21ST INTERNATIONAL CONFERENCE ON ENGINEERING DESIGN, ICED17
21-25 AUGUST 2017, THE UNIVERSITY OF BRITISH COLUMBIA, VANCOUVER, CANADA

CONCEPT FOR INVESTIGATING THE APPLICATION OF METHODS IN PRODUCT DEVELOPMENT

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Abstract

The use of methods is a success factor in modern product development and is of decisive importance for the overall economic success of a company. The positive effects of using a method have been extensively described in numerous scientific investigations. However, existing investigations also repeatedly show that the application situation of methods in industry differs significantly from the theoretical guiding principles, and that a comparatively subdued use of methods takes place in companies. This article describes the results of a literature research and an investigation into the current status of the use of methods in product development. Based on these initial findings, a basic research approach is described in order to improve the use of efficient methods in future practice. Obstacles to the use of current methods have to be identified and incentives for the use of new methods established.

Keywords: Design engineering, Design methodology, Design methods, New product development

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Please cite this paper as:
Surnames, Initials: *Title of paper*. In: Proceedings of the 21st International Conference on Engineering Design (ICED17), Vol. 7: Design Theory and Research Methodology, Vancouver, Canada, 21.-25.08.2017.

1 INTRODUCTION

The development of successful products is a key task of the development department in a company and is of crucial importance to overall corporate success. One of the success factors is an efficient approach in the area of development, which is subject to numerous requirements because of its high responsibility – a responsibility that is becoming more and more important, especially due to shortened development periods as well as intense international competition. Developing a successful product is a complex task for which no general guidance can be given due to the different conditions in a development process. The production of new products is an individual process that requires a systematic approach because of its importance to a company and the limited resources for development. One approach for the efficient development of new products is the use of methods during the development process. Through the use of methods, elementary tasks can be processed and the work steps of product development to a great extent predetermined. Because of their importance, the use of methods is one of the prerequisites for an efficient development of new products and should in principle be pursued by any company. Even though the effects of the use of methods are largely known, the existing initial situation still shows an ambivalent interpretation of methodological approaches in many companies (cf. Engeln, 2006, p. 1; Lindemann, 2009, p. 1; Graner, 2013, p. 1; Lindemann, 2016, p. 623).

2 STATE OF THE ART

2.1 Impact of the use of methods

The development of successful products requires a development process that consists of numerous individual stages. Due to its importance, a development process is sometimes a great challenge to the development department in a company. When considering the entire development process, from creation to market launch, the scope of this process is evident. The performance demands on the Research and Development department are high, as a high proportion of the costs is incurred there. In contrast to the high level of responsibility, the development itself usually results in a comparatively small share of the total costs. Figure 1 shows the development of costs in a development process.

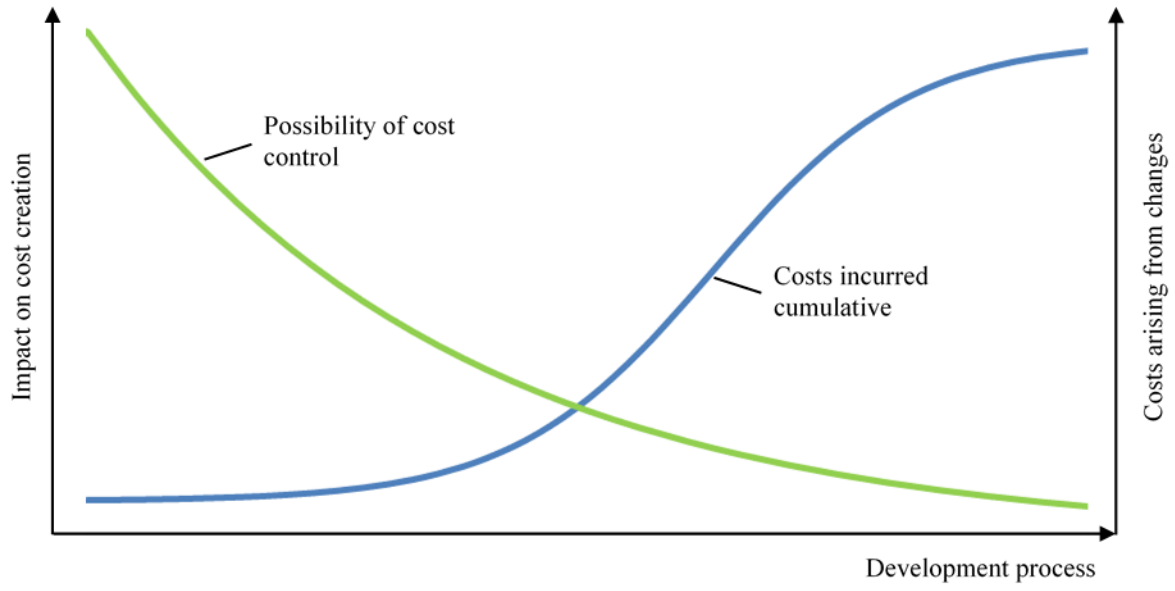

Figure 1. Influence of cost development in the development process (cf. Engeln, 2006, p. 32; Ehrlenspiel, 2014, p. 13)

The extraordinary nature of the development process has often been treated in the literature. According to Engeln and Ehrlenspiel, the high influence on overall costs should be considered above all at the beginning of a life cycle. The actual costs incurred at this time are still low compared to the total cost of the product creation process. It is only in the course of a life cycle that this distribution changes and the financial effort increases (cf. Engeln, 2006, p. 32; Ehrlenspiel, 2014, p. 13). In order to actively avoid

errors, it is important to work systematically and with great care right from the start of a development project. However, especially in a development project, changes cannot be avoided at a later date (cf. Engeln, 2006, p. 31–32). It is precisely this contradiction that decisively determines the problem of development. A large part of the costs is determined at a time when knowledge of the actual product is low. Once the development is more advanced and knowledge is improved, hardly anything can be changed without a major financial investment. For this reason, Ehrlenspiel also calls this "the dilemma of design engineering" (cf. Ehrlenspiel, 2014, p. 13).
One solution to this problem is to employ methods that can be used to systematize the development of a new product. Given the limitations of human cognitive abilities, the use of systematic procedures is intended to simplify complex situations in order to make them more manageable for the developer (cf. Lindemann, 2009, p. 58). The literature cites numerous methods which can support both the technical and commercial sides of a development (cf. Graner, 2013, p. 3). The use of methods can enhance the efficiency of product development and hence the development of more successful products, as shown in Figure 2 on the basis of the elementary effects of method implementation in product development (cf. Graner, 2015, p. 3).

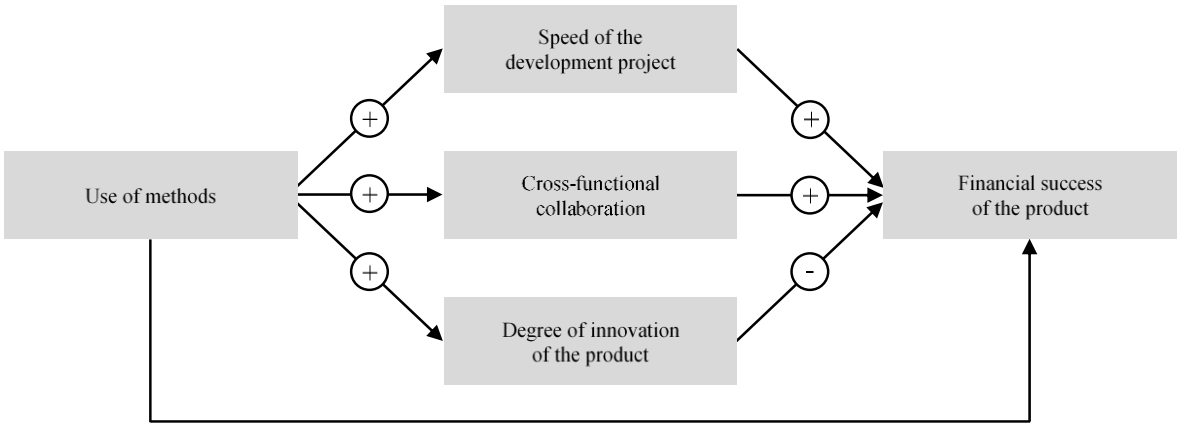

Figure 2. Impact of method use on the financial success of a product (signs symbolize the direction of the effect) (cf. Graner, 2013, p. 100)

According to Graner, the impact of a methodology on the success of a product can be distinguished from direct and indirect effects. Direct effects resulting from the use of methods are objectively measurable changes. The careful use of methods can significantly influence the success of a product in the market. Companies using systematic methods in product development can thus achieve higher sales and lower product costs. Due to these savings, higher average product margins can also be achieved (cf. Graner, 2015, p. 3–4). Indirect effects from the use of the method can be assessed less objectively compared to direct effects. However, scientific studies show that a methodical approach results in faster product development, better collaboration and more innovative products. All of these properties ultimately favor the long-term success of a product on the market (cf. Graner, 2015, p. 4). It should be noted that a high level of product innovation is not necessarily conducive to the financial success of a product on the market. According to Graner, products with an average degree of innovation often generate significantly higher profit margins than products with a high level of innovation (cf. Graner, 2015, p. 6). Another effect of method implementation is the reduction of the risk of malfunction. Systematic procedures in development help to effectively reduce the risk of misdevelopment. This is crucial for the long-term economic success of a company, since changes due to errors in development can only be absorbed in subsequent process steps with great effort (cf. Engeln, 2006, p. 31). Also, the risk of a complete defect development – such as the development of a product without an existing sales market – can be effectively reduced. Yet another effect is the mandatory documentation of work processes that takes place in the course of method application and can serve as legal security for individual employees or the entire company. This documentation is important, especially in the case of product failure – and thus product liability – as it can serve to avert or cushion legal aspects of consequential liability (damage, losses) (cf. Lindemann, 2009, p. 59).
In addition to the aforementioned advantages, there are also some disadvantages associated with the use of methods. The use of methods generally involves a great deal of effort and usually only yields in the

long-term development process. Even if the use of methods according to Pahl and Graner significantly shortens the entire development time, industry surveys indicate that an increased effort is required to implement the methods in the development (cf. Pahl, et al., 2007, p. 782; Graner, 2015, p. 4). Another disadvantage is the risk of incorrect or inadequate use of existing methods. If a decision is, for example, based on an insufficient application of a method, it can suggest a non-existent security. Such a decision can be critical, especially in areas with high unit numbers, as well as in investment-intensive individual developments. Method competence should nevertheless be available in development departments because an assignment is too risk-prone without it. According to Lindemann, methods cannot be understood as a panacea for the development process (cf. Lindemann, 2009, p. 59), nor can they transform a hopeless path into a correct one. The list of advantages and disadvantages of the method approach could be further extended. The basic statement is that the use of methods during the development process facilitates successful development and should in principle be pursued.

2.2 Assessment of the application situation

The use of methods has many impacts that facilitate a successful development process. The motivation for an assignment was described in the previous section. The use of methods can improve the prospects for success of a development and thus also improve the economic success of a company. The development process itself is strongly influenced by the developed product, the environment and the strategic objectives of a company (cf. Engeln, 2006, p. 16).

A literature review on the application of methods shows significant deviation between method usage in the economy and its theoretical foundations. A reason often given for the lack of use of methods is the supposedly high effort this involves. The logical justification advanced is the increasingly shortened development process, which does not allow the use of "clean" methods. The dangers resulting from simplified development are thus opposed to the effort of systematic product development. Due to this conflict, a different application of methods in the companies occurs. Many companies use methods comparatively rarely or completely dispense with their application (cf. Grabowski and Geiger, 1997; Gausemeier, 2000; Graner, 2013; Graner, 2015; Lindemann, 2016).

A preliminary study of design engineering performance in a regional mechanical engineering network (full title "Leistungsmessung in der Konstruktion bei Unternehmen des Maschinenbaunetzwerks Bergisches Land") conducted by the University of Wuppertal's Department of Engineering Design also showed a limited use of methods in development. The study analyzed the product development scheme of several companies. All participating engineers were given a standardized task to ensure comparability of results and had one week in which to implement it. The purpose of this comparison was to record individual procedures for an identical task in several companies and to compare them by subsequent benchmarking. The results of the investigation show that the application of methods in the participating companies hardly took place. The existing tasks were largely implemented without the application of methods on the basis of existing experience. These results confirm the assumption that – for various reasons – development rarely uses methods.

Another result of the literature research is that the selection of methods actually used is manageable. According to Graner, not all methods are used equally frequently (cf. Graner, 2013, p. 54). For this reason, some methods are comparatively well established in companies and others are hardly known. Given this unequal application of development methods, the question arises as to the types of method generally used in the economy and why these are deemed useful by the companies concerned. A study by Gausemeier on the use of methods in product development shows results comparable to those of Graner. According to Gausemeier, methods that increase operational efficiency are used in the economy. On the other hand, methods which tend to strengthen the long-term success of a company are rarely used. Figure 3 shows the results of this survey on the use of methods in product development in Gausemeier's investigation. The figure shows the estimated importance (ordinate) over the use of the method (abscissa) in the economy (cf. Gausemeier, 2000, p. 111).

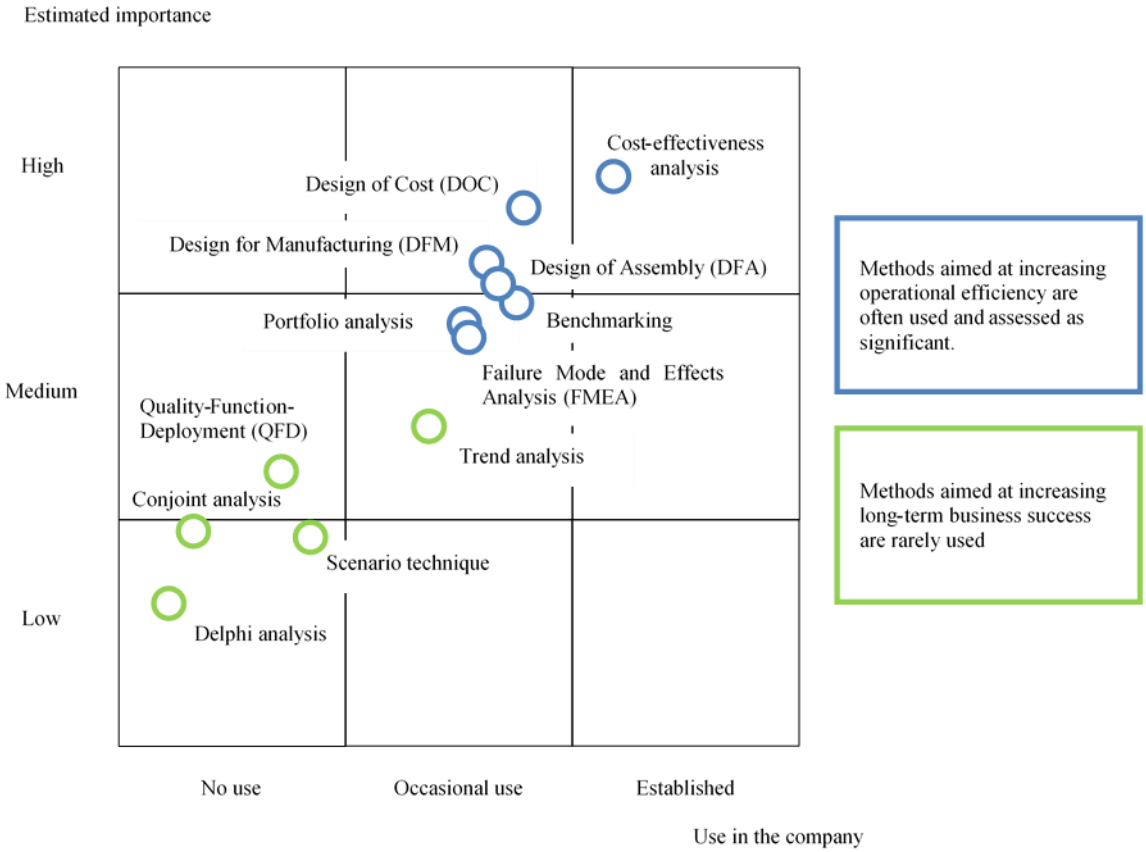

Figure 3. Use of methods in product development (cf. Gausemeier, 2000, p. 111)

The results of the survey presented in Figure 3 clearly indicate that methods directly linked to the success of a company – e.g. profitability analyses – are frequently used. On the other hand, methods that do not have an immediate impact on company success – e.g. Delphi analysis – are seldom applied and are viewed critically by the company. A further insight derived from the present figure is that all methods are arranged more or less exactly along a diagonal, which indicates that the application of methods is by no means accidental, but rather according to their estimated importance. Operational methods that promise immediate success are used predominantly, while the use of long-term strategic approaches is comparatively subdued. In the long term, however, the strategic focus on the success of the companies is of great importance (cf. Lindemann, 2016, p. 624). In general, the current situation of the use of methods in product development is critical.

2.3 Explanation of the existing application situation

The use of methods in development is thus cautious and reserved. This raises the fundamental question why methods are used so cautiously, although their added value for a company is scientifically proven. Recent studies on the use of development methods have shown that the rather low level of utilization of individual methods is due to some crucial hurdles. According to Graner, one of the factors is a lack of support from management. The use of methods is not actively promoted by management. Another reason is the lack of knowledge about available methods. Many companies have little experience in their application. Real work conditions largely preclude the acquisition or extension of knowledge about methods during the working day. Another elementary factor is the time available for consistent use of methods where directly value-added tasks are so much more important in many companies. A final aspect is the additional costs that arise from the use of method, given that the results of method implementation are difficult to determine from the finished product (cf. Graner, 2013, p. 54–55). Figure 4 shows these elementary hurdles during the development process.

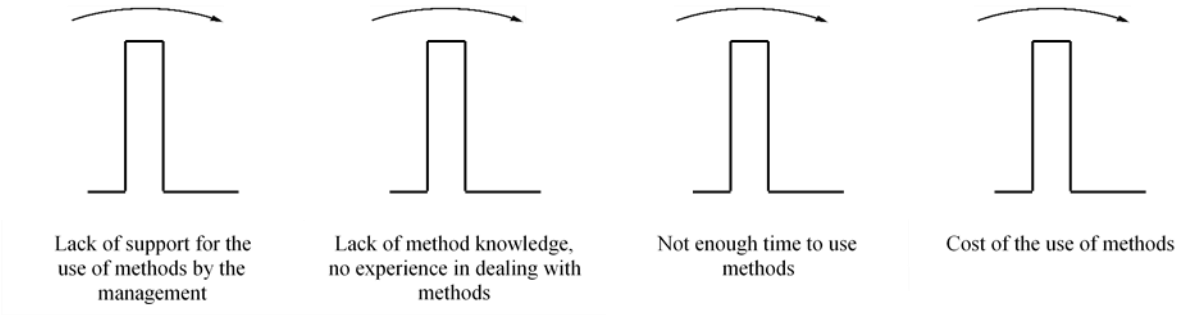

Figure 4. Typical hurdles for using methods (cf. Graner, 2013, p. 55)

The reasons for this reluctance to use methods in development are numerous and have been known for quite some time. According to a survey by Gausemeier of the mechanical and electrical engineering sectors, the reasons for this were similar in the past (cf. Gausemeier, et al., 2000, p. 12). For various reasons, the use of methods in development projects remains no more than moderate, even if numerous scientific studies have repeatedly proven the positive effects of using such methods.
According to Graner, the fundamental effects are, above all, shortening the development period, improving cross-functional cooperation and increasing the level of innovation of the product (cf. Graner, 2015, p. 7) – effects that are largely in line with corporate objectives and whose deployment should, therefore, be actively encouraged rather than avoided. A good example of the ambivalent initial situation is the amount of time that many companies associate with a methodological approach. Even if empirical studies show a shortening of the development period, this is one of the decisive reasons why methods are not used in practice. The existing situation suggests that many companies are unaware of the real impact of using a proven development method.
Lindemann sees survey results as highlighting the widespread lack of understanding of the use of development methods, based on lack of knowledge about their impact on the development process (cf. Lindemann, 2016, p. 624). Many companies think existing methods can hardly be applied in their own development context, which makes the acceptance and establishment of existing approaches difficult. Two of the main reasons for this mistaken assumption are the time-consuming appropriation of method knowledge and the poor transfer of this knowledge to the companies. The theoretical approach of most systematic approaches is often criticized in industry, and the abstract terms in which methods are usually described in scientific publications hinders their practical application (cf. Gausemeier, 2000, p. 113). The result is that many companies only use them in an isolated manner. Furthermore, a prerequisite for the corporate deployment of development methods is a clear record of their effects.
It may be concluded that the overall application of development methods in the economy can only be improved by the targeted mediation of methodological knowledge. An elementary task of research is, therefore, to communicate existing methods more clearly to companies by applying new approaches.

3 RESEARCH APPROACH

The results of the literature research show the numerous effects that legitimize the use of methods in the development of new products. Through the targeted application of methods, more successful products can be developed and the long-term success of a company will be strengthened. However, the literature research also shows that the application situation in the economy often deviates from the theoretical guidelines, and actual corporate use is comparatively subdued. The following are four basic research approaches that are intended to provide new insights in this research area.

Introduction of methods in development

A first research approach is to analyze the existing initial situation in order to determine how methods can be introduced into a company in the future. This entails clear communication of the positive effects of the methods. The long-term use of product development methods can only take place if all stakeholders expressly share a commitment to them. Research to date has established two essential conditions for the introduction of such methods. On the one hand, there must be active support from the management in order to form a substantial basis for the consistent application of methods. This consistent usage of methods should be initiated and actively promoted by the management. On the other hand, the support

of the users is a fundamental prerequisite for successful implementation. Users should learn the right application in a targeted way to ensure safe handling (cf. Gausemeier, 2000, p. 112; Graner, 2013; p. 104). A conceivable approach to raise awareness among participants is the development of an interactive training model based on case studies in which participants will learn the effects of methods. On the basis of direct application in exemplary development projects, the obligatory characteristics associated with the application of methodological approaches can be demonstrated. The case study teams should ideally be interdisciplinary and consist of different hierarchical levels in order to effectively explain the effects in all areas. The aim of this approach is to increase general acceptance and usage of methods through a fundamental sensitization of all sections of a company.

Efficient mediation of methodological knowledge in development

A second research approach deals with the efficient teaching of the necessary methodological knowledge in order to achieve their application in real development projects. Investigation of the existing starting point in many companies reveals the complexity of accessing method knowledge for many employees. According to König und Völker, the cautious use of methods in this context can often be traced back to the insufficient methodological competence of the employees (cf. König und Völker, 2002, p. 16). In addition, available approaches are often too abstract and can only be transferred to individual development tasks with great effort. Above all in scientific publications, methods are mostly described in an abstract way, which makes it more difficult to implement them in development departments (cf. Gausemeier, 2000, p. 112–113). But knowledge should be made available quickly and compactly, in order to keep the training effort low. To achieve meaningful results, the user should be able to make a quick selection of appropriate methods and then quickly and easily obtain the required method knowledge. One possible approach is to digitize individual methods. Through this approach, the user should receive targeted support in the selection, application and evaluation of methodological approaches. With the help of social collaboration software, suitable approaches can and should be made more easily accessible by implementing them in an existing infrastructure. A convenient side effect of a method application of this kind is the automatic recording of the development process as an archive for future development projects. The aim of this research approach is thus to provide an efficient transfer of methodological knowledge especially to the development departments of companies.

Integration of methods into the development process

A third research approach is to examine the fundamental integration of methods into the individual development processes of a company. By analyzing existing development processes, the factors that influence the use of methods can be determined. According to Nijssen and Frambach, a high level of formalization is one of the decisive prerequisites for the continuous application of methods in development projects (cf. Nijssen and Frambach, 2000, p. 128). The key issue here is to determine the properties of a development process that fundamentally favor the use of methods and the conditions that hinder implementation. This should reveal how these characteristics are best integrated into the specific development processes in a company. A possible solution approach consists of the application of existing models, such as the "Münchner Vorgehensmodel" (MVM), which can enable specific adaptation of method application in the development process (cf. Lindemann, 2009, p. 46–50). The active use of methods therefore requires specific adaptation to the individual requirements of a company. The interpretation of a correspondingly adapted model requires numerous influencing factors, such as available resources, organizational structure of the company, and ultimately the size of the development department. The aim of this research approach is to determine the necessary factors to fundamentally improve the conditions for application of the methods in a development process.

Individual team composition based on the requirements of methods

A fourth approach is concerned with the individual composition of teams to increase team performance, which in particular affects the question of team size. The aim is individualization and determination of prescribed team sizes for specific methods (cf. Gust et al., 2017). In order to achieve this, the influencing factors must be determined and weighted. Resources like time, staff, money and qualification influence the selection of a method (cf. Holzbaur, 2007, p. 95). Time and money can be saved by the application of efficient methods. However, this depends on the number and qualification of the team members. In addition, the choice of a method is determined by experience. In order to improve team performance, all influences on performance should be considered and combined with operational factors, in particular

personnel conditions. Influencing factors are for example team size, personal background, demographic characteristics, functional background, and qualification (cf. Lindemann, 2009, p. 24; Becker, 2016, p. 27, 45, 47, 50, 55). These individual influences have been discussed and investigated in several studies (cf. Pelled et al., 1999; Lau and Murnighan, 2005; Becker, 2016). The approach taken here envisages the development of two classification systems. The first leads to a classification of employees. The challenge will be to provide usable results and to be not overly time-consuming. Moreover, employees' data privacy must be guaranteed at all times. In the second system, methods are classified in such a way that they can be combined with the results of employee classification. In order to do this, the methods must be checked for current applicability. The example of brainstorming shows that there is a great need for action in this area. Despite scientifically based knowledge that brainstorming combined with criticism and in individual work leads to better results (cf. Mullen et al., 1991, p. 3–23; Nemeth et al., 2004, p. 365–374), the taught theory has still scarcely been adapted. The aim of this approach is to reveal the interfaces between humans and methods in order to individualize team composition and improve performance.

The four research approaches presented here form the basis for future improvement in the implementation of methods for industrial product development. The positive effects of using methods have been extensively described in numerous scientific investigations. Key goals are reduction of input, improvement of product quality and avoidance of misdevelopments. The research project can in this way make a significant contribution to savings in material as well as human resources, not only in the development phase but throughout the entire lifecycle of the product.

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