4 Methodology

The underlying idea of this paper is the empirical study of method application in the PDP. During the research project IN² – from the Information to Innovation – a survey was implemented covering aspects of method application and innovations management in the PDP of companies.

The inquiry was presented online. The survey was sent from the research institutes and participating firms within the research project IN² to companies employing engineers. Thus, it is not possible to determine an accurate respondent rate. However, 247 engineers have participated in the online survey, resulting in 131 full answer sheets of all 33 questions. The questions concern four central aspects: method application in PDP, innovation and knowledge management and incentives to secure an adequate knowledge management. Additionally various firm characteristics were subject to the inquiry.

The survey provides answers from companies of miscellaneous size and branches. In Figure 2 it is shown that large companies with more than 5000 employees represent the biggest fraction of the sample, small firms with less than 250 employees represent nearly a quarter.

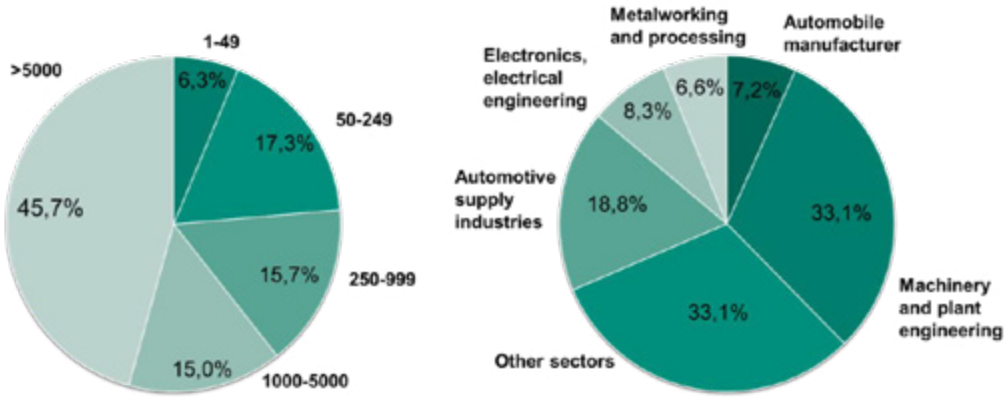

Figure 2: Size of the company, measured as the amount of employees and the industrial sector (multiple choice answers were possible in both cases)

The respondents' companies are confronted with different activities, ranging between the enhancement of existing products (1) and completely new product development (100). Most companies deal with the development of existing products. Thus, they face more a product generation development instead of creating completely new products in their PDP. Therefore, several technological leaps and innovations between the different generations of products are possible, but the basic structure of the products remains largely the same. [24]

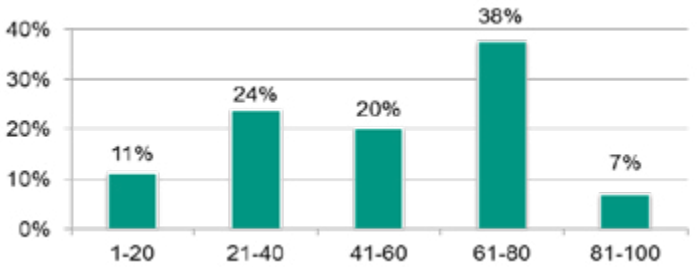

Figure 3: Company focus: further development of the existing products (1) till new developments (100)

The study covers the activities that participants take part in the PDP and the method categories (e.g. creativity, analysis and evaluation) that are most frequently used within these activities. Additionally, it was investigated how methods, used by developers, are rated regarding their quantitative and qualitative applications. Figure 4 represents the frequency of PDP activities of the respondents on a percentage scale. Although the picture demonstrates that the respondents are confronted with all activities of product development, most of the survey respondents face the first-mentioned in the activities of product engineering (project planning and controlling, profile detection, idea detection, modelling of principle solution and embodiment and validation).

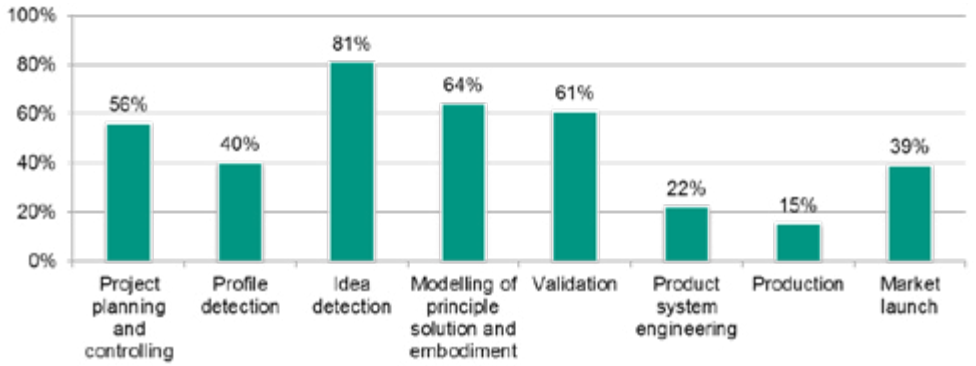

Figure 4: Focus of activities of product engineering

5 Results

In this chapter the results of the study regarding (1) the application of method categories, (2) the suitability of the categories in the activities of product development and (3) the application and assessment of specific methods within a category are presented.

5.1 Application of method categories

The focus of the study was on the use of methods along real ongoing product development processes. Thereby, one question covers the activities of the product development process the participants are involved and which methods categories (e.g., creativity, analysis, or evaluation methods) are most frequently used.

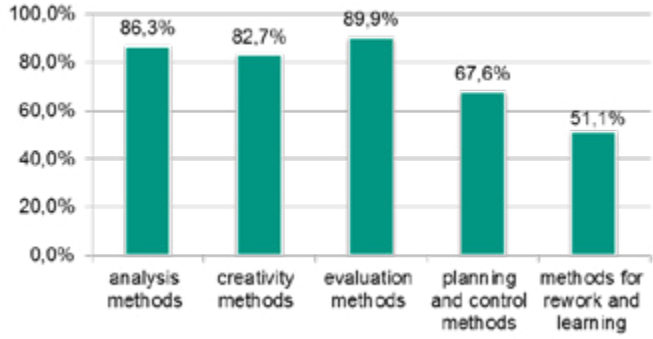

Figure 5: Percentage of people who already have applied the method category

It can be seen that analysis, creativity and evaluation methods are frequently used in practice while only 50% of the engineers employ methods for rework and learning.

5.2 Suitability of the method categories in activities of product development

This chapter will consider the question which methods categories are most suitable for the individual activities in product engineering. It provides results of the quantitative and qualitative method category application. The suitability of the respective method categories were answered on a Likert scale.

The survey covers how methods are evaluated for qualitative use (Figure 6). Major findings reveal that applied methods are usually used with a certain primer focus, though all queried method categories can be found throughout the entire PDP. Thus, for example creativity methods are used not only during the idea generation but also for the support of profile detection and modeling of principle solution & embodiment.

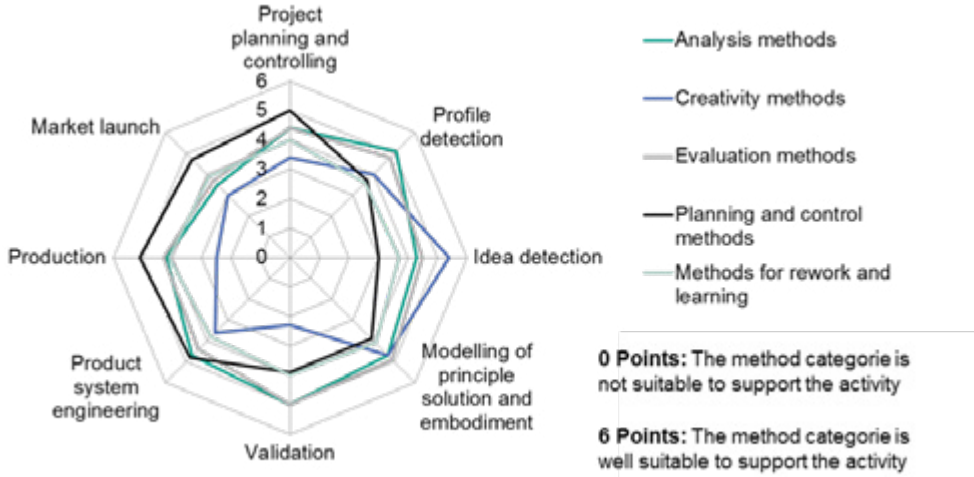

Figure 6: Suitability of the method categories in the activities of product engineering

These individual method categories can be assigned to the iPeM problem solving steps of SPALTEN. S, P: analysis methods (e.g. benchmarking), A: creativity methods (e.g. community platform), L, T: evaluation methods (e.g. value benefit analysis), E: planning and control methods (e.g. jour fix), N: methods for rework and learning (e.g. lessons learned). In order to make the results of the survey (fig. 6) accessible in individual situations in the PDP, the Method categories are assigned to the iPeM in Figure 7. In this way the different methods can be classified and assessed according to the typical product development activities. By this assignment, it is possible to recognize in which activity which type of method is to use sensible.

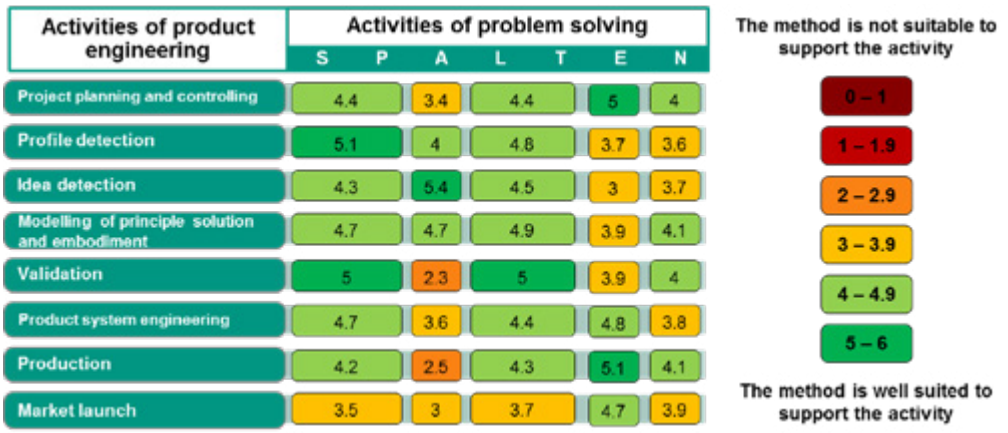

Figure 7: Rating of methods categories according to the iPeM product engineering activities

5.3 Application and assessment of specific methods within a category

In Figure 8 and 9 the frequency and the classification of the success of various methods is shown (within the categories creativity and evaluation methods). Beam a) was received using the frequency of the respective method application while beam b) deals with the perceived success of the method application based on a Likert scale.

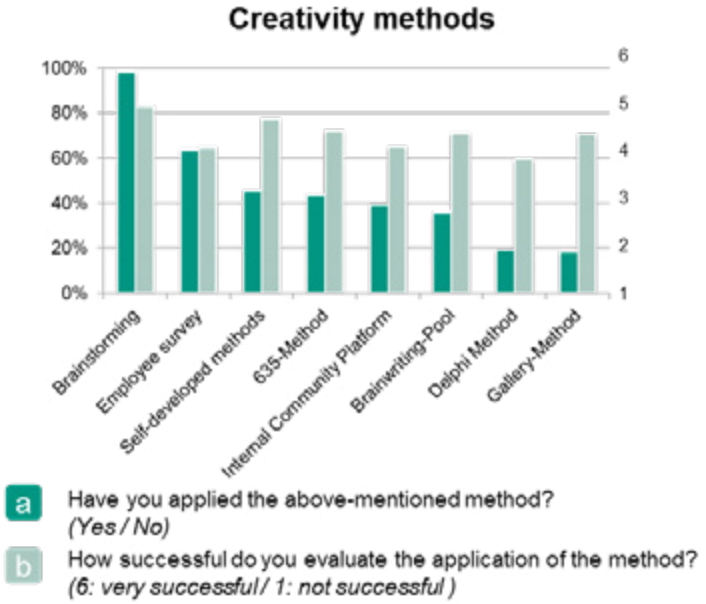

Figure 8: Quantitative and qualitative methods used within the category: creativity methods

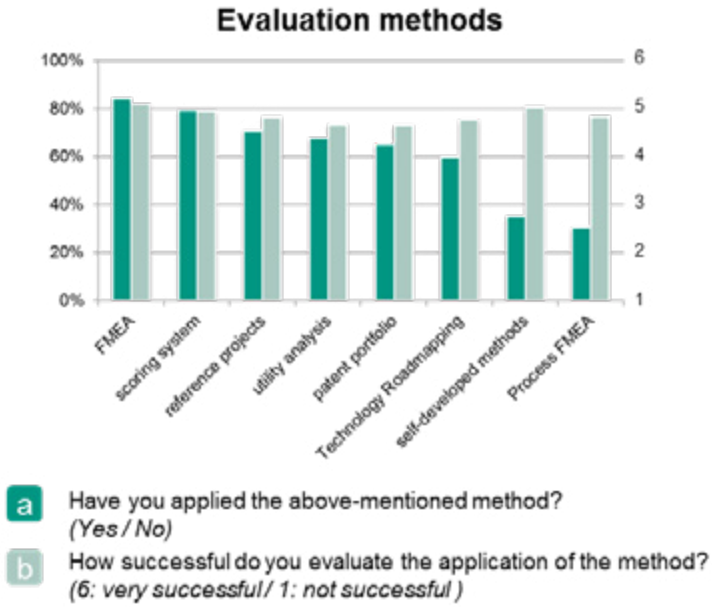

Figure 9: Quantitative and qualitative methods used within the category: evaluation methods

It could be found a very high level of method use over the different categories. However, Figure 8 and 9 show that the use of methods is limited only to a small number of selected methods within a category. For example, brainstorming is used in the field of creativity methods by almost every engineer (98%), while other methods such as 6-3-5 (42%) or brain writing (36%) are less than half as often used. It is conspicuous however that, even the methods used infrequently are considered as successful, as the most popular method. The variance in the evaluation of the suitability of the individual methods was remarkably low, while at the same time the number of used methods within the corresponding category was spread out. Thus, brainstorming, as one of the creativity methods, was by far the most frequently stated method; whereas, the suitability of other creativity methods was evaluated constantly well.
All results are computed using the mean of the respective answers. For robustness issues the median as well as the trimmed values (alpha equals 5%) and variances were also computed to avoid the impact of outliers. In order to save space, the results of these calculations were not put into this paper. The results were not significant differently. Hence, the results are not biased and the results are not significantly influenced by extreme values.

6 Conclusion and Outlook

Hence, it can be concluded that regarding the method selection the well-known methods are the ones which are most frequently referred to and it is rarely questioned whether there are more suitable ones for the current situation. The result is that a variety of methods will be developed but the potential of this variety is not yet sufficiently exploited in practice. Since there are many seldom-applied methods that are evaluated as successful, one purpose of the method research should be the recommendation of situation-appropriate methods to the developers. Due to the dissemination of new and more effective methods, a broadening of horizons of the developer can be achieved. Thus, a more efficient product development can be pursued.
To achieve the method-recommendation, an application for mobile devices “InnoFox” (fig.10) will be developed within the research and development project IN². For an individual method

recommendation, the current situation of the user must be determined. With the help of an interactive questionnaire the situation will be translated into the iPeM activities of product engineering and the activities of problem solving. With additional input of resource parameters such as time, budget or human power, the pool of methods can be filtered. Consequently, only possible methods are still recommended.

Figure 10: InnoFox – Application for mobile devices, which allows a situation-appropriate method selection in product development process. Community-Platform according to [24]

Because of this selection process, matching methods in the areas of product development, knowledge management and future management can be identified and displayed in corresponding characteristics. The detailed method description gives the developer a quick overview of the method, as well as assistance in the method application.
In following works, the "InnoFox" will be used by the project partners in order to evaluate the usefulness of the applications.

Acknowledgments
This research and development project is funded by the German Federal Ministry of Education and Research (BMBF) within the Framework Concept "Research for Tomorrow's Production" and managed by the Project Management Agency Karlsruhe (PTKA).

Citations and References

[1] Wynn, D. C., "How Can PD Process Modelling Be Made More Useful? An Exploration of Factors Which Influence Modelling Utility", In: *International Design Conference DESIGN*, Dubrovnik, 2010.

[2] Jänsch, J., "*Akzeptanz und Anwendung von Methoden im industriellen Einsatz – Analyse und Empfehlungen aus kognitionswissenschaftlicher Sicht*", Dissertation, TU Darmstadt, VDI Verlag, Düsseldorf, 2007.

[3] Browning, T. R. & Ramaseh, R. V.: "A Survey of Activity Network-Based Process Models for Managing Product Development Projects", In: *Production and Operations Management Society,* pp 217-240, 2007.

[4] Oerding, J., "Ein Beitrag zum Modellverständnis der Produktentstehung – Strukturierung von Zielsystemen mittels C&CM", *In: IPEK-Forschungsberichte*, Vol. 37, 2009.

[5] Lindemann, U., „*Methodische Entwicklung technischer Produkte - Methoden flexibel und situationsgerecht anwenden*", Heidelberg: Springer Verlag, Berlin, 2009.

[6] Ehrlenspiel, K. & Meerkamm, H., „*Integrierte Produktentwicklung - Denkabläufe, Methodeneinsatz, Zusammenarbeit*", Carl Hanser, 2013.

[7] Lüdcke, R., "Effizienzverbesserung durch gezielte Führung in der Produktentwicklungspraxis ", In: *Fortschritt-Berichte VDI*, VDI-Verlag, Vol.1, No.367, 2003.
[8] Hubka, V., "*Design Science Introduction to the Needs, Scope and Organization of Engineering Design Knowledge*", Springer, London, 1996.
[9] Stetter, R. & Lindemann, U., "The Transfer of Methods into Industry". In: Clarkson, J. and Eckert, C. (Eds.) *Design Process Improvement - A Review of Current Practice,* Springer, London, pp.436-459l, 2005.
[10] Franke et al., *"Managing Early Phases of Innovation Processes and the Use of Methods within - Empirical Results from an Industry Survey"*. 17th International Conference on Engineering Design Stanford, 2011.
[11] Yeh et al., *"Performance Improvement in New Product Development with Effective Tools and Techniques Adoption for High-tech Industries"*. In Quality & Quantity 44 (1), p. 131–152, 2010.
[12] Birkhofer, H., Jänsch J. & Kloberdanz H., "An extensive and detailed view of the application of design methods and methodology in industry", In: *Proceedings of the 15th International Conference on Engineering Design,* 2005.
[13] Bender, B., "*Erfolgreiche individuelle Vorgehensstrategien in frühen Phasen der Produktentwicklung*", Dissertation, TU Berlin, 2004.
[14] Stetter, R., *"Method implementation in integrated product development"*, Dissertation, Technische Universität München, 2000.
[15] Lohmeyer, Q., "Human-centered modeling of product developement systems in consideration of the synthesis and analysis of dynamic systems of objectives", in: *IPEK-Forschungsberichte,* Vol. 59, 2013.
[16] Albers, A., Lüdcke, R., Bursac, N., & Reiß, N., „Connecting Knowledge-Management-Systems to improve a continuous flow of knowledge in engineering Design Processes", In: *Tools and Methods of Competitive Engineering TMCE*, 2014.
[17] Albers, A., "Five Hypotheses about Engineering Processes and their Consequences", In: *Tools and Methods of Competitive Engineering TMCE,* 2010.
[18] Albers, A., & Braun, A., "A generalised framework to compass and to support complex product engineering processes", In: *IJPD*, 15(1/2/3), pp 6–25, 2011.
[19] Meboldt, M., "Mental and formal modelling, a contribution to the integrated product development model (iPeM)", In: *IPEK-Forschungsberichte,* Vol. 29, 2008.
[20] Albers, A., Reiß, N., Bursac, N., Schwarz, L., & Lüdcke, R., "Modelling Technique for Knowledge Management, Process Management and Method application – A Formula Student exploratory study", In: *Proceedings of the 3rd International Conference on Modelling and Management of Engineering Processes*, 2013.
[21] Braun, A., "Model Based Support of Product Development - Potentials of Modelling Product Engineering Processes using the example of the Integrated Product Engineering Model (iPeM)", In: *IPEK-Forschungsberichte*, Vol. 72, 2013.
[22] Albers, A., Burkardt, N. & Meboldt, M., "SPALTEN problem solving methodology in the product development", In: *Conference on Engineering Design ICED*, 2005.
[23] Albers, A., Bursac, N., Urbanec, J., Lüdcke, R. & Rachenkova, G., "Knowledge Management in Product Generation Development – an empirical study". In: *Proceedings of the 25. DfX Symposium*, 2014.
[24] Albers, A., Maul, L. & Bursac N., "Internal innovation communities from a user's perspective: How to foster motivation for participation". In: M. Abramovici and R. Stark (eds). *Smart Product Engineering*, p. 525–534, 2013.