NordDesign 2018
August 14 – 17, 2018
Linköping, Sweden

Development methods for 2030: An interpretation of scenarios in the application of methods

Albert Albers[1], Nikola Bursac[1], Florian Marthaler[1], Andreas Siebe[2], Nicolas Reiß[1], Tobias Hirschter[1]

[1]IPEK – Institut für Produktentwicklung, Kaiserstraße 10, Karlsruhe, (Albert.Albers, Nikola.Bursac, Florian.Marthaler, Nicolas.Reiß, Tobias.Hirschter)@kit.edu
[2]ScMI Scenario Management International AG, Klingenderstraße 10-14, Paderborn, Siebe@scmi.de

Abstract

Using the scenario analysis, context scenarios of the application of methods were derived, for the strategic orientation of development method research. The scenarios of the application of methods are interpreted in this article. For this purpose, a multi-level concept was developed, in which in a first step an expert study with alumni and employees of the IPEK - Institute of Product Engineering of the Karlsruhe Institute of Technology (KIT) was carried out with 32 participants. The participants of the study were presented with concise short videos that illustrate the application of development methods in the respective scenario. The respondents' task was to evaluate the scenarios with regard to the actual situation, desired image and probability of occurrence as well as to identify the opportunities, risks and relevant research priorities of the scenarios. The results of the studies were then consolidated step-by-step in the expert team into a total of seven research clusters and linked with a network analysis. After a brief description of the scenarios of the application of methods, these are discussed in the results of this article with the aim of addressing specific short, medium and long-term research incentives.

Keywords: Methodological Research, Scenario Technique, Application of Methods, Systems Engineering

1 Introduction and motivation

In order to support agile and dynamic processes in the context of product generation engineering, it is necessary to use appropriate and need-based methods that are oriented to the social and technical changes in product development processes (PDP). However, it is difficult to characterise the requirements associated with future changes. Particularly the need of tool support from artificial intelligence (AI) or the alternatives to in-house methods are very research-intensive topics and its future development strongly influences the requirements for methodical support. However, the precedent-setting decisions affecting the research and development process of tomorrow's development methods must already be taken today, whereby early knowledge of their requirements considerably simplifies the development of the systems of objectives. This requires a look into the future. An important method to support strategic decision-making processes is the scenario analysis (Fink, A. & Siebe, A., 2016). Therefore, scenarios of the application of methods for the year 2030 were developed and presented in comic format with the help of the storytelling method. The scenarios of the application of methods are summarized in this article. In particular, current trends in application and research of development methods will be discussed. The key findings of this contribution are the incentives and ideas for research on development methods, which are derived from the scenarios of methodological research. These incentives and ideas were identified within the framework of an expert survey conducted by the IPEK - Institute of Product Engineering of the Karlsruhe Institute of Technology (KIT) and consolidated and processed by a team of experts.

2 State of the art

2.1 Future of the development methodology

Areas of influence of the development methodology in the future include the rapid development of the technologies to be developed, the changing market situation, the economic and social change in attitudes towards sustainability awareness, or the fourth industrial revolution with focal points such as big data, embedded systems, robust networks, cloud computing or IT security (Persson, J.G., 2016, p. 378), (Bauer, W., Schlund, S., Marrenbach, D. & Ganschar, O., 2014). In addition to lean development methods, the future lies in the integration of information-based approaches in product engineering. For example, a large part of the waste in product engineering is due to loss of information or waiting time for decisions or information (Holman, R., Kaas, H.W. & Keeling, D., 2003, p. 31). For this reason, literature increasingly demands the use of consistent knowledge management systems and information management systems. In addition, digital methods will have a growing influence on the product development process in the future and lead to more innovative solutions, processes and project schedules. The so-called virtual product engineering will be introduced in all phases of product development (Eigner, M., Roubanov, D. & Zafirov, R., 2014).

Furthermore, it can be observed that product engineering is increasingly being introduced into the overall context of corporate planning. For example, it is often not enough to simply develop superior products - only a promising overall concept can ensure the competitiveness of machine and plant engineering companies. More and more approaches can be found in literature, which promote product engineering with a close link to the development of business models (Köster, O., 2014), (Nippa, M., 2005), (Spath, D. & Demuß, L., 2006). Another major challenge is the integration of cross-company collaboration into the product development process. For example, cooperation in the development of vehicles in development networks between automobile manufacturers and automotive suppliers is indispensable (Altfeld, N., 2014). Major incentives for innovations can be attributed to a close cooperation with suppliers. It can also be observed

that the development networks are becoming more and more complex and that the demands for development methodology and supporting IT are growing. The increase in complexity is mainly due to the advancing coordination and communication with the rising number of development partners. This is reinforced by the increasing efforts to integrate often domain-specific approaches in development (Neumeyer, S., Lünnemann, P., Woll, R., Hayka, H. & Stark, R., 2016, p. 26).

The future of development methodology is therefore presented with various challenges. Furthermore, different trends and future developments can be identified in literature. For this reason, there is a need for an aggregated presentation of the complex development methodology environment in the form of scenarios and their interpretation.

2.2 Own groundwork

This article is based on the scenarios of the application of methods, which are presented in the article Szenarien der Methodenanwedung: Ein Impuls zu strategischen Ausrichtung der Methodenforschug in the December issue of "Konstruktion – die Zeitschrift für Produktentwicklung und Ingenieur-Werkstoffe". The scenarios of the application of methods were developed in distributed teams in cooperation between WiGeP, the Wissenschaftliche Gesellschaft für Produktentwicklung, the IPEK - Institute for Product Engineering of the Karlsruhe Institute of Technology (KIT) and the consulting firm Scenario Management International (ScMi). For further and detailed information on the procedure and process of the scenarios, please refer to the contribution in the December issue of Konstruktion – Zeitschrift für Produktentwicklung und Ingenieur-Werkstoffe. To interpret the scenarios, brief descriptions of the scenarios are repeated in the following chapter. The three to four-minute short videos of the application of methods scenarios can be viewed using the respective QR code (Albers, A. et al., 2017). This paper focuses primarily on the German research and industrial landscape.

Scenario-Story 1 - Flexible, dispersed and virtual: In Scenario 1, the methods are applied in a particularly agile and flexible manner across domains throughout the entire product development process. The engineers work together in decentralized teams in virtual space with the support of artificial intelligence. Among other things, this enables the fast, efficient and targeted integration of specialists (see Figure 1) (Albers, A. et al., 2017).

Figure 1. Video excerpt of Scenario-Story 1 – Flexible, dispersed and virtual! (Albers, A. et al., 2017)

Scenario-Story 2 - Finding instead of searching: The application of the method in Scenario 2 is carried out standardised in central teams. The smart integration between the method users and the systems as well as the technical integration between the methods and the systems has become widely accepted. Artificial intelligence and intuition support the designers in the product development process (see Figure 2) (Albers, A. et al., 2017).

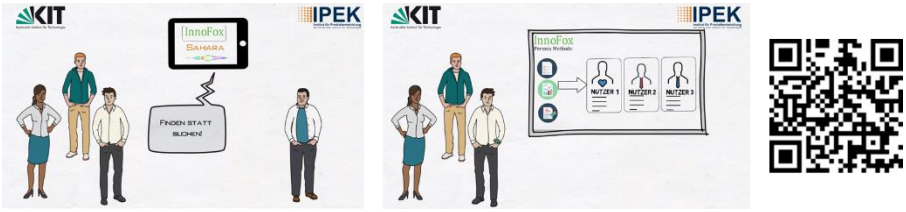

Figure 2. Video excerpt of Scenario-Story 2 – Finding instead of searching! (Albers, A. et al., 2017)

Scenario-Story 3 – Show me, don't tell me!: Scenario 3 is characterized by a very agile application of methods throughout the entire product development process. Especially co-creation with the customer in the context of open innovation projects has become widely accepted. The engineers are trained in methodology, work together with artificial intelligence and make partly intuitive decisions. In addition, is the primary focus on the technical integration of the methods (see Figure 3) (Albers, A. et al., 2017).

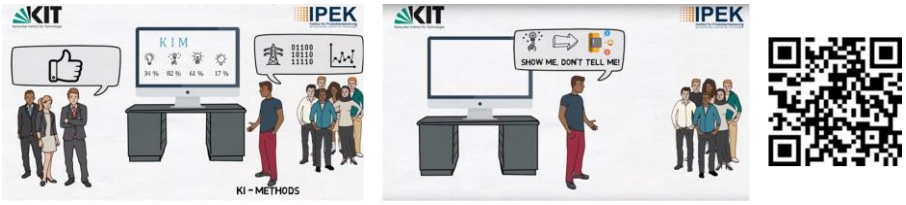

Figure 3. Video excerpt of Scenario-Story 3 – Show me, don't tell me! (Albers, A. et al., 2017)

Scenario-Story 4 - Law and Order: Scenario 4 can be characterized by a rigid, standardized and automated application of methods. The methods are applied in central teams, whereby the high degree of digitisation enables a workflow-based product development process with standards and checklists (see Figure 4) (Albers, A. et al., 2017).

Figure 4. Video excerpt of Scenario-Story 4 – Law and Order! (Albers, A. et al., 2017)

3 Research questions and –approach

The methodologically developed scenarios, which are reviewed by experts and conclusively selected by members of the WiGeP – Wissenschaftliche Gesellschaft für Produktentwicklung, are based on the interconnected and complex influences from the field of methodological research. Thus, the scenarios of the application of methods can be used to generate insights and research ideas for methodological research. The following research questions are derived from this:

- Which trends are already emerging in today's application of methods?
- Which reference scenario best describes the favoured world of the future application of methods?
- How can expert surveys be used to describe the probability of occurrence of scenarios?
- Which research priorities with regard to methodological research can be deduced from scenarios of the application of methods?

The research priorities are derived from the five-stage concept illustrated in Figure 5.

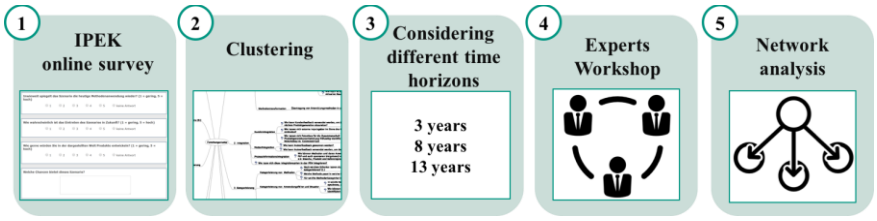

Figure 5. Concept for deriving research priorities

The first step is to conduct an online survey with alumni and employees of the IPEK - Institute for Product Engineering. The four scenarios of the application of methods will be shown to the participants in short videos. After each presentation, the participants are interviewed according to two categories of questions.

The questions of the first category are quantitative decision questions and they cover the actual situation of the application of development methods, the desired image as well as the probability of occurrence of the scenarios of the application of methods. These are the basis for quantitative analyses and for the development of roadmaps of the future application of methods (see Figure 6, left). The questions in the second category serve to interpret the different futures of the application of the method and are presented as free fields in order not to restrict the creativity of the participants (see Figure 6, right).

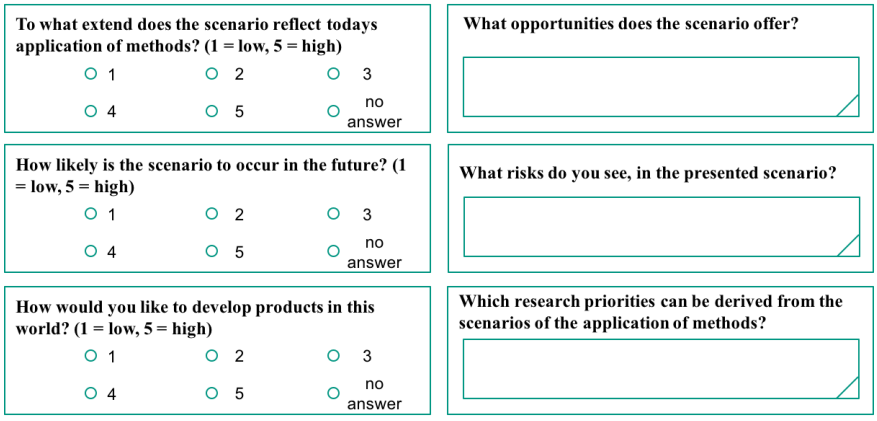

Figure 6. Screenshot of the survey to answer the research questions

A total of 32 participants took part in the survey. Of these, about 70% work in science and 30% in industry. Most of the participants from industry work in the automotive manufacturing or automotive supply sector. More than 60% of participants state they have more than three years of work experience.

During steps two to four, the collected data is increasingly consolidated and standardized. The clustering is visualized in the form of a mind map. The aim of the clustering is to prepare the data identified in the survey in a format suitable for further processing. Subsequently, the research priorities of the individual research clusters will be standardized with regard to the time horizon up to 2030 according to short-term (3 years), medium-term (8 years) and long-term (13 years) work packages. This standardisation makes it possible to carry out a network analysis after the expert workshop, which serves to define the specific research priorities, in order to be able to address the next concrete fields of action.

4 Results and added value

The quantitative result of the study reveals clear trends in the positioning of the scenarios with regard to the actual situation, the desired scenario and the probability of occurrence of the scenarios.

Figure 7 shows the participants' assessment of the actual situation, the desired scenario and the probability of occurrence.

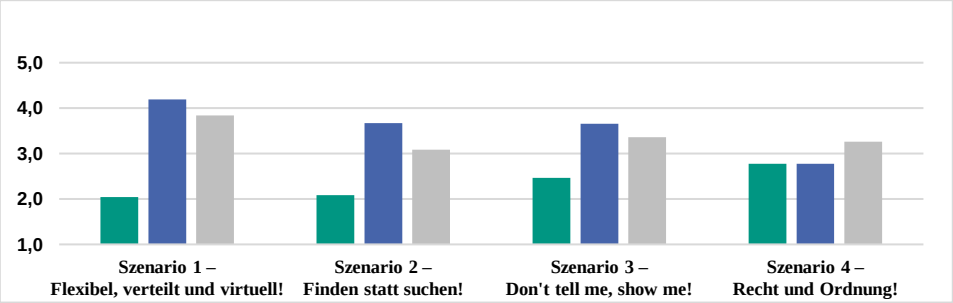

Figure 7. Actual situation, desired scenario and probability of occurrence of scenarios

It becomes clear that *Scenario 1 - Flexible, dispersed and virtual!* is the preferred scenario. *Scenario 3 – Show me, don't tell me!* as well as *Scenario 4 - Law and Order!* show, according to the assessment of the participants, tendencies of today's application of methods. It is precisely the rigid, automated application of methods that participants consider to be less desirable. Overall, it can be stated that all scenarios could occur with a relatively high probability in the future. It is therefore clear that an orientation of methodological research, which is robust for the future, is imperative. At the same time, methodological research must focus on the favoured *Scenario 1 - flexible, dispersed and virtual!*. The qualitative key findings of this contribution are seven identified research clusters that result from the consolidated research priorities. The matrix of the scenario research cluster visualised in Figure 8 is the result of the cluster analysis between the projections of the scenarios and the focal points of research carried out in the expert workshop.

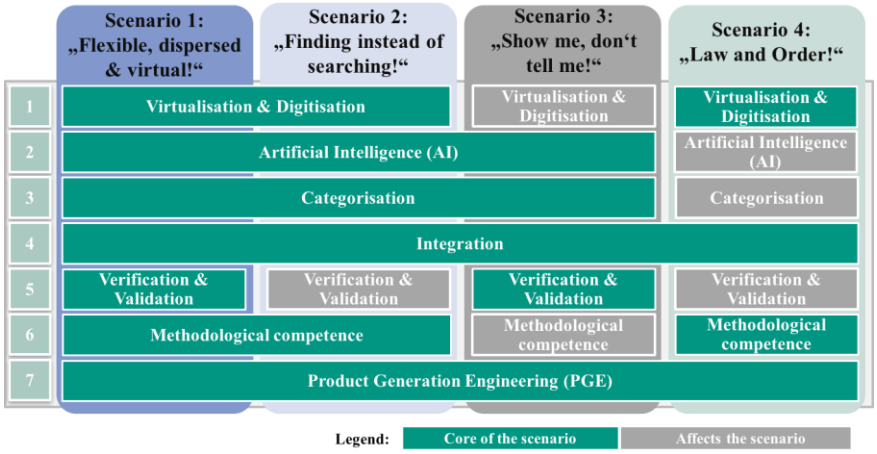

Figure 8. Results of cluster analysis

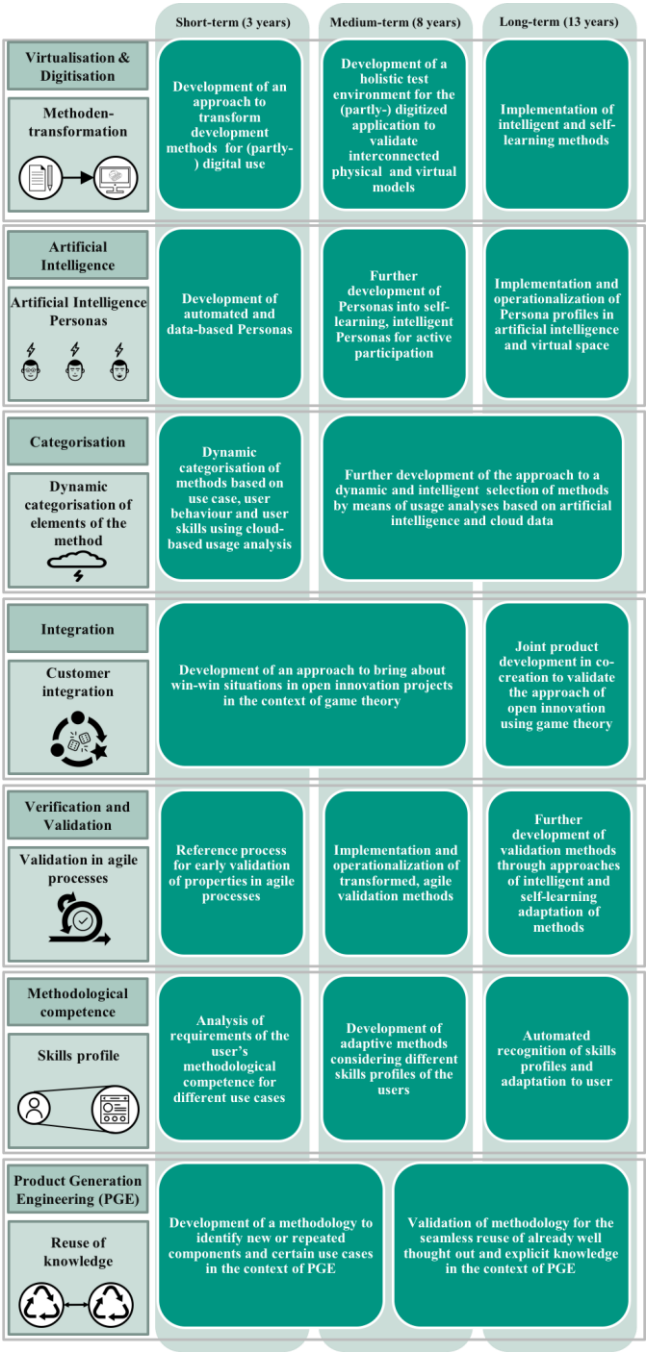

Figure 9. Research cluster 3 to research cluster 7

Most of the similarities indicate that the research clusters are robust for the future. Figure 9 presents the short-term, medium-term and long-term research priorities for each research cluster.

Finally, the network analysis shows the direction and intensity of the interconnection of the research clusters (see Fig. 10). The thickness of an arrow from one research cluster to another illustrates the strength of the influence. The results of the network analysis show that the individual research clusters interact strongly. The research clusters *product generation engineering (PGE)*, *virtualisation & digitisation*, *artificial intelligence (AI)* and *methodological competence* are particularly strongly interconnected. Research in the individual areas can thus

not be operationalized sequentially and independently of each other, but should rather be harmonised once certain research results have been achieved.

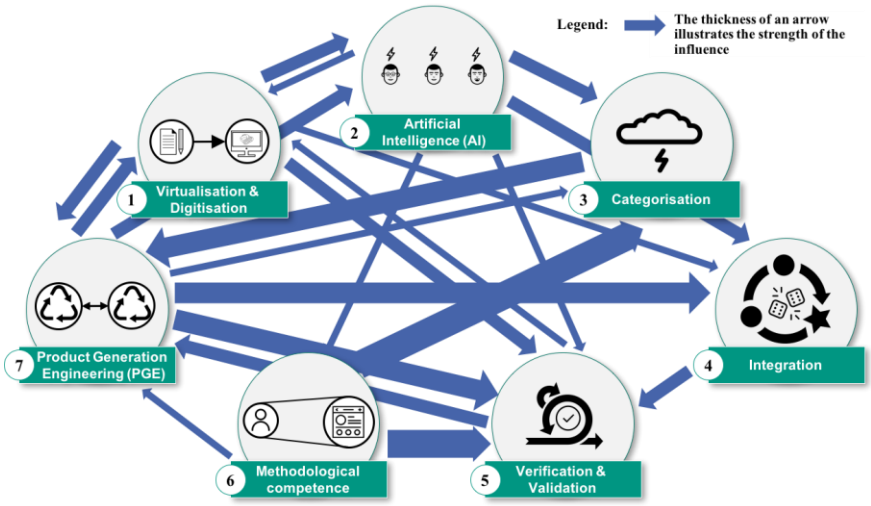

Figure 10. Network analysis of research clusters

5 Discussion and Outlook

The identified research incentives are based on methodically derived scenarios that have been verified by experts and thus address important incentives for the strategic orientation of methodological research. The quantitative evaluation of the participants of the study and the results of the network analysis clearly indicate that research results in the area of *product generation engineering (PGE), virtualisation & digitisation, artificial intelligence (AI)* and *methodological competence* must be achieved in order to accomplish the favoured *Scenario 1 - flexible, distributed and virtual!*. Furthermore, the high consistency of the six other research clusters with respect to Scenario 1 illustrates how robust the identified research ideas are. These should be further investigated in the form of individual and collaborative research projects. Moreover, the scenarios presented above are an excerpt of the developed population. Furthermore, when applying the method, it should be noted that future research using trend analysis and scenario techniques is subject to uncertainties. Contrary developments are to be monitored and the validity of the results continuously evaluated. In conclusion, the scenarios of the application of methods are interpreted by WiGeP to derive priority programmes, in addition to the research incentives published here. The identified research projects will be published in the form of a scenario brochure in November of this year and are available to be discussed by the scientific community.

Citations and References

Albers, A., Bursac, N., Marthaler, F., Siebe, A., Reiß, N., Bender, B., Lachmayer, R. & Vietor, T. (2017). Szenarien der Methodenanwendung – Ein Beitrag zur strategischen Ausrichtung der Methodenforschung. In Konstruktion – Zeitschrift für Produktentwicklung und Ingenieur-Werkstoffe., 12/17, Springer VDI-Verlag, Düsseldorf.

Altfeld, N. (2014). Gestaltung von stabilen Forschungs- und Entwicklungsnetzwerken. Dissertation, Abteilung Maschinenbau, Universität Wuppertal.

Bauer, W., Schlund, S., Marrenbach, D. & Ganschar, O. (2014). Industrie 4.0 Volkswirtschaftliches Potential für Deutschland. BITKOM und Fraunhofer IAO Studie.

Eigner, M., Roubanov, D. & Zafirov, R. (2014). Modellbasierte virtuelle Produktentwicklung. Berlin: Springer Verlag.

Fink, A. & Siebe, A. (2016). Szenario-Management – Von strategischem Vorausdenken zu zukunftsrobusten Entscheidungen. Frankfurt am Main: Campus Verlag.

Holman, R., Kaas, H.W. & Keeling, D. (2003). The future of product development. The McKinsey Quarterly, no.3, pp. 28-39.

Köster, O. (2014). Systematik zur Entwicklung von Geschäftsmodellen in der Produktentstehung. Dissertation, Fakultät für Maschinenbau, Universität Paderborn, HNI-Verlagsschriftenreihe, Band 325.

Neumeyer, S., Lünnemann, P., Woll, R., Hayka, H. & Stark, R. (2016). Systems Engineering im Kontext der unternehmensübergreifenden Produktentwicklung. In S.O. Schulze, C. Tschirner, R. Kaffenberger & S. Achva (Hrsg.), Tag des Systems Engineering. 25-27 Oktober 2016, Herzogenrauch. München: Carl Hanser Verlag. pp. 23-34.

Nippa, M. (2005). Geschäftserfolg produktbegleitender Dienstleistungen durch ganzheitliche Gestaltung und Implementierung. In G. Lay & M. Nippa (Hrsg.), Management produktbegleitender Dienstleistungen – Konzepte und Praxisbeispiele für Technik, Organisation und Personal in serviceorientierten Industriebetrieben. Heidelberg:Physica Verlag.

Persson, J.G. (2016). Current trends in product development. In L. Wang & T. Kjellberg (Hrsg.), Procedia CIRP, vol. 50, 26th CIRP Design Conference, 15-17 Juni 2016, Stockholm, Elsevier, pp. 378-383.

Spath, D. & Demuß, L. (2006). Entwicklung hybrider Produkte – Gestaltung materieller und immaterieller Leistungsbündel. In H. Bullinger & A. Scheer (Hrsg.), Service Engineering – Entwicklung und Gestaltung innovativer Dienstleistungen. Berlin: Springer Verlag. pp. 463-502.