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Improving distributed collaboration – methods for identification and developing of improvement potentials

Katharina Duehr[a]*, Emre Kavakli[a], Albert Albers[a]

[a]*Karlsruhe Institute of Technology (KIT), IPEK- Institute of Product Engineering, Kaiserstr. 10, 76131 Karlsruhe, Germany*

* Corresponding author. Tel.: +49-721-608-43953; fax: +49-721-608-46051. *E-mail address:* Katharina.duehr@kit.edu

Abstract

Due to the increasing globalization, collaboration in product development between different locations is gaining more importance. Current circumstances, such as the *Covid-19* pandemic, are even forcing the introduction of distributed collaboration in product development. Regarding to the *Covid-19* pandemic, in many cases the transition was completed in a short time and even unplanned. The transition to a distributed approach creates new, unexpected problems in the collaboration of distributed product development teams, which have to be solved continuously. Therefore, the aim of this paper is to develop a concept that offers methods for the continuous improvement of distributed collaboration that are appropriate to the specific circumstances. Following a literature search, 135 participants were asked about the need for methodological support in identifying and developing improvement potentials in distributed collaboration. The demand was confirmed by the majority of participants. Consequently, a concept was developed to methodically support the improvement process. The developed concept was designed as an interactive tool, which offers the user methods for methodical approach to improvement potentials in accordance with his needs and resources. The basis is the problem-solving methodology *SPALTEN*. For a standardized and comprehensive description of the methods, fact sheets were prepared. The tool and the concept were evaluated in the industry in a distributed and agile development simulator. The evaluation confirmed the added benefit of the methodical support for the improvement process in the distributed collaboration.

Keywords: distributed product development; collaborative design; design methods; problem solving

1. Motivation

"Getting together is a start, sticking together is progress, working together is a success" - Henry Ford

With these words, Henry Ford highlights the importance of collaboration, which is establishing itself more and more as a success factor for a company [1]. Due to the increasingly shorter product life cycle and growing global competition, companies are being encouraged to operate globally and virtually in order to be close to the market as well as to shorten development times through the successful utilization of time horizons and the simultaneous processing of tasks across different locations. At the same time, globalization also increases the accessibility of globally distributed knowledge.[2] [3] Current circumstances, such as the Covid 19 pandemic, even require the implementation of distributed working methods to reduce physical contacts to a minimum to control the pandemic [4]. Every product development process is unique and individual [5]. With the implementation of the distributed working method, product development is confronted with new problems in the many unique product development processes, such as the difficulty of work coordination, the higher conflict potential among employees, and the slower communication between different locations due to indirect communication through the use of electronic media and the different time horizons, which leads to delayed and filtered transfer of information [6]. According to ALBERS et al.'s definition, problems are a discrepancy between the current state and the

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target state [7]. To transform the actual state into the target state, improvement potentials have to be identified and consequently addressed in order to improve general conditions of collaboration in distributed product development. These improvement potentials either remain undiscovered in the field or are not systematically addressed when they are discovered. [8] Therefore, a demand-oriented provision of methods for the identification of potentials in the collaboration of the distributed product development team has been developed by applying the problem-solving method *SPALTEN*. This aims to systematically identify and improve the largely undiscovered improvement potentials through the successful application of methods.

2. State of the Art

2.1. Distributed product development

Due to globalization and the reduced time for the development of technological innovations, companies have to adapt to the changing conditions in order to remain globally competitive [9]. As a result, collaboration is increasingly organized through distributed teams [10]. Distributed teams are groups of people with a common purpose who perform interdependent tasks across locations and time periods and communicate through technology [11]. The global presence is an advantage that makes it possible to tap into additional projects and market potentials, as products can be adapted to the specific markets [12]. A further advantage is the global connection, which leads to an increased knowledge acquisition and bundling [4]. By cleverly exploiting different time zones, both flexibility and agility can be increased through a day-long workflow [13]. The reduction of travel and the resulting decrease in site costs lead to a lowering of company costs [14]. In order to be able to exploit the described opportunities, it is necessary to overcome the challenges that arise from the distributed working. The challenges arise mainly from physical distance. The lack of physical distance between team members can lead to insufficient corporate identification. In addition, the absence of direct communication between team members can further hinder the integration of team members into the team and make communication and trust-building between team members more difficult due to a loss of body language and opportunities for non-work-related conversations. Consequently, this reduces the motivation of employees in their work. [11] Furthermore, misunderstandings and conflicts can occur, which on the one hand are culturally and linguistically related or on the other hand arise from information loss caused by different time zones [14].

ALBERS et al. summarize success-relevant influencing factors of distributed product development. These factors outline aspects that need to be addressed to overcome the challenges posed by the implementation of distributed product development [15]. This summary of the success-relevant influencing factors is based on the systematic literature analysis by DUEHR et al. [16]. Furthermore, the success-relevant factors were classified into the three dimensions defined by KERN: *people, technology* and *organization* [17]. From various studies, communication in particular emerges as a central factor relevant to the success of distributed product development [18]. In terms of the successful implementation of distributed cooperation, LINDNER and EBERT make a recommendation on technologies, working methods and leadership to meet distributed challenges [4] [19].

2.2. Identifying improvement potentials: Problem definition and problem-solving process

A problem is an unwanted current state, which differs from a wanted target state [7]. Furthermore, it is defined that between the current and target states exists a barrier to be overcome. This barrier may include missing or unknown resources, existing or insufficiently defined goals and restrictions. [20]

Differences between target and current states lead to waste. Waste is an improper or an inefficient use of resources such as capacity, working time and qualifications. Occurring wastes impair the company's success and cause demotivation if identified wastes are not quickly eliminated. [21]

The process of problem solving supports the adjustment of the current state to the target state and is simultaneously accompanied by an improvement of the actual state and deals with the waste. There are a variety of process models for this process. They can be distinguished according to their focus (universal to technical) and the level of detail of their descriptions (low to high) [20]. An overview of existing process models for problem solving in product development is presented in the work of ALBERS et al [22]. The process of product development is also assigned to the problem-solving process [7]. In this paper we focus on the *SPALTEN* methodology according to ALBERS et al. [22].

SPALTEN describes a universal approach to solve problems of different boundary conditions and degrees of complexity. The problem is solved in several phases. The basic structure of the *SPALTEN* methodology consists of seven steps, each of which can be dealt with separately, sequentially or dynamically in the course of the problem-solving process. The individual phases are named as follows: situation analysis; problem definition; alternative solutions; solution selection; scope analysis; decision/implementation; follow-up/learning. The approach of problems with the *SPALTEN* methodology is supported by the use of tools and methods that have to be used in accordance with the given boundary conditions. [22] There is a variety of methods to support the different *SPALTEN* phases. These methods can also support the product developers in the various product development activities [23]. There is a demand-oriented and interactive catalog of methods for productive development, the so-called *InnoFox*, which is designed to support the user

in the individual phases of the product development according to the *SPALTEN* methodology [24]. Specific methods with a focus on the improvement of distributed collaboration are currently very limited in the literature. Only a few methods, such as the *Team-Space* methodology, concentrate on the improvement of distributed collaboration [25]. DUEHR initially presented the necessary steps to address improvement potentials in distributed collaboration [8]. Through a comprehensive literature review, BRAUN also summarizes different approaches to characterize methods [26].

To support a continuous problem solving, KOSTKA describes the *continuous improvement process* (*CIP*) as a process of permanent improvement, which is carried out in numerous small steps, while considering the internal know-how of the company. Main characteristics of the *CIP* are among others the elimination of waste, the focus on processes, the involvement of all employees and the associated teamwork. [27]

3. Aim and Methodology of Research

Although numerous efforts have been made in recent years to provide methods for product development, there is still little methodological support for the demand-based identification and development of improving potentials in distributed collaboration. Further there is still no approach available that combines the topics of distributed collaboration, continuous improvement process and methodological support while considering the specific circumstances of the development organization and the ongoing improvement process of distributed collaboration. For this reason, firstly a survey was carried out in this paper in order to investigate the state of the art regarding methodical support for improving collaboration in distributed product development. Secondly, an approach for a methodical support was developed to meet the requirements of the different topics. This approach aims to continuously improve distributed collaboration in order to bring its benefits to the company.

The research hypothesis was formulated on the basis of a literature review:
„Methods are used to support the identification and development of improving potentials in the collaboration of distributed product development. The success of this approach depends on the provision of demand-oriented methods, since the product developers either have no knowledge of the numerous methods or despite their knowledge, do not realize the appropriate use of the methods. Also, the often-unknown benefit-effort ratio of the application of methods leads to a low acceptance of the use of methods. The use of demand-oriented methods will therefore advantageously support the improvement process of the distributed collaboration. “

Based on the research gap and the defined hypothesis, research questions were defined to structure the research project:

- FF1: Is there a need for a methodological approach that supports the identification and development of improvement potentials in distributed collaboration in product development?
- FF2: How should a methodical approach be designed to support the identification and development of improvement potentials in distributed collaboration in product development?
- FF3: Which optimization of the process of improving collaboration in distributed product development can be achieved by the practical use of the developed concept?

This paper was structured according to the *Design Research Methodology* [28]. After an initial literature research on *clarification of the research gap*, a quantitative survey was conducted in *Descriptive Study 1 (DS1)* to determine the need for a methodological support in the identification and developing of improvement potentials in distributed collaboration. In the *Prescriptive Study (PS)* the concept for the methodological support with the provision of demand-oriented methods was developed. The concept was evaluated in the *Descriptive Study 2 (DS2)*. A two-day development simulator served as the evaluation framework. In a development simulator, a shortened realistic product development process with all its phases is run through and thereby accurately but abbreviated reflects the reality. The task here is complex to ensure that the participants realize the need for development methods and a structured way of working. [29] The successful completion of the task also requires a functioning collaboration between the locations [30]. Since the development simulator concept of OMIDVARKAJAN et al. focuses on the collaboration of team members and the completion of the development task in two days, it is showing great opportunities as a research environment and therefore it is suitable for the initial evaluation of the developed concept in order to observe the progress of the distributed collaboration during the workshop. [30]

4. Demand identification

The goal of the survey is to identify the demand to methodically support the identification and development of improving potentials in distributed collaboration. The survey was conducted with the online survey application *LimeSurvey*. 135 product developers from Germany participated in the survey. The number of participants was reduced to 118 by asking specific questions about the participants' experiences in distributed collaboration. 32 closed questions were asked, most of them were structured in a five-level (1-5) *Likert scale* with the answers "does not apply" (1) to "does apply" (5). The remaining questions contained non-standardized answers. In this case, possible answers were adapted to the question. All questions are related to the following topics:

- Occurrence and handling of problems in distributed collaboration
- Provision of a systematic approach to handle problems

in distributed collaboration

The results are displayed using pie charts and box-plot diagrams. The box in the box plot represents the area between the lower and upper quartile. Therefore, the box refers to the area in which the average 50% of the data is located. Another presentation of the scattering of the data is the Median Absolute Deviation (MAD). The MAD shows the deviation of the data from the average.

As shown in Figure 1, the increased relevance of distributed work described in the literature due to the *Covid-19* pandemic was confirmed by the participants.

In order to identify the demand for a systematic approach to problem identification and solution in distributed collaboration, problems that occur in distributed collaboration must first be clarified. 111 participants confirmed the occurrence of problems in distributed collaboration. Only 7 participants stated a problem-free distributed collaboration.

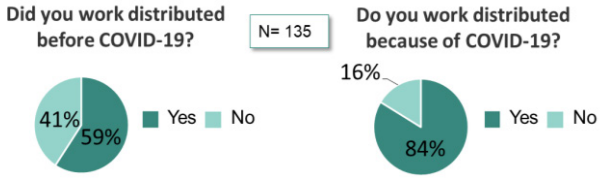

Fig. 1. Distributed working: (a) before Covid-19; (b) during Covid-19

A systematic approach to identify problems in distributed collaboration is not or only partially known to the participants (70%), 51% of whom stated that they had rather no knowledge about it. Figure 2 shows a similar result concerning the evaluation of the participants' knowledge about a systematic approach to address problems in distributed collaboration. Both the box and the MAD also display the range of data between the response options "tends to apply" and "tends not to apply".

Also, participants were asked questions about the provision of a systematic approach by the company to identify and solve problems in distributed collaboration. The availability of a systematic approach was evaluated, and the participants' feedback on the outcome of a systematic approach was obtained. 87 participants stated that the company had provided a systematic approach. The remaining 31 participants said the company did not provide any support at all. 73 of 87 participants, who have received support, stated that they were not entirely satisfied with the support provided. Therefore, 57 of the 73 participants expressed the wish for an improvement of the existing approaches. 26 of the 31 participants, who did not receive any support at all, indicated that a systematic support was desired. In addition, the box and the MAD also underline the results, which are shown in Figure 3.

Overall, the survey revealed the following result:

A systematic approach to provide a methodical approach for identifying and developing potential for improvement is partially available. However, the majority of the participants are not satisfied with the existing approach. Therefore, an improved methodical support is welcomed and considered to be beneficial for the distributed collaboration

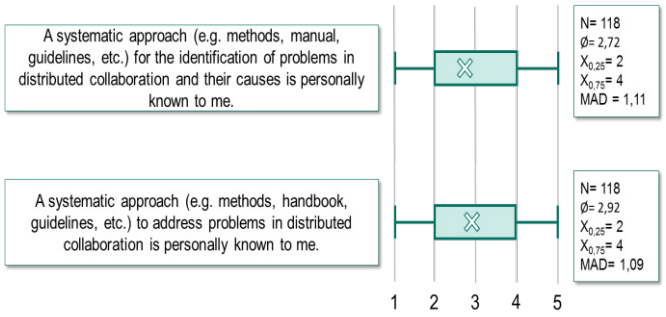

Fig. 2. Knowledge of systematic approach

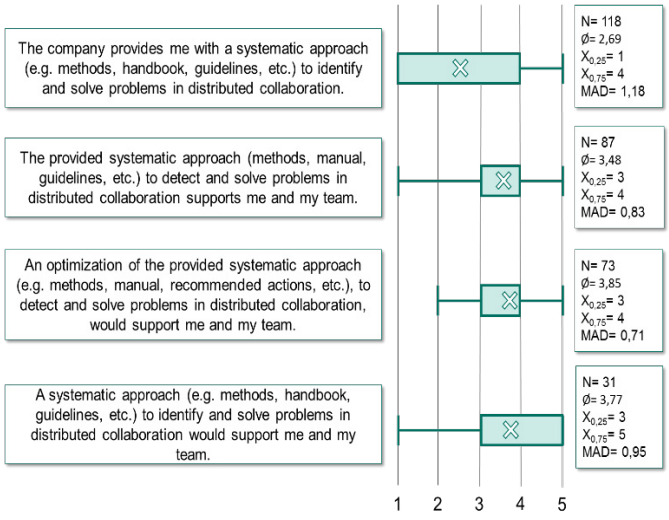

Fig. 3. Provision of a systematic approach.

5. Methodically support to improve distributed collaboration

The state of the art and the *DS1* results revealed the demand to methodically support the identification and developing of improving potentials in distributed product development. To ensure that both existing and newly developed methods can be applied in a targeted and successful manner, methods must be chosen and applied according to the specific circumstances. For this reason, a concept was developed in the *PS* which provides methods for improving cooperation in distributed product development. It was designed as an interactive tool for the provision of methods. The first step was to define selection criteria to support the situation- and demand-oriented selection of methods to improve distributed collaboration. The selection criteria are based on results of literature research and the *InnoFox*, as mentioned in chapter 2, and were further adapted to the subject of distributed collaboration. This is to ensure the situation-specific suitability of methods in the improvement process of distributed cooperation. Selection criteria include the number of available employees, the

planned implementation time, the integration into the *SPALTEN* process, and the request whether a moderator is required for the method. Providing methods appropriate to the circumstances is achieved by an algorithm written in the Visual Basic programming language. The algorithm compares the selection criteria in pairs with the characteristics of methods contained in the method repertoire. The description of the methods in the database is in binary codes. The aim is to provide only methods which exactly match to the inputs. This means also that methods can be developed specifically for inputs to which no methods can be assigned yet. Once the properties of the methods match with the selection criteria, the methods are provided to the user through a list. After that, the user is free to choose a method. For the decision, the user has the option to view the *abstract, the required resources and the advantages/disadvantages* in a short cut. More detailed information are available in the briefings, which are intended to support the implementation of the methods, but can also be used for decision making. Method briefings were prepared to facilitate the adaptation and the implementation of the selected methods in the individual development context. In this context, the user also has the free implementation option of the methods and can further adapt the presented methods according to his resources and boundary conditions. The method briefings are structured according to predefined contents, based on the described selection criteria and literature results (characterization of methods and method description in *InnoFox*). They serve both to give the user a quick overview of the method and to support the developer in implementing the method. The contents are listed as follows: *Classification by SPALTEN, methodological approach, possible implementation (distributed or not), scope, required resources, input/output, description, staff competences, advantages/disadvantages, literature.* Additionally, *annexes* can be attached to the brief descriptions to support the user in implementing methods through templates and detailed instructions. For easier usage and extension of the method provision tool, manuals are also provided to the user.

This method provision tool was evaluated during a two-day development simulator. The participants experienced the product development process starting with the concept development up to the implementation in order to fulfill the customer's requirements. Thereby, four participants took different roles and were assigned to different locations. After the first day, the tool and the provided method were applied. After the application of the method, the lack of communication between the team members on the status of the specific tasks was identified as the main problem, which supports the results of the state of the art on success-relevant influencing factors. The developed measurement for this problem was the establishment of scheduled and structured feedback sessions to keep the team members informed about the current status of the specific tasks. In the case of occurring problems, the discussed problems will be addressed immediately. On the second day, the improvement measurement was implemented. The implemented measurement led to a more target-oriented work and to a mutual support in the specific tasks. Through a survey the feedback of the participants was gathered. It contained only closed questions based on a *Likert scale*. They dealt with the evaluation aspects of BLESSING & CHAKRABARTI: *Support Evaluation, Application Evaluation and Success Evaluation*. [28] *Success Evaluation* was conducted by asking questions about the improvement process. Thereby, it was questioned whether the tool supported the participants in this process and improved the distributed collaboration. Regarding the evaluation types *Support Evaluation* and *Application Evaluation*, questions concerning the functionality and handling of the tool were asked. The answers given by the four participants were mostly positive. They confirmed the improvement of the distributed collaboration. Using the tool in general also supported the improvement process methodically. Regarding the functionality and handling of the tool, the participants stated that the tool was very user-friendly, and the tool was able to provide situation-specific methods.

6. Discussion

The DS1 survey confirmed the demand for methodical support to identify and develop improving potentials in distributed collaboration. Due to the large number of participants from the product development, the assumption can be drawn that the product development requires methodical support. Methodological support is already provided to some extent by the companies, but it was considered unsatisfactory by a majority of the participants. The growing relevance of the distributed collaboration in the product development was confirmed by the literature research as well as by the participants. In addition, the implementation of distributed working methods is accompanied by the occurrence of problems. Consequently, the demand for a methodical problem solution is most likely present in all product development departments in distributed companies. In order to analyze this assumption in detail, further analyses should be carried out that focus on various specific sectors and the level of implementation of distributed product development. In addition, the existing support should also be taken into consideration in more detail. The evaluation results of the *DS2* study confirmed the benefits of a method supply tool for recommending methods for identification and developing of improving potentials in distributed collaboration. The realistic development simulator encouraged the participants to intensify their collaboration, so that appropriate methods had to be applied for solving problems occurring during collaboration. Thus, the suitability of the development simulator proved itself and could be used for future studies. By answering the research questions, the hypothesis, presented in chapter 3, was initially confirmed. Despite the confirmation of the defined hypothesis, the Success Evaluation still must be conducted in larger groups of participants and during longer periods of time, in order to analyze the continuous improvement in distributed

collaboration regarding different boundary conditions. Functionality of the tool and its self-explanatory handling were confirmed by the participants within the Support Evaluation and Application Evaluation. Due to the small number of participants, this should be further analyzed as well.

7. Conclusion and Outlook

Based on the state of the art and the *DS1* survey results, it is important to approach the improvement process in distributed collaboration methodically. When selecting methods, it is important to select those that support the specific circumstances. On the basis of these findings, a concept was developed in this paper, after the input of situation-specific information, provides the user with appropriate and practical method recommendations. An initial study in a two-day development simulator confirmed the added value of a situation-specific provision and use of methods to identify and develop improving potentials in distributed collaboration. To analyze additional impacts of the methodological support on the process of improving distributed collaboration, future studies of similar scope will be conducted under different conditions. As part of this paper, the evaluation was conducted in a development simulator with a two-day time horizon. In order to consider further impacts, additional time horizons will be considered in future studies Time horizons can be divided into three-time frames: short (single-day study), medium (multi-day study) and long (multi-week study). Future observations require variations in the number of study participants to reflect differing boundary conditions for the method provision. To apply the aspect of continuous improvement, the concept shall always be optimized and extended. The method repertoire is to be extended beyond the usual universally usable methods by newly developed methods, such as the Team Space Method. Therefore, new methods need to be developed, focusing on the improvement of distributed collaboration.

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