INTERNATIONAL DESIGN CONFERENCE - DESIGN 2016
Dubrovnik - Croatia, May 16 - 19, 2016.

APPROACH TO TRANSFER METHODS FOR DEVELOPING MODULAR PRODUCT FAMILIES INTO PRACTICE

G. Beckmann, N. Gebhardt, T. Bahns and D. Krause

Keywords: method transfer, design practice, product family

1. Introduction

"Knowledge transfer does not just happen, it has to be planned, supported and worked at – and it takes a long time" [Wallace 2011]. Design researchers develop new methods [Cantamessa 2003] to support designers in industry, but few of them get used. More industry uptake is needed [Andreasen and Wallace 2011], however there are many reasons for the lack of use. Design research is fragmented and needs consolidation [Andreasen 2009]. Methods are often weakly built on prior research or empirical studies: a more rigorous research approach is needed to improve industry uptake [Blessing and Chakrabarti 2009]. Design methods do not fit the needs of engineers [Badke-Schaub et al. 2011] nor are they adapted to the individual user. One reason are inexperienced researchers and their missing knowledge about industry [Kreimeyer 2016]. Methods are too complex and theoretical, the effort to apply them too high and only software prototypes are provided [Geis et al. 2008], [Wallace 2011].
According to Wallace, no one in research (where the focus is on publishing results) or industry (which is focused on selling products) is responsible for integrating new design methods into practice. He states that "Knowledge transfer is the missing link" [Wallace 2011]. To contribute to better uptake of new methods by industry, this paper focuses on the active transfer of new design methods and presents a new method transfer approach based on a visual method and process description.

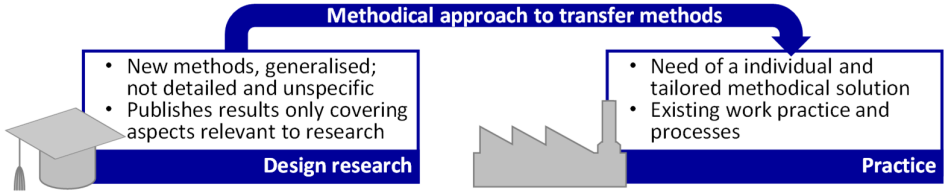


Figure 1. Connecting academia and practice with an approach to transfer methods

To answer the question of how the transfer of new design methods from academia into practice can be supported, the following are presented here:

- The scientific foundation of the newly developed approach through comparison of existing approaches
- A detailed description of the new methodical approach for the transfer of methods, including the new visual tool, to support researchers transfer methods into practice
- A case study on using the new support to transfer an existing method for developing modular product families (the Integrated PKT-Approach)
- Final discussion of the results.

2. Scientific foundation

Figure 2 gives an overview of knowledge transfer types. Short-term transfer is, for example, training of practitioners from industry or approaches that integrate new design methods in companies. For long-term transfer, design research needs consolidation to improve recognition [Cantamessa 2003], [Blessing and Chakrabarti 2009]. Education of design students plays an important part, particularly when alumni take methods into their jobs [Chakrabarti and Lindemann 2016]. Wallace describes long term cooperation of research institutions and companies as a transfer type [Wallace 2011].

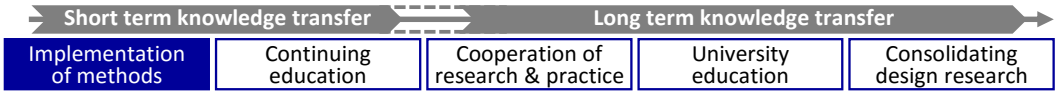
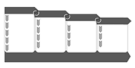


Figure 2. Types of and contributions to knowledge transfer [Beckmann et al. 2014]

This paper focuses on implementing methods. Transfer approaches and models in the design research community were identified using a literature study. Table 1 shows a selection of general approaches to method transfer, including their main focus and their major activities. Approaches and case studies reporting implementation of a specific method were not included. The approaches shown deliver sets of measures, not strict procedures, for examples [Viertlböck 2000], [Stetter and Lindemann 2005], [Geis et al. 2008]. Stetter and Lindemann assign tasks to different layers, carried out in parallel and iterative steps, which are linked to several existing support tools. Other approaches, e.g. [Messerle et al. 2014], give more concrete procedures, but at a high level of abstraction. The Munich Model of Methods [Braun and Lindemann 2003] focuses on special activities of method transfer, namely the selection and adaption of methods, and proposes a web-based method database. Approaches further specialised to individual aspects, like adaption of methods, can be found, e.g. [Zanker 1999], but are not shown in Table 1.

Table 1. Comparison of transfer approaches

	Model for the Strategic Planning of Method Integration [Viertlböck 2000]	Munich Model of Methods [Braun and Lindemann 2003]	Method Implementation [Stetter and Lindemann 2005]	Method Transfer Model [Geis et al. 2008]	Process for the Implementation of Idea Processes [Messerle et al. 2014]
Approaches					
Focus	- Model describing the typical integration process	- Support selection, adaptation by web-based method data-base	- Layer model for general transfer support - Provides standard tools	- Pillar model of actions needed for successful transfer	- Modell for the integration of idea management
Major activities	- Continuous analysis & identification of weaknesses - Centralised coordination - Centralised collection of experiences - Development of a strategic product development environment	- Clarification of method application - Method selection - Method adaptation - Method application	- Initiation of the implementation - Analysis of the product development system - Choice and adaptation of methods - Implementation of methods - Evaluation of the impact	- Simplification of methods - Adaptation of methods - Promotion of methods - Development and implementation of appropriate training	- Preparation - Diagnosis - Realisation - Evaluation and improvement

Comparing the approaches provides similarities on how to achieve a successful method transfer. Table 2 summarises these similarities along with other success factors that have been collected in [Beckmann et al. 2014] from existing empirical studies e.g. [Geis et al. 2008] and interviews with engineers working in industry.

Table 2. Summarised success factors for methods transfer

• Understanding the company needs	• Pilot projects and examples	• Mediate and quantify benefits (adequate KPIs)
• Planning, management and control	• Training and providing support	• Anchoring in organisation
• Adapted, simple, fitting methods	• Top management support	• Method champions (experts)
	• Convincing and involvement of people	• Improve, update, evaluate

The approaches presented are usually high-level descriptions and often miss specialised tools that support researchers while analysing and implementing design methods. The transfer approaches are not

adapted to the characteristics of individual design methods. Most transfer approaches seem to have been developed for small methods (brainstorming). The challenges of implementing complex methods (e.g. QFD), including several sub-methods and methodical tools, is not addressed. Individual support for transferring methods built on several sub-methods (methodologies) and that have an impact on several company stakeholders will be explored in the next section.

3. New methodical approach to transferring design methods into practice

The transfer approach developed aims to support design researchers to transfer new methods into a company. The framework is built on existing approaches and research. It focuses on the transfer of complex design methods that contain several sub-methods. It provides easy-to-use transfer tools that support understanding of the new design methods and current development practices in the company. Intended users of this support are:

- Design researchers, particularly academic method developers (main users)
- Company methods experts who are motivated to incorporate new ideas from research
- Students who are using new methods during an internship or thesis in a company
- Graduates educated in new design methods who have recently taken up a career in industry.

The approach provides help at two separate stages of method transfers (Figure 3). In the first stage (A), method transfer independent of a specific company, the method developers generally prepare new but validated design methods for integration into a company. The design methods are modelled, analysed and prepared using a new Method and Process Visualisation (MPV). MPV illustrates the activities of the methods along with the information most relevant to the specific integration project.

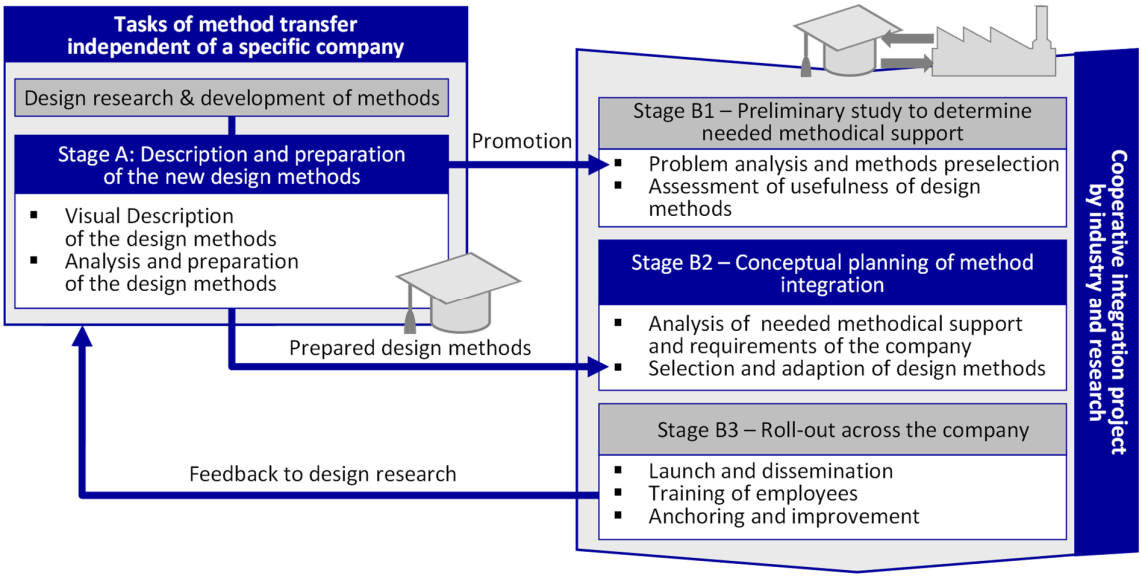


Figure 3. New methodical approach to transferring design methods

Before entering the second stage, design researchers need to promote the methods to companies. In the second stage (Figure 3), the integration of design methods into a specific company is supported as a collaborative integration project between industry and academia. In a preliminary case study (Stage B1), the needs for methodical support are roughly analysed, generally suitable methods are selected and tested, and the decision is made on whether the methods are useful to the company.

The conceptual planning of method integration (Stage B2) is followed up with a detailed analysis of the company, the methodical support required and the existing product development systems into which new methods must fit using the Method and Process Visualisation (MPV). Individual design methods or activities in the methods are selected and adapted for integration. The result of Stage B2 is a reworked development system (development process and organisation), including the integrated methods from

research. In the final stage, B3, the new product development system is rolled out across the company. Feedback on the integration process provides valuable input to research. The approach stages are explained in the following section, focusing on Stages A and B2 and the MPV tool.

3.1 Stage A – Description and preparation of the methods developed in design research

In Stage A (Figure 3), the new methods developed by academia are visually described and prepared separate to any specific company.

3.1.1 Visual description of the design methods

The aim of the visual description is to create an in-depth understanding of the design method procedure, identifying any potential for improvement and collecting the most relevant information needed to transfer, adapt and integrate the method, all in one document. The Method and Process Visualisation (MPV) was developed to describe extensive design methods (methodologies, including sub-methods and tools, such as QFD), rather than simple methods (e.g. brainstorming). MPV (Figure 4) is based on existing ways to model processes, such as SADT [Ross and Schoman 1977] and methods description models [Birkhofer et al. 2002]. It was presented in [Beckmann and Krause 2013]. The main driver for the development was the idea of collecting all relevant method transfer information in a visual representation.

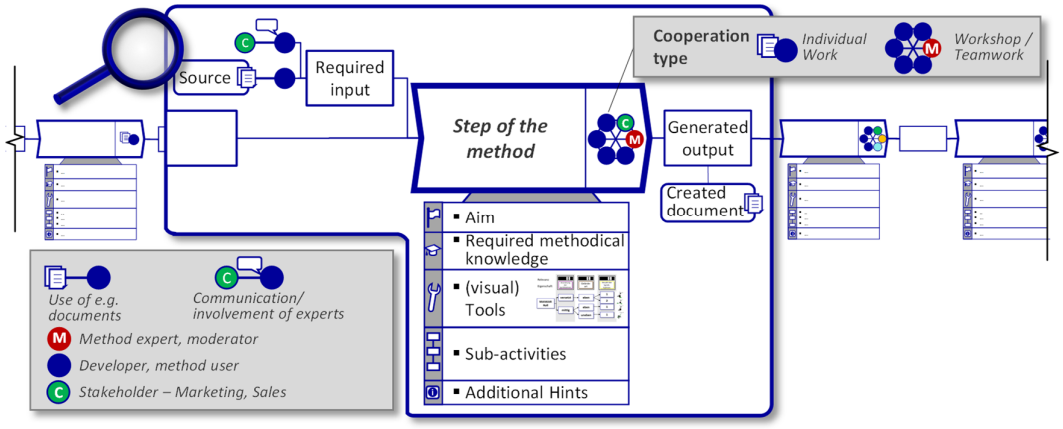


Figure 4. Method and Process Visualisation (MPV) cf. [Beckmann and Krause 2013]

To create a MPV of a design method, the design researcher decomposes the method into steps and describes each step using the following entities (Figure 4):

- Name of method step
- Required inputs and sources, differentiated into knowledge that could be included only by integrating experts and information gathered from documents or computer systems
- Generated output of the step and documents created
- Type of cooperation, differentiating between single person work and workshops/teamwork. Colour coding shows which groups of people are working together in each step.

After modelling the procedure, inputs and outputs and cooperation type used, an additional description card is added for each step, covering more information needed to transfer the methods:

- Aim of the step
- Methodical knowledge and skills required to perform the step
- (Visual) tools used, including a picture of a tool to allow easy recognition of the steps
- Sub-activities and additional hints to further describe the step.

A template for the MPV is available for the drawing program Microsoft Visio.

3.1.2 Analysis and preparation of scientific design methods

It is recommended that the person modelling the method is not the researcher who developed it. Modelling allows the researcher to check the consistency of method procedures and whether all information needed to apply the method is easy available.

After modelling the method researchers classify and sort the method steps to allow easy selection of the method or method steps to meet the variety of methodical needs in a company. If a company needs help analysing the existing properties of their products and all method steps aimed at analysing product properties are grouped into one category, picking the right one becomes easier. The researcher can also group closely related steps of the method into "method modules" that include steps that should be used together. The result of Stage A is a fully described method with all information that is required to transfer the design method into practice easily available.

3.2 Stage B1 – Preliminary case study to estimate company methodical needs

Preliminary case studies are carried out in Stage B1 (Figure 3). The problems in product development in the company are analysed, using a process analysis or interviews with stakeholders. Figure 5 gives an overview of possible actions during this stage. If a need for methodical support is detected (Figure 5), the fields of action required can be mapped against available design methods to find the one that best suits the company [Brosch 2014]. It is assumed that suitable methods generally exist that do not naturally fit the work processes of the company and cannot be used directly. In this case, the next stage, B2, is entered to start detailed analysis and adaptation of the design methods to the company.

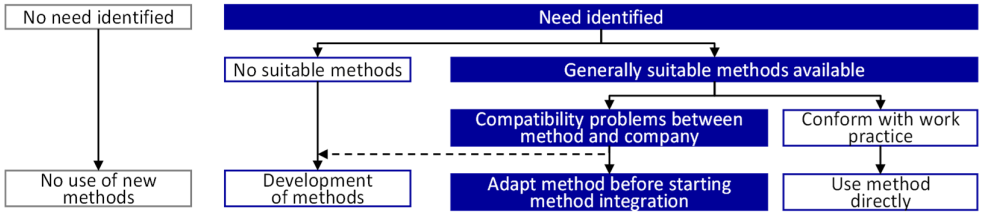


Figure 5. Possible actions after preliminary case study

To efficiently examine the general usefulness of the design method selected, a pilot study is carried out, involving only a part of the product or company. This step provides vital insights for method transfer. For example, management could be more easily convinced to finance methods implementation if successful use cases exist; a group of key users is available to support method transfer from inside the company; the workforce can be trained in the method, using examples from their own company and the researcher can observe existing work habits.

3.3 Stage B2 – Planning the conceptual integration of methods

The aim of Stage B2 (Figure 3) is to define a future new development system of the company that includes new methods, ideas, steps and tools from design research. Starting with a detailed analysis of design methods needed, existing development habits and company requirements, the methods or parts of the design methods are selected and adapted to suite the company.

3.3.1 Analysis of need for design methods and general requirements of the company

The existing product development process of the company is analysed and visualised using the Method and Process Visualisation (MPV; Figure 6, lower part), which provides information about the current methods, tools and software systems. The initial MPV was extended to model design processes, with symbols to visualise process steps that contain a decision-making process. In addition to analysis of the development process, the existing organisational structure of the company, the development department and stakeholders who are affected by the methods are studied. The organisation charts used for the analysis are consistently styled like the MPV (e.g. same colour schema for stakeholders) and contain further information needed for the transfer, e.g. existing methodical skills of the workforce and the potential of organisational units to support the change.

3.3.2 Individual method selection and adaption

Based on previous analysis, the new visualised design methods (upper part, Figure 6) can be compared to the identified methodical needs and the existing development process (lower part, Figure 6). The first criterion for method selection is comparison of the method aims (Figure 6, upper left corner) and methodical needs of the company. Besides the methodical knowledge and skills needed, the tools and cooperation types used to perform the new method should be judged for conformity with existing company practice. At the end of this selection, one or more steps, one or more series of linked steps, or the whole method is selected for integration. Integration of a whole method is the unlikeliest option, since existing steps in the company development process probably cover comparable actions in another way (e.g. another tool). Not replacing established steps and only adding new steps can make the change process less invasive to the workforce.

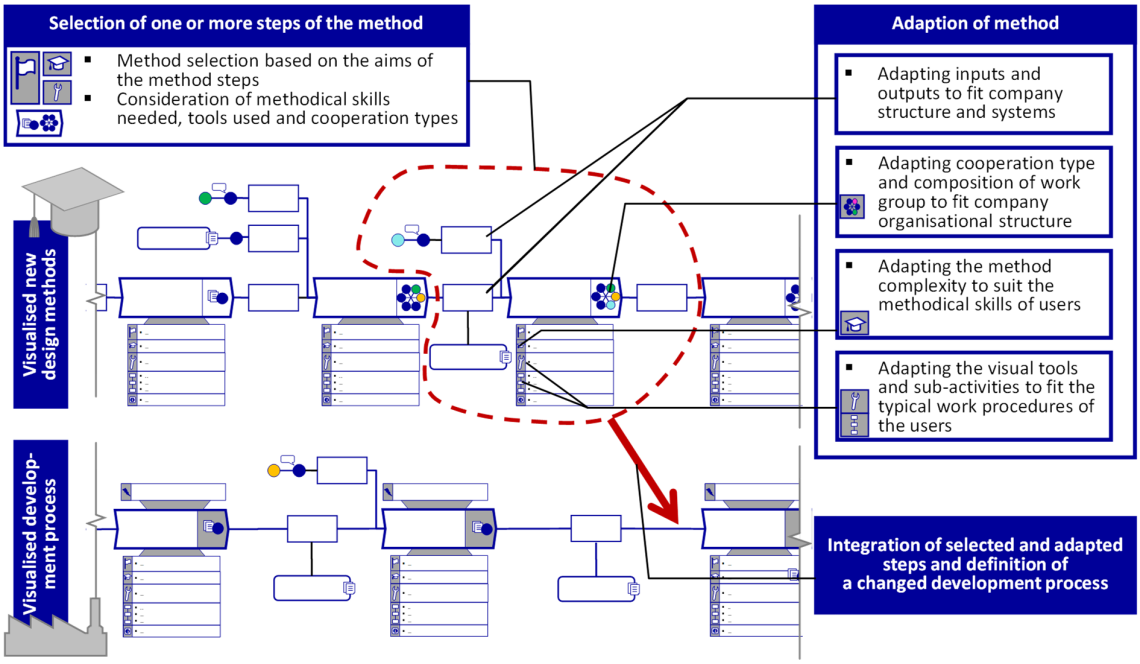


Figure 6. Selection and adaption of method supported by the MPV

After selecting the steps of the new design methods, adaptations needed are carried out to make them fit the existing work practice of the company (Figure 6, right). Including new methods means changing the daily work practice. The acceptance of new methods highly depends on whether the methods fit their given problem and traditional ways of working. Method transfer could be more successful if only things that need changing are changed and new methods and tools feel familiar to users in existing work procedures (Table 2). This does not mean that unsuitable working habits should remain, but the researcher should keep changes to the most relevant measures and core ideas of the new method.

The inputs and outputs of the methods are changed to fit existing company structures and computer systems. For example, if the new method requires a list of product components, the input could be adapted so that this information is automatically extracted from an Enterprise-Resource-Planning system. This helps to minimise the additional effort created by using the method and increases acceptance. For each step of the new method, the cooperation type and the stakeholders affected are compared to experts in the company using the MPV and organisational charts. Sub-steps of the method along with the tool used are changed to fit company procedures and nomenclature. Finally, method complexity should be reduced as much as possible. The new process and its tools can be tested in small case studies prior to introducing the process to the whole company.

The result of this stage is a new development process, planned in detail, including changes made to the organisational structure, which has to be rolled out and tested in daily work (Section 3.4).

3.4 Stage B3 – Roll-out of method across the company

Roll-out of the methods (Stage B3, Figure 3) is not discussed here in detail, though change management processes provide tips on how to change a company. Three general activities are recommended: Launch and dissemination of the new processes and structures; Training of employees; Anchoring and improvement. These measures can be supported by experience and examples of good method use, the key method users created from the preliminary case study, and by using the detailed information collected during analysis of the existing company using the MPV (Section 3.3.1). A person or team needs to be in charge of testing, maintaining and continuously improving the new process to foster lasting use and acceptance.

4. Case study on an application of the transfer approach

Following the transfer approach developed and described in the previous section, the application is divided into activities to prepare the methods in the research domain, independent of companies and a company-specific method implementation project. The example design method, the Integrated PKT-Approach, is described first. Then the setup and results from integration of the design method in an elevator company is presented.

4.1 Example method for the case study – the Integrated PKT-Approach

The Integrated PKT-Approach for the Development of Modular Product Families [Blees et al. 2010], [Krause et al. 2013] (Figure 7) supports designers when developing a product family that contains a set of product variants. Its usefulness has been demonstrated in case studies [Eilmus et al. 2012] and is the example design method used in this case study. Similar methods in research are [Harlou 2006], [Lindemann et al. 2009] and have been collected by [Simpson 2013]. Such methods integrate knowledge from different departments of a company. The new product family concepts have far-reaching impact and integrating these methods means vast changes in the whole company.

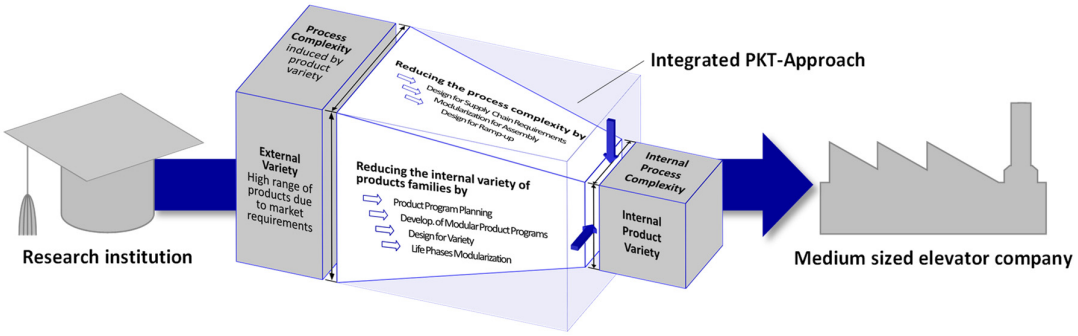


Figure 7. Integrated PKT-Approach [Krause et al. 2013] as example design method for transfer

The Integrated PKT-Approach consists of combinable method units that are specialized to different aspects of product family development. It is workshop-based for integrating product knowledge from different disciplines; it uses visualisation methods to foster discussion in project teams and supports redesign, modification and design of components to reduce product variety.

The visual description of the Integrated PKT-Approach (Section 2.1) is discussed in [Beckmann and Krause 2013]; a short summary of the findings is given here, focussing on the integration of a design method into an elevator company. The aim of the case study is to provide answers on whether the methodical approach developed supports researchers while transferring methods into industry.

First, the Integrated PKT-Approach was modelled using the MPV [Beckmann and Krause 2013]. This helped clarify which resources are needed and which interactions between product developers and other company positions are necessary. The consolidation of methods supports the identification of potential areas of improvement in method details, such as order of steps or visualisation tools used. MPV was used by researchers to check the consistency of their new method procedures.

4.2 Setup of the case study

The case study was part of a public-founded two-year research project that was carried out with a medium-sized elevator developer and producer that had around 200 employees. The case study aimed to evaluate the level of uptake of the design method in the company and the support provided to the researcher (who transfers the design method) by the new transfer approach. The research project was conducted by a researcher and the employees of the company. It aimed to replace the existing 'design everything new to order' strategy with a pre-developed modular system. The company was not using any methods for developing products with a high product variety and had no defined process to pre-develop elevators independent of a specific order. Another goal was to enable autonomous use of the Integrated PKT-Approach in the company. Six designers were trained in the new design methods (Integrated PKT-Approach) during two-day training and parts of the design method were used in the project assisted by the researcher. The research project can be seen as a preliminary case study, as defined in the last section, to evaluate the usefulness of the design method to this specific company. In the second half of the project a masters student supervised by the authors analysed the company and its existing development system and created concepts to include the steps and tools of the Integrated PKT-tool in the company. In this project phase, which was 6 months long, the new transfer approach and the MPV were used. The results reported were gathered by participation, observation and interviews with the CEO and four project members of the company.

4.3 Results of the case study

Three examples that showed the impact of the project and research on practice were selected. The main outcome is a new order fulfilment process (schematically shown in Figure 8, highlighting examples of the integration of methods). It contains several ideas from the Integrated PKT-Approach to ensure that no product variety is created that is unwanted. The process also includes a new sustainment process to foster the continuous development of the new pre-develop modular product system which was adapted for the company based on a new method [Bahns et al. 2015]. A selection of method steps from the Integrated PKT-Approach are included within the sustainment process developed by three researchers in cooperation with an employee of the company.

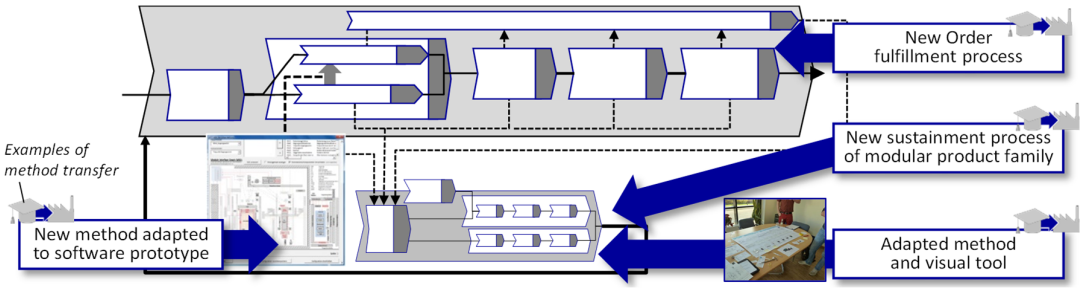


Figure 8. Examples of methods integrated in the schematically shown order fulfilment process

According to the CEO, the new processes are running in daily business and a high portion of elevators sold use modules developed by this new process. The early and strong commitment of the CEO to these new processes particularly helped. However, the employees tended to simplify and further adapt the process to their needs. For example, a feedback loop that was originally planned to be a paper-based process has become personal feedback to the new person in charge of module development because of short communication paths within the fairly small company.

Within the sustainment process a concept was developed to include a methodical visual tool to represent the rough structure of the product family, called the Module Interface Graph (MIG) (Figure 6, lower part, left). An Excel-based software prototype was developed to show potential time savings when using a computer supported tool on a single database to communicate between sales and development departments. While the tool showed how computer support could fit into typical work practice (Excel is a commonly used tool), the prototype is not yet in daily use.

The Variety Allocation Model (VAM) is a visual support tool that maps varying customer requirements with varying product components to analyse product variety during its development; it is integrated into the new process. The VAM was often criticised in the past for being too complex and theoretical, but it now used regularly in the company. The new position placed in charge of continuously developing the modular product family was filled by a young engineer who is very open to new methods. The methodical tool was simplified and adapted in such a way that the original method theoretically defined entities of the model that directly fitted typical working steps within the order fulfilment process. The adapted model is used to check new designs in CAD regarding the requirement of creating high external product variety with low internal product variety.
Finally, the project fostered awareness of the smart handling of high product variety that is addressed in the Integrated PKT-Approach and started the change from order processing by engineer to order to using a modular pre-developed system, which also had far-reaching technical consequences beyond organisation, method and process-related advancements.

5. Discussion and conclusion

Design research can have an impact on practice if it is actively fostered. Especially encouraging is that the ideas and new ways of thinking about product variety, as promoted by the Integrated PKT-Approach, has spread across company's management and development department. Close cooperation together with the development of adapted methods fostered knowledge transfer. The method transfer approach, including the analysis and visual representation of the majority of the transfer relevant information on the new method, and existing work practices in the company using MPV was helpful as a basis for discussion. Visual description of the new development processes eased its distribution.
The examples chosen show how different method integration can look: A top-level change in order processing, including the new strategy of a modular system and the mind-set behind using such a system; a software prototype whose interfaces are aligned with the typical work procedures of the company, showing possible benefits but not yet used; and the adaption of a methodical tool that now fits the needs of a new job in the company.
The integration of new methods, including designated work procedures and tools as part of the approach to transfer methods presented, is a way to change daily practices. Methods integrated into newly defined processes are a way to transfer ideas and theoretical ideal procedure models, which stand behind the methods, to everyday business. Thus, can a method or knowledge transfer be considered a success when the method or the new processes is not explicitly used but the ideas behind it have been adopted in practice? Yes, e.g. Pahl and Beitz described their design methodology as an explicit tool for young engineers, while experienced, successful engineers apply it automatically and implicitly without knowing the actual methodology [Pahl et al. 2007].

Acknowledgement

Thank you to the German Federal Ministry of Education and Research for funding this work, as well as dedicated students and LUTZ Elevators for their contribution to the case study.

References

Andreasen, M. M., "Complexity of Industrial Practice and Design Research Contributions – We Need Consolidation", Proceedings of 20. Design for X Symposium, Meerkamm, H. (ed.), Lehrstuhl für Konstruktionstechnik, Neukirchen, 2009, pp. 1–9.

Andreasen, M. M., Wallace, K., "Reflections on Design Methodology Research: ICED11 Design Research Keynote", DTU Podcasts, Kopenhagen, 2011.

Badke-Schaub, P., Daalhuizen, J., Roozenburg, N., "Towards a Designer-Centred Methodology: Descriptive Considerations and Prescriptive Reflections", The Future of Design Methodology, Birkhofer, H. (ed.), Springer, London, 2011, pp. 181–197.

Bahns, T., Beckmann, G., Gebhardt, N., Krause, D., "Sustainability of Modular Product Families", Proceedings of ICED 2015, Weber, C. et al. (eds.), Design Society, Milan, 2015, pp. 185–194.

Beckmann, G., Gebhardt, N., Krause, D., "Transfer of Methods for Developing Modular Product Families Into Practice – An Interview Study", Proceedings of Design Conference 2014, Marjanović, D. (ed.), Dubrovnik, Croatia, 2014, pp. 121–130.

Beckmann, G., Krause, D., "Process visualisation of product family development methods", Proceedings of ICED 2013, Lindemann, U. et al. (eds.), Design Society, Seoul, 2013.
Birkhofer, H., Kloberdanz, H., Sauer, T., Berger, B., "Cleaning up design methods - describing methods completely and standardised", Proceedings of Design Conference 2002, Marjanović, D. (ed.), Dubrovnik - Croatia, FMENA, Zagreb, 2002.
Blees, C., Kipp, T., Beckmann, G., Krause, D., "Development of Modular Product Families: Integration of Design for Variety and Modularization", NordDesign 2010, Dagman, A., Söderberg, R. (eds.), Chalmers University of Technology, Göteborg, 2010, pp. 159–170.
Blessing, L. T., Chakrabarti, A., "DRM, a Design Research Methodology", Springer, London, 2009.
Braun, T., Lindemann, U., "Supporting the selection, adaptation and application of methods in product development", Proceedings of ICED 2003, Folkeson, A. (ed.), Design Society, Stockholm, 2003.
Brosch, M., "Eine Methode zur Reduzierung der produktvarianteninduzierten Komplexität", TuTech, 2014.
Cantamessa, M., "An empirical perspective upon design research", Journal of Engineering Design, Vol. 14, 2003, pp. 1–15.
Chakrabarti, A., Lindemann, U. (eds.), "Impact of Design Research on Industrial Practice", Springer, 2016.
Eilmus, S., Gebhardt, N., Rettberg, R., Krause, D., "Evaluating a methodical approach for developing modular product families in industrial projects", Proceedings of Design Conference 2012, Marjanovic D. et al. (eds.), Dubrovnik, Croatia, 2012, pp. 837–846.
Geis, C., Bierhals, R., Schuster, I., Badke-Schaub, P., Birkhofer, H., "Methods in Practice – a Study on Requirements for Development and Transfer of Design Methods", Proceedings of Design Conference 2008, Marjanović, D. (ed.), Cavtat - Dubrovnik, Croatia, 2008, pp. 369–376.
Harlou, U., "Developing product families based on architectures: Contribution to a theory of product families", 1st ed., Department of Mechanical Engineering, Technical University of Denmark, Lyngby, 2006.
Krause, D., Beckmann, G., Eilmus, S., Gebhardt, N., Jonas, H., Rettberg, R., "Integrated Development of Modular Product Families: A Methods Toolkit", Advances in product family and product platform design: Methods & applications, Simpson, T.W. (ed.), Springer, New York, 2013, pp. 245–269.
Kreimeyer, M., "Implementing Product Architecture in Industry: Impact of Engineering Design Research", Impact of Design Research on Industrial Practice, Chakrabarti, A., Lindemann, U. (eds.), Springer International Publishing, 2016, pp. 383–398.
Lindemann, U., Maurer, M., Braun, T., "Structural Complexity Management: An Approach for the Field of Product Design", Springer, Berlin, Heidelberg, 2009.
Messerle, M., Binz, H., Roth, D., "Implementation of idea processes in the specific context of business practice", Proceedings of Design Conference 2014, Marjanović, D. (ed.), Dubrovnik, Croatia, 2014.
Pahl, G., Beitz, W., Blessing, L., Feldhusen, J., Grote, K.-H., Wallace, K., "Engineering Design: A Systematic Approach", 3rd ed., Springer, London, 2007.
Ross, D., Schoman, K., "Structured Analysis for Requirements Definition", IEEE Transactions on Software Engineering, Vol. 3, 1977, pp. 6–15.
Simpson, T. W. (ed.), "Advances in product family and product platform design: Methods & applications", Springer, New York, 2013.
Stetter, R., Lindemann, U., "The transfer of methods into industry", Design process improvement: A review of current practice, Clarkson, J., Eckert, C. (eds.), Springer, London, 2005.
Viertlböck, M., "Modell der Methoden- und Hilfsmitteleinführung im Bereich der Produktentwicklung", Dr. Hut, München, 2000.
Wallace, K., "Transferring Design Methods into Practice", The Future of Design Methodology, Birkhofer, H. (ed.), Springer, London, 2011, pp. 239–248.
Zanker, W., "Situative Anpassung und Neukombination von Entwicklungsmethoden", Shaker, Aachen, 1999.

Gregor Beckmann, Dipl.-Ing.
Hamburg University of Technology (TUHH), Institute of Product Development and Mechanical Engineering Design (PKT)
Denickestraße 17 (L), 21073 Hamburg, Germany
Email: gregor.beckmann@tuhh.de