9 Context-Adapted Methods of Modern Product Development: Recommendations and Best Practice Examples

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Abstract

Product developers continue to face many challenges when it comes to ensuring the most efficient and effective product development possible. In order to meet these challenges, appropriate support is required. But what do expedient supports look like? This contribution addresses the challenge of developing methods that are as flexible as possible and adapted to the context as a form of expedient support. To this end, general aspects that such a method should take into account are presented at the beginning, as well as the overarching question of what is basically understood by methods that are flexible and adaptable to the context. The core of this contribution is then formed by recommendations for the development of context-adaptable methods and supports. Examples from the institute's everyday life are used as best practices and briefly presented where possible. The aim is to provide future product developers with suggestions for, in particular, the development of flexible and adaptable methods and also to further minimize the reservations that still exist about this.

9.1 Introduction

Today's product development has become increasingly decentralized, global and distributed all over the world, enabled by enormously improved information technology support (Lindemann 2016; Ehrlenspiel and Meerkamm 2017; Bender and Gericke 2021).

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Companies are faced with the challenge of providing their customers with the right products of the right quality in an acceptable time. The underlying effectiveness and efficiency of product development have a great influence on the success of companies. However, reliable, fast and company-specific product development processes are required in order to be successful, which holistically include both the product and the later target market, and thus the customer. The performance of the design methods and tools used in this process is a decisive factor. Therefore, it is no wonder that intensive research work has been carried out for many years on the development of suitable engineering design methods, as well as their transfer and application in industrial practice. Nevertheless, there are still reservations about "academic" methods and approaches, which are often still perceived as too complex and time-consuming (Binz et al. 2011).

This is aggravated by the fact that it is no longer sufficient to know the current requirements for methods; it is equally important to have knowledge about future requirements and framework conditions. How different application scenarios of future methods can look like is shown with four conceivable scenarios in Albers et al. (2017).

An understanding of the necessary method components as well as the inclusion of the addressed application environment will have an influence on a successful application. Hence, the core of this contribution is the presentation of methods adapted to the context, as they have been developed at the Institute for Engineering Design and Industrial Design (IKTD) and which can also be used for product development in general. The aim is to offer support for product developers in the future—in addition, general recommendations are made.

With the underlying assumption that a significant obstacle for the introduction of (new) methods is their lack of adaptability to the respective application context and thus non-flexible use in different situations, views or opinions on the most important terms of this contribution are presented in the following in a brief form.

9.2 Clarification of Terms and Situation Analysis

Within the contribution under the term method all supports are subsumed, which hold a processual describing basic idea, as well as an improving one. This includes classic procedures that describe the organizational framework and processes and contain individual process steps that frequently overlap or have to be run through in parallel—known in the domain of mechanical engineering as design methodology—but also terms such as tools, guidelines, frameworks and the like. A clear change can be seen, in the further development of all these supports, especially away from rigid constructs to more flexible models with more application relevance—as can be seen, for example, in Gräßler et al. (2018) as well as Graessler and Hentze (2020). A very catchy example is the further development of the VDI guideline 2221 (VDI Guideline 1993) to the VDI guideline 2221 (VDI Guideline 2019 Part 1), in which a significantly stronger process orientation is present as an essential innovation. Particularly worth mentioning are the exemplary product development processes in different contexts contained in part 2 (VDI Guideline 2019 Part 2) and the explanation of activities depending on defined process phases.

This rethinking in the design of support emphasizes the necessity of a context-adapted method development, which was named as an assumption before. From the author's point of view, however, the term "context-adaptation" covers much more than the mere reference to the operational environment. Without claiming to be exhaustive, some central aspects are named below. First, the context itself must be considered. This ranges from the operational environment of the future product, the company developing the product (SME, large companies), the existing method and product development knowledge itself to the consideration of available resources. How many personnel can be deployed, what budget is available, what software and what machines can be used?

On the other hand, adaptability of the method to the context itself becomes necessary: Methods must be able to act flexibly and variably according to the situation. In addition to the dissolution of rigid, sequential models, methods are expected to provide situationally appropriate steps. Steps that are not appropriate must not be applied and the awareness for changing circumstances must be sharpened. The next problem under consideration may require a completely different solution path. Thus, a context-adapted method is understood as a support that acts flexibly depending on the context—for example, by omitting steps, adapting sets of criteria, selecting methods that fit to the situation. Often, the time factor is a decisive criterion for selection in everyday industrial life.

9.3 Superordinate Aspects of a Method Development

Aligned with the development of a method to support a situation, the development of the "right" method must be ensured, as discussed in the introductory chapters. The right method is understood as whether an expedient support can be offered. "If and how an engineering design methodology can provide this support in reality has to be assessed using appropriate criteria" (Binz et al. 2011). As early as 2009, criteria in the form of requirements for methods were defined in a contribution, whereby their consideration supports the targeted development of appropriate development methodologies (see Fig. 9.1). Five aspects are distinguished, which can be divided into 19 further requirements (from 8 groups): Normativity, Didactics, Uncertainty, Competitiveness as well as Match & Limit. "The objective (of this work) was to define a set of requirements on engineering design methodologies that provides a mean to assess the outcome of the development of methodologies (...). Interdependencies between the requirements, if existent, have been reasoned and analyzed." (Keller and Binz 2009).

This set of criteria is always used at IKTD when developing new methods. In addition to the requirements addressed there, a focus of the IKTD's method development is on small and medium-sized enterprises. As a consequence, emerging methods should be able to be used without (expensive) software applications.

Aspect	Group Description	Grouped requirements
Normativity	*Revisability* by appropriate and accepted means	Validation Verification
	Scientific soundness by backing up the hypotheses of a methodology	Objectivity Reliability Validity
Didactics	*Comprehensibility*	Comprehensibility Repeatability Learnability Applicability
Uncertainty	Providing a *structure* for complex tasks and problems and *compatibility* with different environments	Handling complexity Problem solving cycle Structuring Compatibility
	Providing *flexibility* for the designer using degrees of freedom when applying a methodology	Flexibility
Competitiveness	*Practical relevance and competitiveness* by satisfying a need for a methodology	Innovativeness Competitiveness
	Usefulness	Effectiveness Efficiency
Match & Limit	Problem *specifity* allowing links between an assignment and a matching methodology, and defining the application limits of a methodology	Problem specifity

Fig. 9.1 Aspects of a methodology, description of related groups, and grouped requirements on engineering design methodologies (Keller and Binz 2009)

9.4 Best Practice Examples of Methods for Developing Context-Appropriate Support

In the subchapter on situation analysis and clarification of terms, a wide variety of aspects were named whose consideration has an influence on the design of context-appropriate methods. But how can they actually be taken into account?

One recommendation could be to base the development of such methods on the general steps of the Design Research Methodology (DRM) by Blessing and Chakrabarti (2009). According to this, four steps are to be followed in the development of a purposeful support. Starting with a Research Clarification (RC) to determine the research objective, a build-up of understanding—for example, through intensive literature reviews or even supplementary analyses of empirical data—takes place in Descriptive Study I (DS I). In the

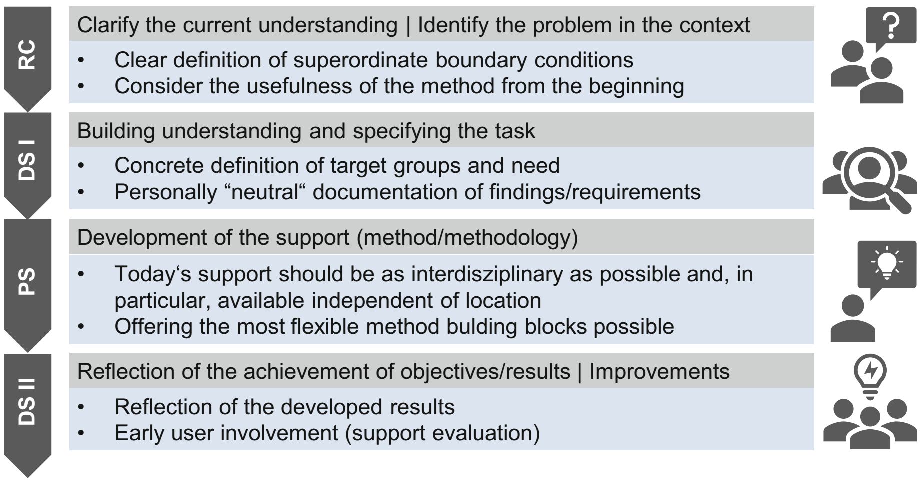

Fig. 9.2 Recommendations for the development of flexible context-adapted methods

subsequent Prescriptive Study (PS), the synthesis of expectations and experiences ultimately leads to the development of a support for a previously identified problem, which is finally reflected upon and evaluated in the Descriptive Study II (DS II) stage. These four stages can be run through in variable depth and repetition depending on the research question to be answered.

This procedure is transferred to the development of context-adapted methods and shown in Fig. 9.2. Here recommendations are named, whose consideration can be necessary for reaching an appropriate context adaptability.

Based on the previous findings, possible support is presented in the following in the form of best practice examples from the IKTD. These are listed in a chronological order in which they are applied in a product development process.

9.4.1 Best Practice for Generating and Documenting Appropriate Problem Ideas

Frequently, the development of appropriate support already fails when it comes to formulating the actual need for support. In doing so, identifying and defining problems worth pursuing can be a challenge. "We fail more often because we solve the wrong problem than because we get the wrong solution to the right problem" (Ackoff 1974). However, the IKTD's emoji method (see Fig. 9.3) provides support that can be used to generate application-oriented and thus user-focused, new problem ideas in a structured manner (Binz et al. 2019).

"Problem ideas" represent, in our view, defined tasks for the early stages of product development. The goal of encouraging the product developer to identify and formulate new

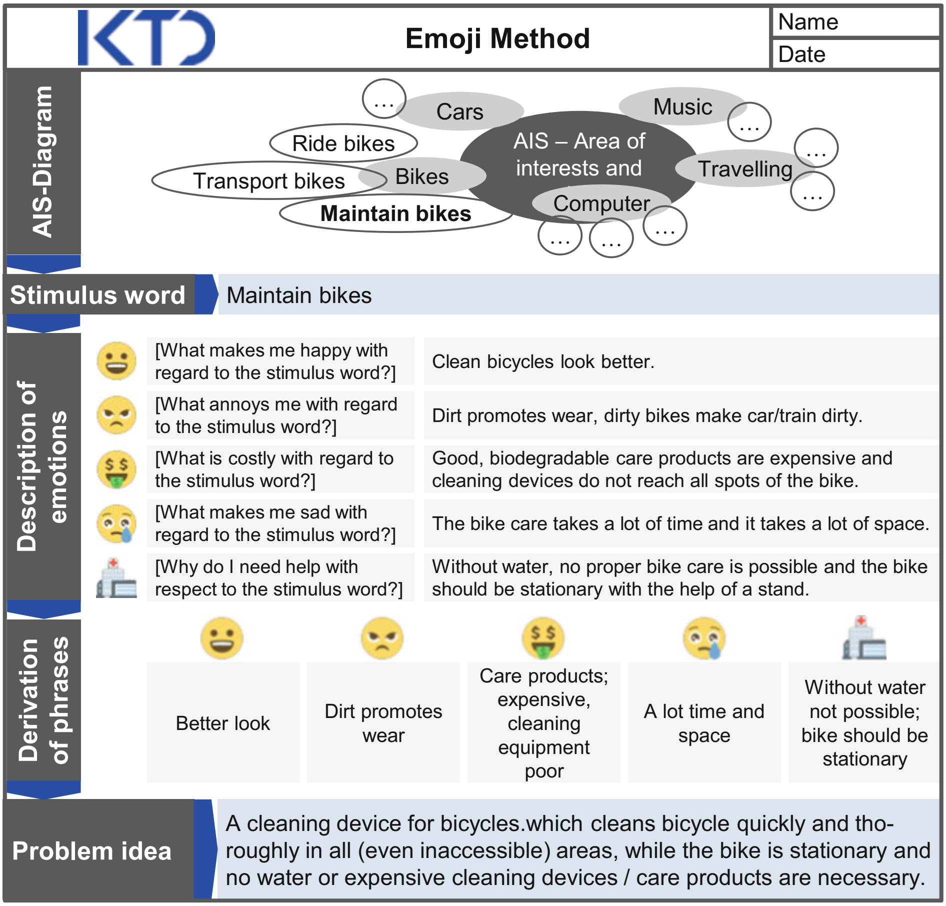

Fig. 9.3 Emoji Method adapted to Herrmann et al. (2019) and Binz et al. (2019)

problem ideas consists of several steps. First, the establishment of an Areas of Interest and Skills diagram (AIS) takes place, supported by a verb catalog similar to the main feature list of a requirements list. Then, a stimulus word is identified. This can relate to an individual person as well as to an issue in a company.

The emoji method thus specifies problems, needs and open solution fields for collected interests and skills. The next step is the description of emotions regarding the stimulus word. The five emojis used should represent what makes the user happy, sad and angry. In addition, costs and necessary equipment are analyzed. In a further analysis, the most important points of the described emotions are then summarized in short textual core modules. A final synthesis of the derived phrases leads to a clearly defined problem, the problem idea (Herrmann et al. 2019).

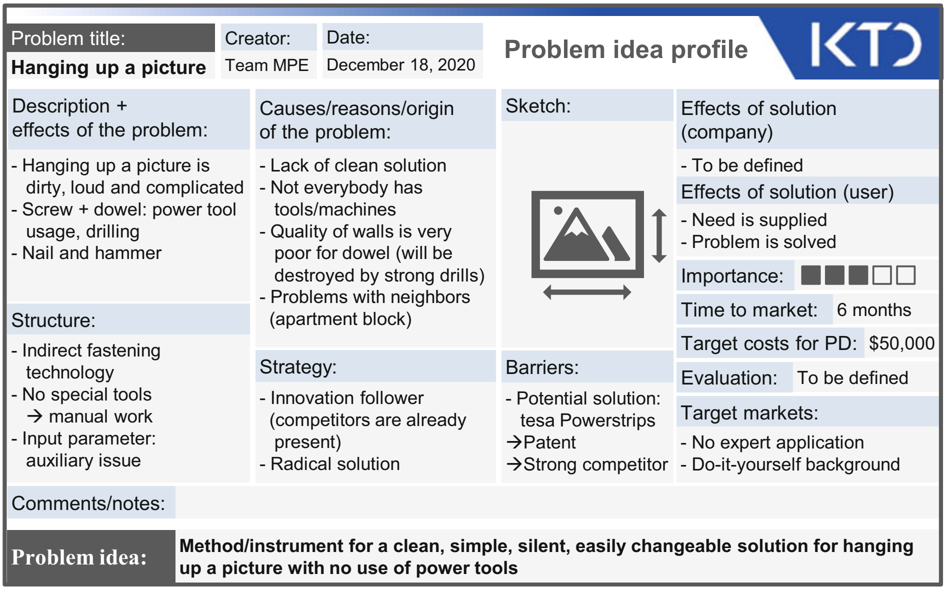

Fig. 9.4 Problem idea profile (adapted to Herrmann et al. 2017)

Based on initial applications and a discussion of the information to be stored, provided and distributed, a "problem idea profile" (see Fig. 9.4) was subsequently developed that can be used for documented problem analysis (Herrmann et al. 2017).

Summarizing, the following can be stated. There is often unsatisfactory communication regarding the expectations of the product to be developed. Information that addresses a customer's need or problem or the benefit of a new product or process is not clearly stated. As a result, new ideas and new products fail because they do not address the real problem. The challenge is therefore to ensure precise documentation and comprehensible provision and distribution of information. With the presented supports, this can be made possible and a higher "context adaptability" can be achieved.

9.4.2 Best Practice for the Selection of Methods Appropriate to the Situation

Product development and design methods have been an integral part of development processes for decades. Numerous method collections exist for the representation of a large variety of methods existing there, in which methods are classified by means of the most diverse categories and criteria. In the DFG (German Research Foundation) Collaborative Research Center SFB 1244 "Adaptive Envelopes and Structures for the Built Environment of Tomorrow" another method map has been developed. This is particularly suitable for the centrally combined representation of the largest possible number of

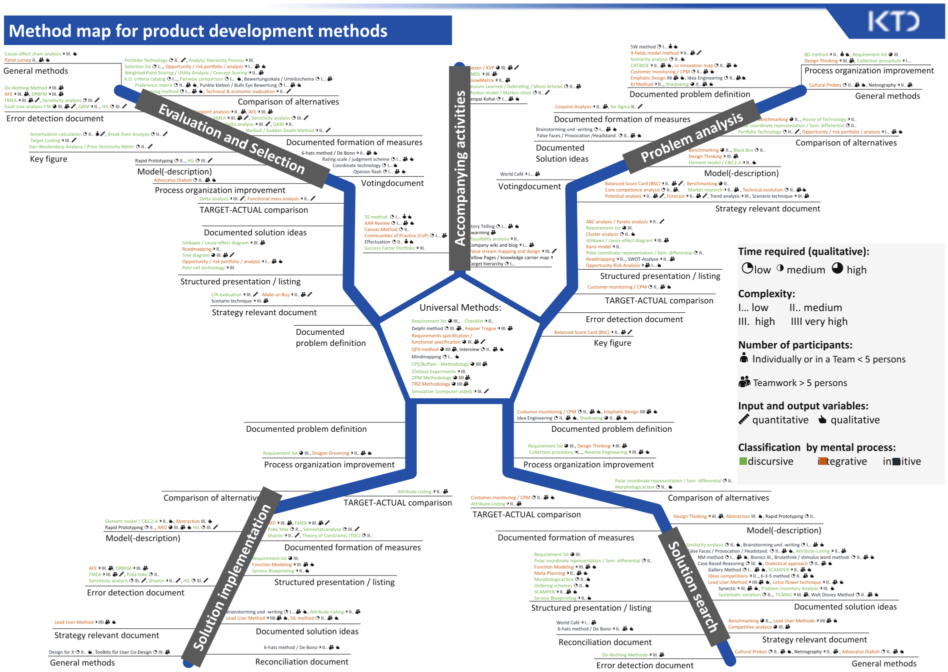

Fig. 9.5 Method map (Honold et al. 2019)

methods in method classes and at the same time supports the selection of the correct method in an interdisciplinary context. The result is shown in Fig. 9.5 (excerpts). The complete method map is included in Honold et al. (2019).

The method map contains 133 methods and is divided into five branches, each representing one of the activities problem analysis, solution search, solution implementation, evaluation and selection, and accompanying activities. The branches in turn bundle methods with comparable results. The structure chosen in this way makes it possible for the user to be guided purposefully to a suitable method with the help of the branches via the activity. The additional information provided in the form of symbols ensures that the methods can be used in the appropriate context. The right method can be selected depending on the available time, a permissible method complexity depending on the expertise of the users involved, available personnel capacities, or also desired input and output variables (quantitative or qualitative) as well as different forms of thought processes.

In addition to the provision of such selection representations, further, more context-specific method provision is also conceivable. One such best practice example is a catalog of knowledge management solutions for the product development process, which was created within a higher-level development of a product development-specific knowledge management procedure for SMEs (Laukemann et al. 2017). A particular feature is the examination of the company context—here the product development process—in which

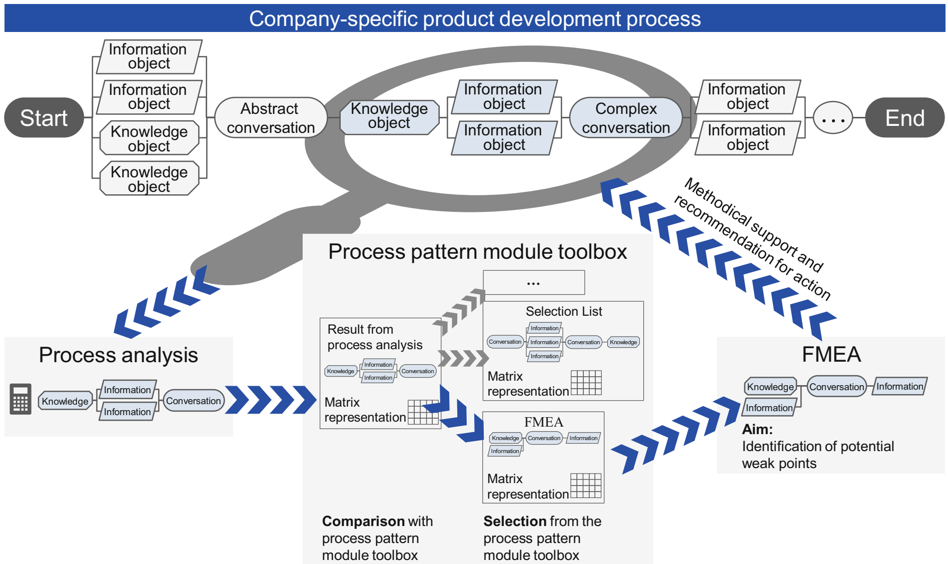

Fig. 9.6 Analysis and procedure of a process-adapted method provision in the context of knowledge management at SMEs (adapted to Laukemann et al. 2015)

the support is to take place, as well as the methods that are to be used for support. Methods can be used particularly well adapted to their context if this is very well known. This has resulted in a procedure in which the company-specific product development process is analyzed with regard to the need for support with the aid of the "Knowledge Modeling and Description Language" according to Gronau (2009). In this analysis, the methods modeled in the same way with KMDL are used, which are assigned situationally to the correct points in the development process by means of process pattern analysis. The basic conceptual sequence is shown in Fig. 9.6 and described in Laukemann et al. (2015, 2017).

A similar approach has proven to be successful in the selection of knowledge elicitation methods appropriate to the situation (cf. Roth 2020) as well as in the situational support of the feedback of test knowledge into product development (cf. Karthaus et al. 2015). In an abstracted form, the underlying idea can be represented as sketched in Fig. 9.7.

The core idea is to match certain abilities of a method with a situation (e.g., a process), i.e., to achieve the best possible fit. In this context, methods have inherent abilities, which should be assigned as best as possible to characteristics that are yet to be operationalized from a subject matter. This is an analogy to the procedure shown in Laukemann et al. (2015).

In conclusion to these examples, a clear need for the situation-oriented provision of methods can be determined. Different best practices were presented for this purpose. In addition, the method map provides a practical method for visualizing and selecting suitable support. With suitable selection criteria (required time, necessary number of participants,

Fig. 9.7 Core idea of a situation-adapted method selection

etc.), a context-adapted and thus application-oriented selection of the right methods is explicitly made possible.

9.4.3 Best Practice for the Demand-Driven Provision and Employment of Methods

In order to provide demand-oriented methods, it is first necessary to know the user groups and their specific needs. If the general aim is to determine needs or to understand specific user groups, surveys are usually suitable. These can be conducted in a wide variety of forms. To define a basic understanding, a generally valid picture is usually first generated by means of intensive literature research before this is compared with industrial practice (cf. as well for example Blessing and Chakrabarti 2009).

To carry out such a systematic literature search, the following four-stage procedure has proven successful at the IKTD:

1. Analysis and determination of all relevant synonyms of the subject under investigation.
2. Execution of a search in previously defined indexed electronic databases—use of the synonyms from (1)
3. Initial selection of the found contributions
4. Detailed analysis of the relevant contributions

The result of such a search is shown in Fig. 9.8 as an example of how radical product ideas are defined in literature. The procedure offered support, starting from a very large amount of data, to systematically arrive at a manageable information situation. This is particularly important if a fundamental issue is to be well understood—for example, if a suitable support is to be offered for a problem to be defined in more detail.

If the core is then about the provision of such support, it is necessary to know the need of the later user. How this need can be determined and how it can also look is demonstrated in Hommel et al. (2020). The survey conducted there examines user needs as well as obstacles in the application of aluminum foam sandwich. The possibilities named for providing information in a method-supported manner are conspicuous. The answers range from paper-based documents to design catalogues or design guidelines as well as an online platform. From this, a clear necessity can be derived that the provision of methods should also be tailored to the needs of the subsequent users. In particular, digital forms of information provision seem to be preferred (Hommel et al. 2020). This supports the

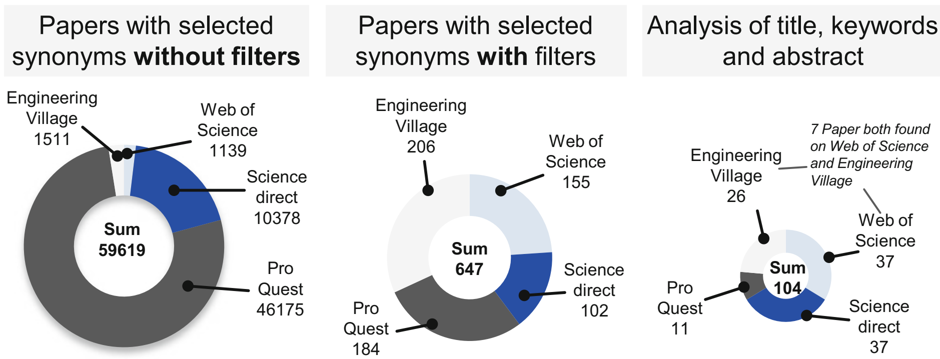

Fig. 9.8 Result of a structured determination of relevant contributions (cf. Herrmann et al. 2018)

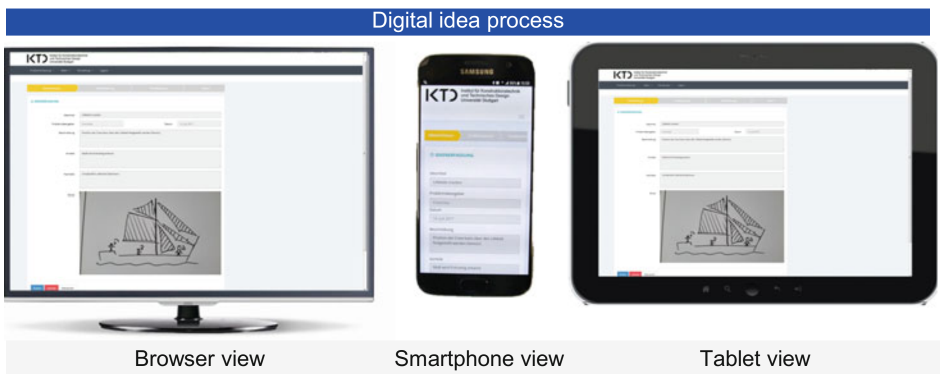

Fig. 9.9 System-independent web app for targeted support of the idea process (Binz et al. 2017)

premise formulated at the beginning of the situation analysis that support should be provided as flexibly as possible and independent of location.

If the focus is not only on the form of provision, but also on support at the appropriate point in time in the product development process, a solution can be seen in digitized methods. Two small best practice examples of successful digitization will be briefly presented.

The first example shows the digital idea process implemented at the IKTD via web app (see Fig. 9.9).

This is intended to provide targeted support for the management of ideas. For example, initial idea sketches can be digitally assessed in the evaluation process and stored and used in a targeted manner as part of systematic knowledge management. Furthermore, a digital profile for the purposeful recording of solution ideas, an evaluation logic for digital evaluation, as well as a digital report are available. The implementation of this support as a web app provides a device- and system-independent application that does not require a local installation on the user's device. Communication with the program is purely server-based via a web browser.

In the second example, an internet-based platform has been created to support the development of additively manufactured parts (see also Weiss et al. 2018). The content of the platform is grounded on the collection and evaluation of previously determined support needs. The structure of the support offered is based on the time sequence during a product development project. The result is shown in Fig. 9.10.

It should be emphasized that when using the platform, the users can decide for themselves in which steps they need support and in which they do not. This means that this support can be used in particular depending on the existing knowledge of the product developer. Therefore, the support offered adapts situationally to the level of experience.

Thus, a special focus in this chapter was on the user-oriented development of a support. In order to make this possible, it is imperative that the needs of the user as well as the

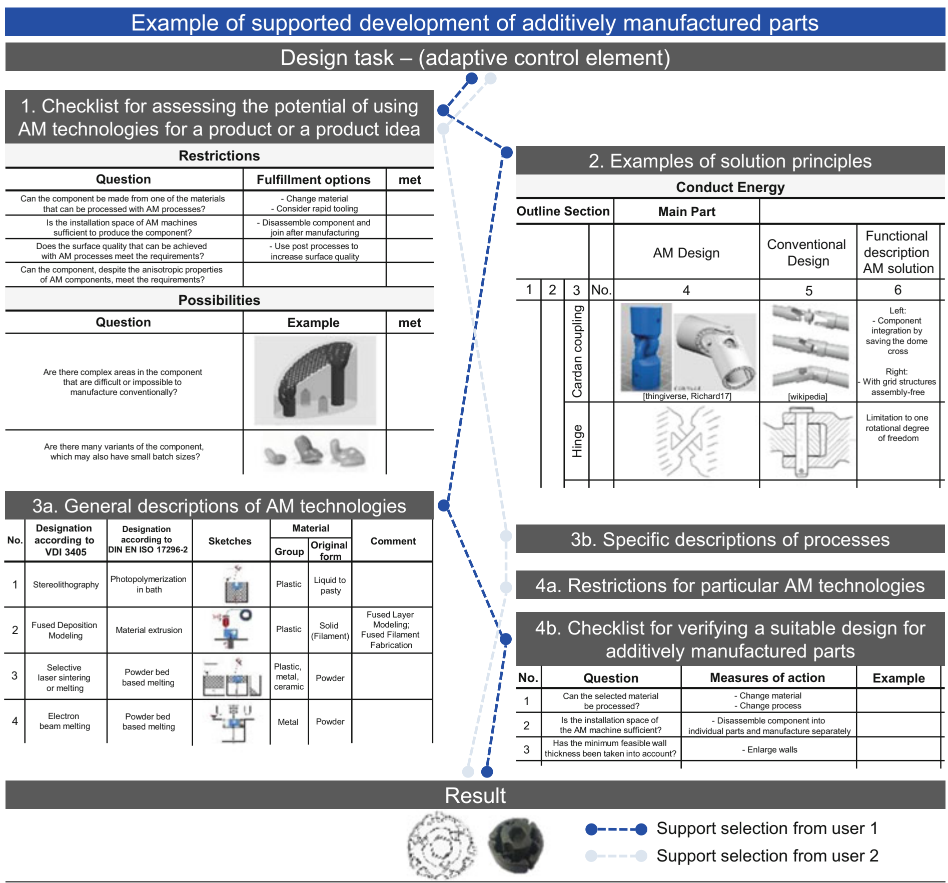

Fig. 9.10 Knowledge and demand-oriented method provision (adapted to Weiss et al. 2018)

environment itself are considered in advance. Methods that are developed can often be offered in digital form and should be able to be used flexibly, depending on the situation.

9.4.4 Best Practice for the Company-Adapted Implementation of Processes and Methods in Companies

The introduction of methods is accompanied by an ongoing debate regarding their applicability in practice (Gericke et al. 2013). In Messerle et al. (2014), the question of which problems exist in particular and how they can be solved was therefore investigated in the field of idea processes. The result is a process for the introduction of idea processes in companies, which was subsequently tested and validated in practice. The aim of this process, illustrated in Fig. 9.11, is to support the adaptation of methods and processes so that they fit to the specific context and circumstances of the respective company.

In the process, four basic steps with their respective sub-steps can be identified. First, the introduction is planned (Preparation Phase), based on the necessary recognition that existing processes or conditions require a change. This is followed, among other things, by steps to check the fit with the corporate strategy, to determine the implementation team and to define the project more precisely.

In the second phase (Diagnosis Phase) of the implementation process, it is then necessary to assess the existing situation and processes (framework conditions, problems, etc.). The result of this diagnosis phase is the development of a first, rough concept. Within the framework of this rough concept, questions are asked such as "Which methods or which tools best support the user in his individual work in everyday life?" and "Which

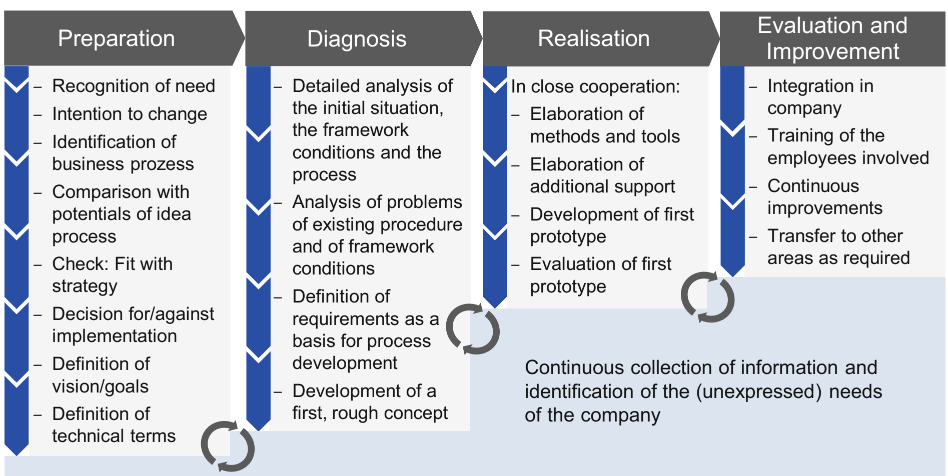

Fig. 9.11 Company-adapted implementation of processes and methods in accordance with Messerle et al. (2014)

process steps, or process sub-steps, are necessary and thus useful, or which can be omitted?"

The subsequent phase of realization concretizes the concept. In addition, a first prototype is created and initial evaluations, in this case of the idea process, take place.

In the final phase of evaluation and improvement, the new process is embedded in the corporate landscape. This is followed by employee training and regular review loops in which the new process is checked and further optimized.

Transferred to the overall context of this contribution, the procedure presented provides elementary steps for the introduction of new processes as well as new methods in companies. A very central aspect is the constant reflection of the corporate context and thus a focus on the application field as well as the users themselves.

9.5 Conclusion

The central element of this contribution are the best practice examples presented. These examples show how the necessary aspects of context-adapted methods mentioned in the chapter on clarification of terms can be achieved in an appropriate way. The goal of all these considerations is to provide methods and thus support that are accepted in the industrial environment and contribute to the success of the company in a way that adds value. Among other things, the available resources of a company must be kept in mind, company-specific processes must be known, and the future user must be kept in mind. Today's methods should be as intuitive, flexible and location-independent as possible.

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