

Research and Consulting in Data-Driven Strategic Product Planning

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ABSTRACT

Industry 4.0 and digitalization have transformed the industrial world. Many manufacturers create additional customer value by offering data-based services. However, companies can benefit from analyzing data themselves, too. Through data, companies can learn about product usage and behavior. This enables them to systematically improve their products. But finding improvements through data analysis is not trivial. Henceforth, we developed a method for the data-based identification of product improvements. This method was created in a joint research project with four companies from different industrial sectors.

The paper at hand introduces our approach of combining research and consulting in terms of a case study from our research project. The result is a research and consulting concept which is optimized for a two days workshop. From our point of view, there is no other way in researching methods for strategic product planning but through working together closely with companies. This is especially important as methods must be researched for practical usage. Simultaneously, it is essential to never forget that companies only participate in research projects if they clearly see a benefit. A benefit through consulting.

Keywords: Strategic Product Planning, Industrial Data Analytics, Research via Consulting, Consulting via Research

1. INTRODUCTION

The industrial world is changing: Industry 4.0 and the mega trend digitalization have started a process which brings up both new opportunities for growth as well as new challenges for manufacturers. Certainly, one major challenge arising is the increase in competition which is also a consequence of another mega trend from the last decades – globalization. As these phenomena are entirely new, dedicated research is necessary to find answers to all the questions arising. Building on this, it is essential to provide companies with a suitable consulting on how to tackle these challenges. But only when research and

consulting are combined and work hand in hand, the benefits for research institutions and industrial companies will be maximized. Hence, in this paper, we will present our approach of combining research and consulting.

First, we name challenges of combining research and consulting. As all our research projects include multiple companies, we have gained lots of experiences on working with companies in a research context over the years. The challenges we name in this paper are the ones we regularly face. Second, we introduce our research project DizRuPt. This project represents a fitting example of combining research and consulting as it includes all challenges mentioned before. Third, we show our approach of combining research and consulting in the research project introduced. The corresponding results are presented using a consistent case study from the project.

2. CHALLENGES OF COMBINING RESEARCH AND CONSULTING

When combining research and consulting, multiple challenges arise. Challenges are always specific to a project, but very often there are great similarities from one project to another. In the following, we present the most crucial challenges we regularly face in our research projects with companies.

Bridging the Gap Between Theory and Practice

In every research project, it is one of the most crucial challenges to bridge the gap between theory and practice. This gap is the result of different expectations and perspectives at the beginning of a research project. On the one hand, researchers strive to answer specific research questions using a lot of theory from literature. On the other hand, companies participating in the research project aim for solving their specific problems and gaining a competitive advantage. They search for effective and easy-to-use answers to their questions and often struggle with (too) formal research approaches.

In order to address this field of tension and close the gap between theory and practice, the solutions presented by the research institutions must be easy to understand and easy to apply. The theoretical concepts must be simplified and reduced

to the essentials. Furthermore, employees must be trained in the respective subject area. This is especially important as it prevents different understandings of the topic in the later course of the research project. Finally, from our experience, workshops with companies must be focused on the companies' needs. Only then, companies can identify with the questions at hand and provide valuable input.

Creating the Methodology

Our research group mainly focuses on creating methodologies which address problems in the context of strategic planning. As that is a very broad and diverse research area, the topics we work on differ from, for example, product planning to competence development. Consequently, each project needs an individual approach.

So, at the start of the methodology creation process, a first basic concept must be created. Usually, the input comes from an in-depth literature analysis. As this first approach is very theoretical, the application of the methodology in workshops is essential. Only a successful application secures the validation of the methodology. Consequently, the workshop experience and feedback from participants is crucial in order to improve the first basic concept. But, since there is only a limited number of companies in our research project, options for testing are restricted. Additionally, no company will conduct more than two workshops focusing on the same topic only for research purposes. Another factor to consider is time. Each workshop, its preparation as well as its post-processing take time which limits the number of workshops for a specific time frame. Finally, clear deadlines and milestones are defined within the research project, so the overall time frame for testing the methodology is also subject to limitations.

Increasing the Cooperation of the Companies (Research via Consulting)

Usually, pilot companies name between one and three employees as the core team to work in the research project. But in most cases, the research project is only one of their projects and faces competition from company specific projects as well as the daily business tasks. This leads to a conflict of interest as the employees must prioritize projects and tasks every day.

In this regard, research projects mainly face four challenges which influence the cooperation of companies. First, as mentioned above, daily business is the most distracting factor. As customer orientation is key for many companies, tasks directly related to customers are always of highest priority.

Second and closely related, as strategic topics and projects do not earn money immediately, these projects are easily delayed even though they may be very important for the company in the long run. But tasks which are important and urgent always have a higher priority.

Third, in many cases, the core team of the pilot company cannot complete all tasks from the research project alone. It needs to rely on expert knowledge from different departments. The experts from these departments do not know the project and its goals, plus they have little direct benefit from participating. In some cases, they may pursue different, even contradicting goals and see the research project as a threat to their well-known jobs.

Fourth, in some cases, a company might not be interested in a particular aspect of the research project. In that case, it is very difficult to increase the cooperation of the company as it does not see any benefit in the task.

Creating Value for the Companies (Consulting via Research)

In order to increase the cooperation of the participating pilot companies, it is necessary to create value for them. In this context, the value can describe various things, for example: a solution for a general problem, a concept for a question or challenge which the company has to deal with etc. But often, companies and research institutes have got a different expectation of how this value looks like in detail. For us in strategic planning, results of a research projects and therefore, value for the companies are e.g. concepts for the digitalization of processes, fields of action for introducing existing products to new markets, a roadmap for new product and service ideas etc. In contrast, companies often hope for results which promise to create profit immediately after the project. But especially for our strategic topics, there usually is no direct revenue stream as the changes made can only be evaluated from a long-term perspective. Most of the time, even an initial investment is necessary, so the financial short-term result is likely to be negative. Additionally, we as researchers of strategic planning can only guide the way and provide the companies with suitable methodologies and approaches. The industry experts within the company have to work out specific solutions for their company and integrate these themselves.

3. DATA-DRIVEN STRATEGIC PRODUCT PLANNING

In our research project DizRuPt, we focus on data-driven strategic product planning. Strategic product planning describes the process from the identification of future success potentials to the finalization of a development order. It consists of three fields of activities: Foresight, product discovery and business planning [1]. Strategic product planning provides the basis for the subsequent product development. Data-driven strategic product planning describes the integration of data analytics into strategic product planning. Data analytics refers to the process of accessing, aggregating and analyzing large amounts of data from multiple sources. This enables companies to extract knowledge from data in order to understand historical and predict future events [2].

The usage of data in product planning represents a new approach and promises great benefits. By using data analytics, companies can achieve a true customer-centric design [3]. This means that products can be improved by integrating the product users into the process through the analysis of the corresponding product usage data [4, 5, 6]. Therefore, it is necessary to extract knowledge about product usage from the results of the data analysis and, subsequently, derive new requirement specifications for the improvement of the product [7].

The benefits mentioned above especially apply when there are a lot of product instances in the field which collect and send data. Then, the information from the instances in the field can be used to improve new product generations as well as the products in the field via retrofitting [8]. In this context, retrofitting describes the process of replacing and modernizing single parts of a product in use in order to add new functions and features which the product did not have when it was built [9, 10]. This often leads to improved performance of the product.

Besides product usage data, other data can also be integrated into the process. Additional data from different sources such as service records, inventory locations etc. increase the value of the product usage data exponentially [11]. As a result, there is a strong development demand for a methodology integrating the

customer into the strategic product generation and retrofit planning by analyzing various kinds of data [4]. Therefore, we developed a methodology for the data-based identification of product improvements. It consists of the three phases *Hypotheses Identification*, *Data Analysis* and *Derivation of Product Improvements* (see fig. 1).

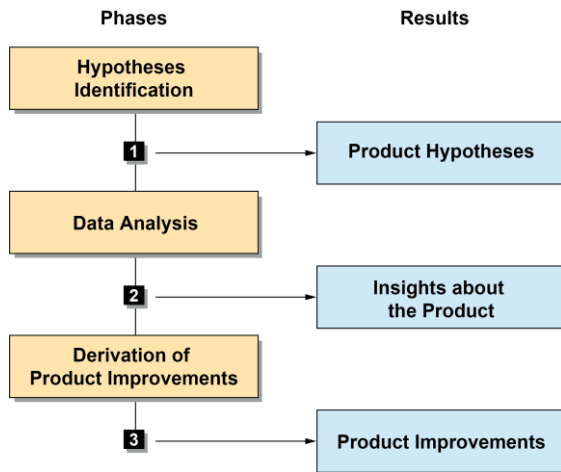


Fig. 1. Process Model of the Methodology for Data-Driven Strategic Product Planning

In the following, the three phases are briefly explained in order to create a common understanding.

Complex technical systems have hundreds of possible data points. As it is not possible to analyze all of them, a focus on certain aspects must be set as early as possible. In this regard, hypotheses about the behavior, usage or problems of the product can be very helpful [12]. In order to test these hypotheses, they must fulfil certain requirements including a consistent and precise formulation, well-founded knowledge as a starting point for the hypotheses and a sufficient degree of concretization for validation [13]. Additionally, the identified hypotheses should be prioritized in order to analyze the most relevant ones first [12].

Subsequently, the hypotheses must be analyzed. Therefore, the necessary data must be acquired and a suitable data analysis method must be chosen [14, 15, 16]. A major challenge in this step is the systematic integration of different data sources along the product lifecycle in order to increase the value of the data, as mentioned above [4].

Once the data has been analyzed, the results and insights must be translated into concrete product improvements. Creativity methods can be helpful in this step to find concepts for solutions [1]. Once a promising concept has been found, it must be decided whether the improvements will only be considered in future product generations or if they will also be used for retrofitting products in the field. In this regard, cannibalization effects must be considered. These effects describe a competitive situation between the company's own products due to inaccurate product differentiation [17, 18]. So, it must be analyzed whether a retrofit would harm the revenue potential of future product generations as customers would rather retrofit their existing products instead of buying a new one. In this case, the value added via retrofit is either too high or the value added in the new product generation is too low. This situation must be avoided.

In the following, we present our approach of combining research and consulting. We focus on the first phase

Hypotheses Identification and use a case study with a company from our research project as a practical example.

4. CASE STUDY: APPROACH AND RESULTS

Our approach consists of five phases: *Scientific Processing*, *Training of the Companies*, *Initial Workshops*, *Experiences, Feedback and Revision* and *Final Workshops* (see fig. 2). This approach is an elaboration of the Design Research Methodology (DRM) with its four stages *Research Clarification*, *Descriptive Study I*, *Prescriptive Study* and *Descriptive Study II* [19].

Following, each phase of our approach is discussed and its results from the case study are shown.

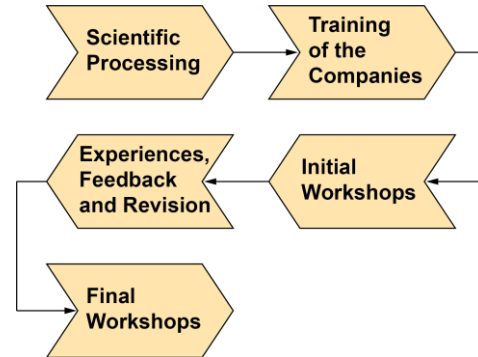


Fig. 2. Process Model Describing Our Approach for Combining Research and Consulting

Scientific Processing of the Topic

Hypotheses about a specific product represent the result of the first phase of our research project. As the term hypothesis already caused confusion at the kick-off meeting of the project, we had to start our work with the definition of the term hypothesis. Therefore, we looked up multiple definitions from various fields and merged them into a definition suitable for our project:

A hypothesis is an assumption about an existing fact. It is a preliminary, presumed answer to a question that has not yet been answered. The assumption recorded in the hypothesis is considered probable based on a theory.

It is a formulated proposition that can be verified and, in particular, be falsified in reality. If the hypothesis does not pass the test, it is rejected (or modified if necessary). [20–22]

Additionally, we identified characteristics of hypotheses and their expressions [21]:

- Statement area: Does the hypothesis include all elements, at least one element or a proportion?
- Concretization: How concrete is the hypothesis?
- Study Objective: Does the hypothesis describe a relation, a difference or a change?
- Directionality: Does the hypothesis describe the direction of action?
- Specificity: Does the hypothesis contain information about the magnitude of the effect?

These characteristics are important for the validation by data analysis. They determine whether a hypothesis can be checked easily or, for example, whether further concretization or a higher specificity is necessary. Furthermore, we identified

different types of hypotheses: descriptive, trends, condition-analytical and causal-analytical hypotheses [20, 21]. Every hypotheses type is suited for a different task. For example, causal-analytical hypotheses are used to describe true cause-effect relationships while trend hypotheses describe a development of a variable in a given time frame.

Training of the Companies

After the scientific processing of the topic, we prepared a training for the companies. The training was designed to meet the following goals:

- A common understanding of the term hypothesis in our research project with all participants.
- Knowledge about what characterizes a good hypothesis and what information is necessary for data analysis.
- Practice in formulating good hypotheses.

The training was performed in a very interactive way by learning to create product hypotheses considering their own product. First, the participants had to set up initial product hypotheses on their own. We let them do this without guidance in order to create a bigger learning effect afterwards. After each participant had created a few hypotheses, we introduced them to our *Theory of Creating Good Product Hypotheses*. We showed them the characteristics of hypotheses as well as the different types. Additionally, we presented a chart which shows the evolution from bad to the best hypotheses possible for data analysis using example hypotheses. Fig. 3 shows the improvement of a hypothesis using the example of a motor which fails when its temperature exceeds a threshold.

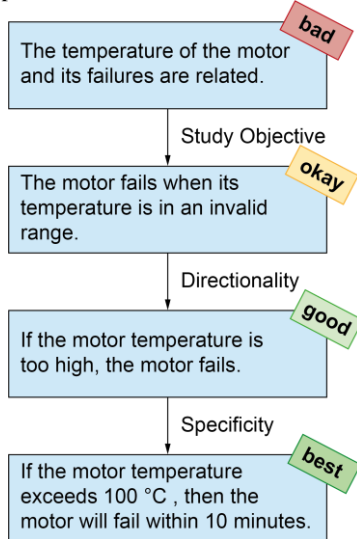


Fig. 3. Improving a Hypothesis by Applying the Characteristics *Study Objective, Directionality* and *Specificity*

The improvement of the product hypothesis is made possible by improving the single characteristics of the hypothesis mentioned above in a certain order. With each step, the hypothesis gains more information, making it more suitable and valuable for data analysis.

Subsequently, we provided the participants with a *Checklist for Product Hypotheses* (see fig. 4). This tool helps to create meaningful hypotheses which are ready for data analysis.

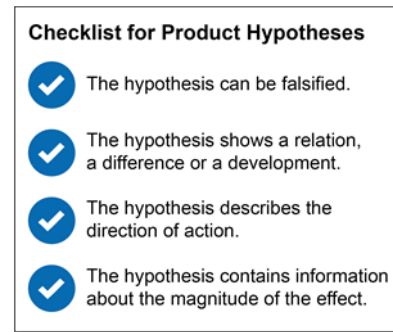


Fig. 4. Checklist for Creating Product Hypotheses Suitable for Data Analysis

Finally, we asked the participants to improve the hypotheses created in the beginning of the training. Using the given examples, the checklist as well as templates for every type of hypotheses (see fig. 5), the participants were able to create well formulated hypotheses very efficiently.

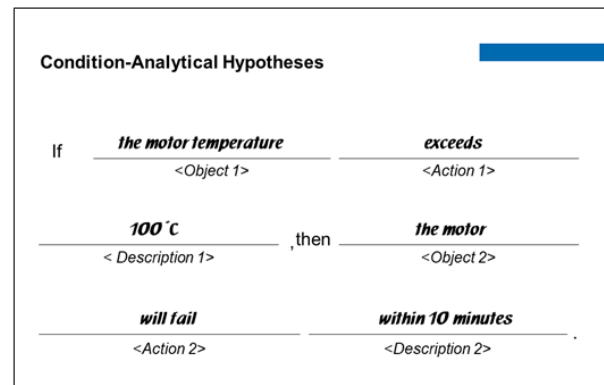


Fig. 5. Template for the Formulation of a Condition-Analytical Hypothesis

Initial Workshops: Consulting via Research

After the training, we conducted initial workshops for the identification of product hypotheses. As a starting point, we took Osterwalder's Value Proposition Canvas (VPC) and modified the left side slightly [23]. Our so-called *Hypotheses Value Proposition Canvas* describes the customer jobs, pains and gains of the customer profile just like the original VPC. Additionally, it checks the fit with the value proposition of a company by listing product functions as well as their strengths and weaknesses (see fig. 6). The method starts on the right side of the canvas which represents the customer view. Here, it is important to list all customer tasks first. The customer tasks describe what customers want to accomplish and which problems they try to solve. These do not necessarily have to be functional tasks; social and emotional tasks are also very important and should be included. Subsequently, the pains customers experience when trying to complete the tasks are searched for. Analogously, the gains which customers desire when fulfilling a task are listed [23]. For the left side, initially all relevant product functions are listed. Then, weaknesses and strengths when fulfilling the product functions are noted. This initial workshop represents the *Consulting via Research* direction. We used this method in a workshop format of 3 hours. The companies participated with interdisciplinary teams of three to four employees. Most of the participants were from R&D.

In our example, customer tasks were e.g. to ensure high quality when producing goods and to ensure safety. Changing production conditions represent a pain which impairs the quality of the goods. On the other side, a safety guarantee would dispel all customer concerns about safety. From this, we asked the participants to formulate hypotheses. Against our expectations, the participants had problems to formulate adequate product hypotheses. Not even when looking at all the tools from the training were they able to derive good product hypotheses. It took a strong moderation and numerous inquiries like “What could be causes for the changing production conditions?” and “What would be necessary to guarantee safety and what is stopping you from it?” to find product hypotheses. Ultimately, we were able to fetch numerous hypotheses, but certainly our approach needed further improvement to make the formulation of hypotheses more intuitive.

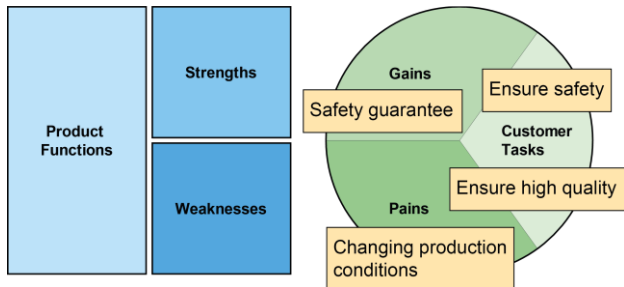


Fig. 6. Hypotheses Identification Using a Modified Value Proposition Canvas

Experiences, Feedback and Revision: Research via Consulting

After the initial workshops with all four companies, we discussed what needs to be improved. Additionally, we talked to a representative from every company and asked for feedback. Through these two steps, we identified the most crucial challenges:

- The formulation of hypotheses is very difficult.
- Good hypothesis could only be achieved by strict moderation.
- The specification of hypotheses is difficult. Values had been negotiated between participants several times.
- In general, the topic is very abstract.

Building on these results, we revised our workshop approach and created a new solution:

- The Hypotheses VPC acts as a collection of fields of action. It is not the goal to directly build hypothesis from the canvas.
- Fields of action shall be analyzed for cause-effect relationships. This helps to formulate hypotheses.
- Partial models which describe the product from different perspectives shall help to search for cause-effect relationships.
- First hypotheses can be simple in order to find a fundamental link. Then an iterative process starts in which the hypotheses will be further elaborated and developed after the confirmation of the fundamental link.

At a consortium meeting we presented our revised and improved approach. The participants from all companies were very content and agreed that the initial problems could be

solved with this systematical approach. Their only fear was that the whole process would take too long as it was a lot more detailed. We agreed to transform this solution into a suitable workshop format with two slots of three to four hours each. So, through the revision of our initial workshops, we addressed the *Research via Consulting* direction which allowed us to create a new approach considering the feedback from the industry.

Final Workshops: Combining Research and Consulting

Our final workshops were split into two parts: in the first workshop, we aimed to create a general and common product understanding. Therefore, we introduced the companies to the specification technique CONSENS which enables the cross-domain description of mechatronic systems using various partial models [1]. Together with experts from the companies, we created three models for their product: *Environment*, *Active Structure* and *Behavior*. While the environment model shows the influences on the product from outside, the active structure model represents internal system elements and their effect-relationships. The behavior model describes activities and transitions of the product.

Based on these three models, the second workshop aimed to identify meaningful product hypotheses. First, we revised the Hypotheses VPC from the initial workshop. Second, we picked the most relevant pains, gains, strengths and weaknesses which represent fields of action. For each field of action, we set up an Ishikawa diagram [24]. With the help of this diagram, we searched for cause-effect relationships in six partial models including the three partial models from CONSENS described above. The partial models and the common product understanding were great assets in this step as they allowed to easily find multiple possible causes for a field of action. In our example, the changing production conditions can be caused by *new machine operators* in the partial model *Personnel* as well as by a *cold air draft* from the partial model *Environment* (see fig. 7).

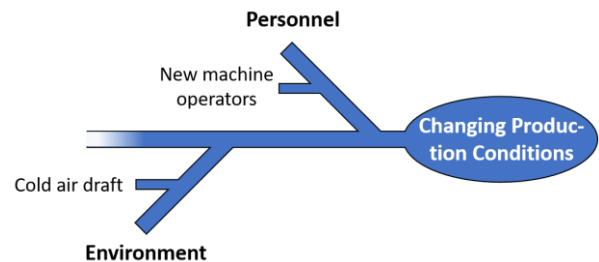


Fig. 7. Cause-Effect-Analysis for the Field of Action *Changing Production Conditions* Using a Modified Ishikawa-Diagram

When the participants felt that they had identified the most relevant possible causes for a given field of action in the Ishikawa diagram, we gave each cause a number. The number of a cause equals the number of its hypotheses, as the formulation of hypotheses is done by combining a specific field of action with each possible cause. Consequently, there are multiple hypotheses for each field of action, e.g. *A cold air draft is a reason for changing production conditions*. Subsequently, we let the participants rate each hypothesis in three dimensions: the probability that the hypothesis is true, the effort to check whether it is true and the magnitude of the influence which the cause has on the field of action. Based on these ratings, the hypotheses are positioned in a prioritization portfolio (see fig. 8).

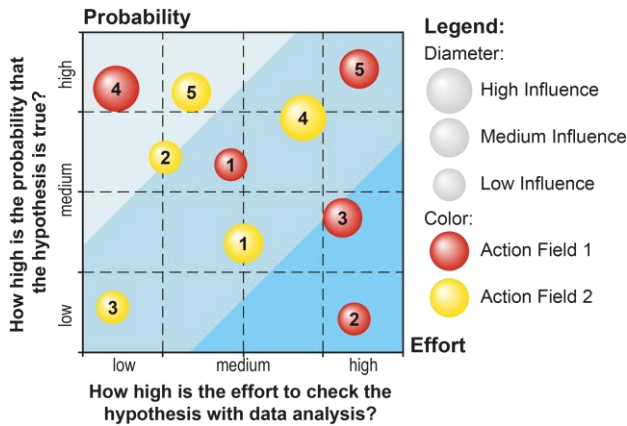


Fig. 8. Prioritization of the Product Hypotheses Using the Criteria Probability and Effort

The portfolio shows which hypotheses should be analyzed first and which should be neglected. Hypotheses which experts guess to be true and which will only take little effort to check represent low-hanging fruits and should be checked first (upper left corner). Then, hypotheses with equal probability and effort ratings should be checked (medium area).

Last, the hypotheses with low probability and high effort in the lower right corner should be checked. Also, hypotheses with a higher influence should always be preferred as they are more relevant for the considered field of action. Choosing the hypotheses from this portfolio ensures that companies do not waste their valuable resources. In our example, the hypotheses rating with experts from the companies worked out very well. The experts discussed all hypotheses one after the other and positioned them into the portfolio.

Overall, the final workshops were a great success. With our revised workshop concept, we were able to achieve meaningful hypotheses in a systematic and easy-to-follow way. Furthermore, the whole process was very time efficient as it only took two workshops of three to four hours each.

5. CONCLUSION

Combining research and consulting is a key factor for developing methodologies and tools which are characterized by a straightforward approach, high implementation efficiency and valuable results. While *Consulting via Research* ensures that companies step out of their comfort zone and get in touch with the latest research results, *Research via Consulting* leads to an understanding of real-world problems and phenomena. But only in combination do research and consulting enable companies to achieve a decisive competitive advantage. Our approach and its results show how the challenges of combining research and consulting in research projects with industrial companies can be met: we were able to bridge the gap between theory and practice by creating an early training and by using an agile research approach. Latter also allowed us to continuously improve the methodology created through increasing customer fit and implementation efficiency. Additionally, we were able to increase the cooperation of the companies by repeatedly asking for honest feedback. As a consequence, this led to true value for the companies which is both the most important goal and the most crucial challenge.

When using the approach presented, three success factors are to be considered:

- A systematic approach: A well-structured, systematic approach is essential to convince the companies of the high value the project offers.
- Communication: An open and honest communication with the companies is the key to a successful project.
- Empathy: Building up empathy for the companies leads to a true understanding of the problems it faces and, consequently, to better solutions.

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For more details about the project, visit www.dizrupt.de

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