A PROPOSAL FOR METHOD TRANSFER BASED ON SUCCESSFUL EXAMPLES OF INTRA-INDUSTRY METHOD TRANSFER

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ABSTRACT

To transfer methods from science to industrial application is an important task of engineering design researchers. However, the way in which this is done leaves still room for improvement. A look beyond the horizon into the intra-industrial transfer of methods can therefore be helpful. Based on general requirements and success factors as well as successful intra-industry transfer examples, this paper proposes the P4I process for the transfer of methods from academy to industry.

Keywords: Knowledge Transfer, Intra-industry transfer, Case study, Organizational processes, Innovation

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1 MOTIVATION

In the engineering design community, the transfer of knowledge between academic research institutions and potential industrial application partners is a very common and multi-layered discussion topic since many years. For example, Eder (1998) asked why design science, which is in his opinion very well elaborated, does not find its way into industry. Franke and Deimel (2004) state that there is a large number of design methods, but that the user is probably left alone in choosing the suitable method for the specific application. In this context, Gericke et al. (2016) note that users select methods according to specific outcomes, which contradicts the current presentation of methods. Jagtap et al. (2014) found out that the uptake of design methods in companies is influenced by the method itself, the way it is developed and how it is used. According to Wallace (2011) there are methods that have been developed too theoretically or abstractly, with no obvious benefit, or even methods that have been developed past the user. Furthermore, he concludes that, in academia, often nobody feels responsible for the transfer. In a recent position paper by members of Design Society's Special Interest Group Design Process (formerly Modelling and Management of Engineering Processes - MMEP), there is even a call for joint work on systems of useful methods (a method ecosystem) to increase their chances of application in industry (Gericke et al., 2020). On the other hand, Birkhofer et al. (2005) as well as Eder (1998) observe that there is also a whole range of industrially developed methods, especially in the field of quality management, which have been established as a kind of an industry standard. Although, this does not mean that any method developed in the industry is automatically a success, it is certainly worth taking a closer look at the implementation characteristics of successful methods developed by industry.

Talking about transfer, it has also to be mentioned that there is very often no clear distinction between the terms 'knowledge transfer' and 'technology transfer'. According to Seaton and Cordey-Hays (1993) technology transfer is "the process of promoting technical innovation through the transfer of ideas, knowledge, devices and artefacts from leading edge companies, R&D organizations and academic research to more general and effective application in industry and commerce." This definition corresponds to the understanding of the authors. However, since this contribution is focused on the transfer of processes, methodologies and methods, these are summarized as transfer objects.

The motivation in academia for knowledge transfer is based on different aspects such as the acquisition of additional funds, the establishment of a bi-directional knowledge flow or the possibility to get new insights to support personal research interest and support one's academic careers (Meyer-Kramer and Schmoch, 1998). On the other hand industry needs scientific knowledge for innovation or optimization of products or processes and thus seeks for sparring-partners in academia to be aware of cutting-edge technologies or to become get in contact with / recruit high-grade technical people (Hicks, 1995). Especially SMEs need knowledge transfer to ensure their survival in the market (Khabiri, 2012).

Typical ways of knowledge transfer between universities and industry are the provision of codified output of academic research (e.g., publications or patents), collaborated or contracted research activities or the employment of university researchers (Bekkers and Bodas Freitas, 2008). Meyer-Kramer and Schmoch (1998) describe that the relevance of each of these ways depends to what degree of a research area is science-based. E.g., chemistry, information and biotechnology are categorized as science-based whereas e.g. mechanical engineering is categorized as less science-based but with a stronger orientation to a short-term applied research, systematisation or development activities. The industrial innovation processes are less radical and less dependent on scientific breakthroughs so that the transfer via collaboration and patents play a more important role. Thus, a transfer of knowledge in the field of engineering design should also meet with fertile ground.

Based on the aspects introduced before, it can be concluded that

- a well-functioning transfer of knowledge and methods from academia to industry is in the mutual interest of both parties.
- the scientific community is aware that there is still room for improvement in the field of knowledge and method transfer.
- there are also successful transfer approaches within the industry.

Motivated by this, this article examines the question of how experiences from successful intra-industry method transfer could be transferred to method transfer between academia and industry. To answer this question the following methodology is applied. First, a literature research on general requirements and success factors of knowledge transfer is conducted. Subsequently, three prominent and successful

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transfer examples of approaches developed in industry are analysed. Based on these findings, a transfer process is inductively concluded.

2 REQUIREMENTS, SUCCESS FACTORS AND IMPLEMENTATION INSIGHTS

2.1 General requirements

In order to derive requirements for knowledge transfer, relevant literature was analysed. The key findings are summarized in the list below. They can be differentiated into requirements for the transfer process and requirements for the transfer object. The requirements are numbered for later referencing.

Requirements for the transfer process:

1. It is important to get familiar with the real situation in the company, its strategy and to understand the boundary conditions of the transfer as well as the motivation for the transfer (Bekkers and Bodas Freitas (2008), Bradley et al. (2013), Ball et al. (2004), Jagtap et al. (2014) and Khabiri et al. (2012)).
2. It is important to select an appropriate problem that can be tackled with the implementation of the transfer object in order to achieve quick-wins (Ball et al. (2004), Cook et al. (2006), Seaton and Cordey-Hayes (1993), Eder (1998) and Kotter (1995)).
3. It is important to consider not only technical but also soft (e.g. organizational or personnel) factors (Bradley et al. (2013), Ball et al. (2004), Cook et al. (2006), Jagtap et al. (2014), Seaton and Cordey-Hayes (1993) and Khabiri et al. (2012)).
4. It is important to understand that knowledge transfer is also a dynamic change process that needs management and support (Bradley et al. (2013), Cook et al. (2006), Seaton and Cordey-Hayes (1993), Jagtap et al. (2014) and Kotter (1995)).
5. It is important to understand transfer processes as collaboration and to include feedback loops (Bekkers and Bodas Freitas (2008), Ball et al. (2004) and Seaton and Cordey-Hayes (1993)).
6. It is important that the will and ability for transfer exist on both sides, i.e. transferor and transferee (Seaton and Cordey-Hayes (1993) and Khabiri et al. (2012)).
7. It is important that the need for transfer is known or adequately communicated in the receiving organisation (Seaton and Cordey-Hayes (1993)).
8. It is important to define a clear responsibility for the transfer object, i.e. ownership, in the receiving organization (Eder (1998)).

Requirements for the transfer object:

9. It is important that the transfer object is or is made transferable (Seaton and Cordey-Hayes (1993) and Jagtap et al. (2014)).
10. It is important that the transfer object is available in a universal or the specific language of the industry or is edited for this purpose (Ball et al. (2004)).
11. It is important that the transfer object is made known so that it can be considered for a transfer at all (Jagtap et al. (2014), Seaton and Cordey-Hayes (1993)).

2.2 Implementation insights

In this section, the previously determined theoretical requirements are compared with practical findings from successful implementation projects of transfer objects developed in industry. Furthermore, additional success criteria are searched for. It should be remarked that the authors have both an active academic background and more than 10 years of industrial experience in the development, adaptation, implementation and optimization of methods. The findings of the literature study can thus also be enriched with practical experience. In particular, the phases of preparation, implementation and sustainable anchoring in the organisation are considered, as these are significant on the basis of the experience gained.

To represent the bandwidth of the subject area, this section analyses each a well-known example of methodology, method and process. When selecting the transfer objects, two examples from the field of Quality Management were included, because these were considered several times as best practices for

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transfer objects within industry in the literature, e.g. Eder (1998) or Birkhofer et al. (2005). The meanings of methodology and method correspond to Gericke et al. (2017)'s definitions.

2.2.1 Methodology - Six Sigma

In industry Six Sigma became famous as "an aggressive campaign to boost profitability, increase market share, and improve customer satisfaction" (Harry, 1998). The origins of Six Sigma can be traced back to Motorola and date back to the mid-1980s (Linderman et al., 2003). As an integrated methodology, Six Sigma is composed of the DMAIC cycle (DMAIC represents the phases define, measure, analyse, improve and control) and more than 45 standard methods and tools logically assigned to each DMAIC phase (number based on a count in Rath & Strong (2008) - number may vary by publication, but is only qualitatively relevant for this paper). This already shows that the effort to train people in this methodology must be particularly high. Based on famous success stories, many companies started the implementation of a Six Sigma programme, although Six Sigma is known as a complex approach (Moosa and Sajid, 2010). But that does not mean that every implementation was successful. There are also reported tragedies of implementation because of the fact that the pitfalls with Six Sigma have not been fully recognized (Goh, 2010).

The motivation for introducing Six Sigma in the reflected cases were to achieve a sustainable improvement in the quality level. In addition, persistent quality problems that had not been successfully solved with existing tools should finally be eliminated. The expectations on Six Sigma were high due to success stories supported by impressive financial savings. Since there was not enough practical knowledge in the application and implementation of the methodology within the organization, the decision was made to work with an external partner to train some selected people in the methodology.

The methodology itself is sufficiently documented in books, application guidelines and technical articles in various forms and degrees of complexity. There is also a large number of websites dealing with the topic. In addition, there are many Six Sigma training providers for all levels of knowledge. A special feature with Six Sigma is that there are different qualification levels, so-called Belts. Beyond that there is a champion training for high-level personnel or project sponsors. The champion training gives managers a basic overview of the possibilities of the methodology and helps to deploy the employees trained in the methodology in an adequate manner. For this reason, in addition to the first (green) belts, the affected managers and executives are also trained as Six Sigma Champions in the organization.

The person responsible for the programme is also given intensive training, the so-called Master Black Belt. The requirements for the Master Black Belt are standardized, as are the requirements for the other Belts. Although there are slight differences between different providers and Six Sigma associations, the guidelines of the European Six Sigma Club (2017) provide a good overview. The Master Black Belt is intended to serve as a multiplier in the introductory phase and is therefore also specially trained as a trainer.

Applied projects must be successfully completed as part of a training course or for certification as a Six Sigma Belt. In the introductory phase, this has the inherent advantage that the applicability of the methodology in the company can be checked for different complexity levels and/or functional areas. In addition, initial savings can be achieved in this way.

2.2.2 Method - FMEA

The Failure Mode and Effects Analysis (FMEA) is a method applied in the field of preventive quality management and is, probably, the most-common method used to analyse and assess risks in industry. It was developed in the mid-1960s as a method to identify product or process problems before they occur (McDermott et al., 2008). Since that, the FMEA has gradually spread in industry. Today, its use is required directly (e.g. IATF 16949 (2016)) or indirectly (e.g. risk-based thinking of ISO 9000 (2015)) in quality management standards. This means that the motivation for the application of FMEA can already be derived from customer or market requirements. FMEA is documented well in theory and practical application, a high number of books, guidelines, training materials and application examples exist. Due to this good level of documentation, the method can be introduced independently or in cooperation with a transfer partner. As the introduction of the method is often linked to a certified quality management system, it can be assumed that a responsible person in the organisation has been defined for the method. Typically, this person also plays a special role for the FMEA implementation and continuous application. This method owner has the task to integrate the FMEA into the process landscape of the organization, to define appropriate roles and to ensure the empowerment. To integrate the FMEA into the processes of

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the organization, it must first be checked into which processes the method can be integrated, how and to what extent. The roles usually describe different degrees of complexity of the application. In industry, the following subdivision of roles can be observed: Method owner, method trainer, FMEA moderator, FMEA user. It can happen that the roles method owner, method trainer and FMEA moderator are united in one person. The individual roles are trained by appropriate competency concepts, but some of them are also sector or company specific. In order to become an FMEA moderator, a very good knowledge of the method as well as application knowledge and moderation competence is required. The transition from FMEA user to FMEA moderator is typically accompanied by internal or external coaching. Communication also plays an important role in the FMEA implementation and later application. Usually, the results or findings of the FMEA application are presented to the management or the affected areas. In addition, untrained participants in FMEA are at least briefly introduced to the benefits and approach of the method. In larger companies it can also be observed that the introduction and application of FMEA is reported on in the intranet or in the company magazine. The application of the FMEA shows usually only medium-term and/or time-delayed successes. Nevertheless, the application of the method generates already quick wins by the evaluation and the reduction of the residual risk of a system, product or process.

2.2.3 Process - Agile Development

Agile design is an example of an agile development processes based on the basic principles of Design Thinking and Scrum, with the goal of creating meaningful and valuable user and requirement-oriented products and services. By combining Human Centred Design with Design Thinking and agile project management methods, human needs can be incorporated into agile processes as requirements and subsequently worked out in incremental development steps (Grashiller et al., 2017). In the case analysed, an agile design process has been in use for more than three years and is continuously being tested by the authors in various projects for its practical suitability in industry. The main areas of application are mostly innovation-driven projects in which companies generate new products or services in pilot teams detached from the existing processes. At the start of each project, an overview of the process is presented, and the individual phases and methods are explained. This is done by a coach who acts as a guide throughout the project. Main focus is placed on simplicity, as the process should always serve as a minimal guide to user-oriented development. Initial feedback from the first deployments showed that the approach has proven itself particularly with first-time users of user centred development: Quick wins can be achieved within a very short time with a manageable effort.

Agile design projects should not exceed the maximum team size of 9 participants, analogous to Scrum. In practice, however, this is not always possible. If a team exceeds this number, it is noticeable that the process cannot always be adhered to, information is lost and the pace is slowed down. Another critical point is the transition between the creative phase and the development phase. The challenge is to transform user requirements into technical properties without losing user-related information. To support internal communication between the two phases, most agile design processes introduce user stories as a special format to specify requirements and structure ideas. The acceptance criteria give measurable parameters to the user story, which represent the degree of fulfilment. (Schlaeffer, 2018). Furthermore, information about the priority, the complexity level, the estimated duration and the responsible person can be added (Rubin, 2014). The application of user stories is common in agile projects, they are used as an input for the product backlog.

In theory there are three elements that are key for successful implementation of design thinking related projects in practice: People, Place and Process (Hasso-Plattner-Institut, 2018). For this reason, a suitable change management process, the composition of the team and the selection of a suitable location have the same high priority. Agile design processes provide a guideline for agile, user-centric development. In industrial implementation, the right interaction of people, methods and organization is crucial. It is especially important to recognize and involve existing interfaces at an early stage, to inspire people and to turn affected people into participants.

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Table 1. Summary of findings for transfer objects Six Sigma, FMEA and agile development

Success factors	Req.-No.	Six Sigma	FMEA	Agile Development
Need for implementation	(1), (4), 7	Sustainable improvement of quality level and solution of persistent problems	Customer requirement or requirement from quality management system	Addressing complex adaptive problems, while productively and creatively delivering products of the highest possible value
Reason for selection of the transfer object	(9)	Documented success stories	Industry standard, recommendation, documented success stories	Documented sucess stories per sprint
Proof of functional capabilities or applicability	(4), 9, 11	Documented success stories	Documented success stories	Documented sucess stories per sprint
Maturity level of documentation of transfer object	10, (11)	High (books, guidelines, training materials, application examples) - universal language	High (books, guidelines, training materials, application examples) - universal language	High (books, guidelines, training materials, application examples) - universal language
Level of collaboration between transferor and transferee	(4), 5, 6	High (consulting, training, coaching)	High (consulting, training, coaching)	High (consulting, training, coaching)
Ownership / Multiplier concept	8	Responsible person: trained as Master Black Belt	Responsible person: method/process owner	Responsible person: trained as agile coach
Identification of boundary conditions and adaptation to the organization	1, 4	Yes, mainly done by the responsible person in collaboration with the consultant	Yes, mainly done by the responsible person in collaboration with the consultant	Yes, mainly done by the product owner in collaboration with the agile coach
Analysis of qualification needs and training concept	1, 3, 4, 6	Yes, mainly done by the responsible person in collaboration with the consultant	Yes, mainly done by the responsible person in collaboration with the consultant	Yes, mainly done by the agile coach
Role concept and selection of suitable persons		Six Sigma Champions, Master Black Belt, Black Belt, Green Belt, Yellow Belt - Requirements for each role precisely described	Method owner, method trainer, FMEA moderator, method user	Agile coach, product owner and development team
Implementation area / approach	2, (3)	Training-oriented pilot phase plus roll-out plus coaching	Training, training-on-the-job, coaching prototypical application - assessment - roll out	Training-oriented pilot phase plus roll-out plus coaching
Communication of transfer object into the organisation	(3), 7	Status presentation and final presentations in management team and affected areas, short training courses for affected persons, Intranet and company newspaper reports on methodology and application successes	Status presentation and final presentations in management team and affected areas, short training courses for affected persons, Intranet and company newspaper report on method and application successes	Status presentation and final presentations in management team and affected areas, short training courses for affected persons, Intranet and company newspaper report on method and application successes
Quick wins	2, 4	Process improvements and savings through training projects (pilot application)	Improvement of the risk assessment of systems, products and processes	Increased responsiveness to dynamic market conditions, cross-functional and self-organizing teams
Feedback loops and continuous improvement	5	Regular experience exchanges and coaching meetings	User meetings, FMEA review meetings	Sprint review, daily, sprint planning, sprint retrospective and refinement events for inspection and adaption
Long-term anchoring in the organization	4	Inclusion of the methodology in the organisation's management manual, including the definition of selection and application criteria as well as sustainability control requirements; definition of target training numbers for Belts per functional area; coaching concept	Inclusion of the methodology in the organisation's management manual and in procedural instructions (e.g. process introduction, product introduction)	Inclusion of the methodology in the organisation's management manual and in procedural instructions (e.g. process introduction, product introduction); training of agile coaches and coaching concept.

Legend: Req.-No. = number of the requirement in section 2.1 of the paper, (x) = support of the implementation of the requirement

2.3 Summary and interim conclusion

The aim of this section was to systematically investigate industrial best practices in order to draw conclusions about the transfer of methods from science to industry. Table 1 gives an overview of the findings from the examples considered. The agreement with the requirements from the literature study is indicated in the column 'Req.-No.'. First, it has been shown that the requirements identified in the literature study are mirrored in the methods developed by the industry, but also that further properties of the implementation could be determined. These are:

- The application and acceptance of a method seems to be increased by the fact that there are already success stories about industrial application.
- Due to available case studies and the good documentation of the transfer object, there is a broad basis of empirical values as to when and in which context a transfer object can be applied.
- The introduction usually follows a change process whose end is the anchoring of the transfer object in the processes of the organization. This is accompanied by a role and empowerment concept.
- The first application is typically done by pilot projects, who serve to gather experience and achieve first application successes in the organization (quick wins). Positive experiences with the first application are followed by a roll-out process.
- The communication of the implementation and application of the transfer object in the organization plays a special role.

It is also assumed that in the development of processes, methodologies or methods in industry, practical application and dissemination is a central idea from the start.

3 THE P4I IMPLEMENTATION APPROACH

This section proposes an implementation approach for the transfer of methodologies, methods and processes from academia to industry. In accordance with the phases to be passed through, this guideline is named P4I.

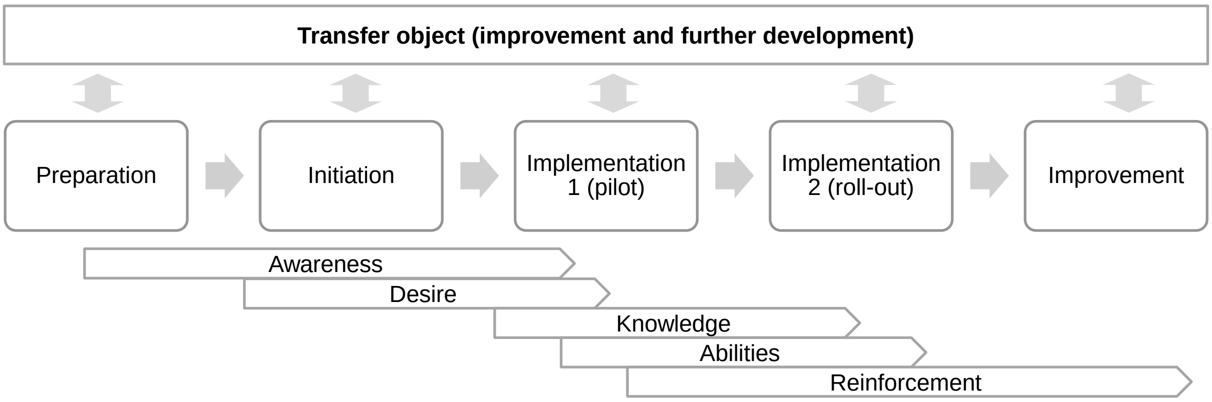

Figure 1. P4I phase model

3.1 Derivation of the P4I phase model

Szulanski (2000) states that a typical knowledge transfer process consists of four steps: Initiation, implementation, ramp-up and integration: The initiation prepares the decision to transfer, the implementation prepares the use phase and the ramp-up supports the achievement of a satisfactory performance. The integration step finally anchors the transfer object in the receiving organization. However, this process assumes that the transfer object is already more or less ready for use and sufficiently documented. This does not always have to be the case for transfer objects that have been developed in academia. Therefore, the transfer process should be preceded by a preparatory phase. A look at the practical examples has also shown that the implementation phase is often divided into a pilot phase and a roll-out phase. To emphasise the different character of the activities, a distinction should be made between these two phases. The roll-out phase also functions as the integration step in the Szulanski model. In addition, a complete implementation process based on the PDCA process model of ISO 9000 should include an improvement phase. In order to ensure that the derived process model satisfies a change process, the tried and tested ADKAR model (Prosci, 2018) is integrated into the guideline. The ADKAR model divides the change process into five phases: awareness, desire, knowledge, abilities, and reinforcement. The P4I phase model is depicted in Figure 1.

3.2 Preparation phase

The purpose of this phase is to make the transfer object ready for the transfer. In the words of Seaton and Cordey-Hayes (1993), this means that the transfer object must be made accessible and mobile, but

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also that the transfer object must be prepared in such a way that it can be received by a third party. For the success of this phase, however, target-oriented communication measures are also important, which have the aim of making the transfer object known. The activities required for this are compiled in the form of a checklist:

- The transfer object has passed initial practical testing is assessed as sufficiently mature for a transfer.
- (First) real application examples are vivid and logically prepared.
- A documentation of the transfer object is available in a form and language that can be understood by a third party with manageable effort.
- Hard and soft application criteria as well as required skills for the successful handling of the transfer object are defined.
- A first success story is documented comprehensively.
- Depending on the defined complexity levels of the application and the required skills, an initial role concept is defined, and training levels (including scope) are defined.
- The transfer object is communicated and made known to the target group.

The checklist criteria show that the quality of the results of the preparation phase improves with each implementation cycle.

3.3 Initiation phase

In the initiation phase the first contact with the receiving organization takes place. The goals of this phase must be to make a conscious decision for the transfer and to prepare the implementation. In this phase at least the following activities should be successfully completed:

- The need for transfer is clearly and comprehensibly formulated.
- Goals, expectations, and boundary conditions of the transfer are discussed and documented.
- Ownership is defined for the transfer object in the receiving organization.
- A suitable pilot area for implementation phase 1 and evaluation criteria for assessing the success of the pilot implementation have been defined.
- An analysis and evaluation of the existing skills and resources of the receiving organisation and the transferor have taken place.
- An organization-specific role concept has been defined.
- A milestone plan for the implementation has been created.
- Support from the management of the host organization is assured.

3.4 Implementation phase 1

The aim of implementation phase 1 is to successfully implement a pilot project. In this phase, the organization-specific adaptation of the transfer object and the qualification of the organization take place. Implementation phase 1 ends with an evaluation of success. The core activities of this phase are:

- Adaption of transfer object to organizational requirements.
- Development of a role-dependent qualification concept in the transferring and the receiving organisation.
- Implementation of the qualification concept in the pilot area.
- Enabling decision-makers to accompany the pilot. This can also include the decision makers of the later roll-out areas.
- Implementation of the adapted transfer object in the pilot area. Give support and coaching depending on roles.
- Support the implementation of the transfer object through internal communication within the organisation.
- Critical reflection of the pilot application regarding the transfer success and make a roll-out decision.

3.5 Implementation phase 2

Implementation phase 2 is to roll-out the transfer object to all relevant areas of the receiving organization. Considering the findings and experiences from implementation phase 1, the transfer object gets anchored in the organization. Here, the special characteristics of a roll-out process

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compared to a pilot application must be considered. As described, the organization-specific adaptation of the transfer object takes place in the pilot phase. This results in greater creative freedom for the employees involved. The characteristic of a pilot application is therefore rather bottom-up, which is often accompanied by a higher acceptance by the participants. During roll-out, an already adapted transfer object is brought into the organization. The creative possibilities are therefore limited. The characteristic of a roll-out is thus top-down. For this phase, the following main activities must be carried out:

- Adaptation of the transfer object on the basis of the findings of the pilot application.
- Development of a roll-out concept based on the findings and results of the pilot application.
- Enabling and coaching the multipliers to carry out the roll-out process.
- Supervision of the roll-out process to ensure that the transfer object is implemented correctly.
- Anchoring of the transfer object in the processes and procedures of the receiving organization.
- Support the roll-out of the transfer object through internal communication within the organisation.
- Critical reflection of the roll-out process regarding the transfer success.

3.6 Improvement phase

The improvement phase primarily serves to continuously improve the handling of the transfer object in the receiving organization. It also provides insights into optimization and further development needs regarding the transfer object. In order to draw conclusions from this phase, a regular exchange of experience could be implemented. For the sake of completeness, however, it should be mentioned that conclusions can be drawn from all phases of the P4I process about the optimisation and further development requirements of the transfer object.

4 CONCLUSION AND OUTLOOK

Based on an inverse transfer of insights from industry into the academic world, this article shows that the transfer of knowledge from academic institutions into industry is a demanding and thus separate task. The summary of the insights gained in the development of the P4I approach shows that knowledge transfer must be intensively prepared and carried out in well planned steps. In addition to the, often technical, transfer object, softer factors of the receiving organization play a significant role, which is why change management needs to be given special consideration. This insight is also considered important by the authors for the engineering design community.
In the sense of the presented approach, the work is not done with this publication. Instead, transfer-oriented researchers in the field of engineering design are invited to test the approach, give feedback, and refine it. The P4I approach cannot and will not claim to be complete, but it would be desirable if it were further refined. For this, at least the marketing of the transfer object, the selection criteria and the application requirements must be worked out more precisely. Furthermore, it is desirable that experiences from other successful knowledge and methode transfer projects will be included.

REFERENCES

Ball, T., Cook, B., Levin, V. and Rajamani, S.K. (2004), “SLAM and Static Driver Verifier: Technology Transfer of Formal Methods inside Microsoft”. In: Boiten, E.A., Derrick, J., Smith, G. (eds), Integrated Formal Methods. IFM 2004. Lecture Notes in Computer Science, Vol. 2999. Springer, Berlin, Heidelberg, pp. 1-20 https://doi.org/10.1007/978-3-540-24756-2_1

Bekkers, R. and Bodas Freitas, I.M. (2008), “Analysing knowledge transfer channels between universities and industry: To what degree do sectors also matter?”, Research Policy, No. 37 (2008), pp. 1837-1853, https://dx.doi.org/10.1016/j.respol.2008.07.007

Birkhofer, H., Jänsch, J. and Kloberdanz, H. (2005) “An extensive and detailed view of the application of design methods and methodology in industry”, International Conference on Engineering Design - ICED 05, Melbourne, August 15-18, 2005, The Design Society, pp. 276-277 (exec. Summ.), full paper no. DS35_188.49

Bradley, S.R., Hayter, C.S. and Link, A.N. (2013), “Models and Methods of University Technology Transfer”, Foundations and Trends in Entrepreneurship: Vol. 9: No. 6, pp 571-650. http://dx.doi.org/10.1561/0300000048

Cook, M.B., Bhamra, T.A. and Lemon, M. (2006), “The transfer and application of Product Service Systems: from academia to UK manufacturing firms”, Journal of Cleaner Production, No. 14 (2006), pp. 1455 - 1465

Eder, W.E. (1998) “Design Modeling-A Design Science Approach (and Why Does Industry Not Use It?)”, Journal of Engineering Design, 9:4, pp. 355-371, https://dx.doi.org/10.1080/095448298261499

https://doi.org/10.1017/pds.2021.19 Published online by Cambridge University Press

European Six Sigma Club, Quality Guidelines. [online] European Six Sigma Club. Available at: https://www.sixsigmaclub.de/six-sigma-club/quality-guideline.html (26.11.18)
Franke, H.-J. and Deimel, M. (2014), “Selecting and combining methods for complex problem solving within the design process”, International Design Conference - Design 2014, Dubrovnik/Croatia, May 18-21, 2014, The Design Society, p. 213 - 218
Gericke, K., Kramer, J. and Roschuni, C. (2016), “An Exploratory Study of the Discovery and Selection of Design Methods in Practice”, Journal of Mechanical Design, October 2016, Vol. 138, pp. 101109-1-101109-10
Gericke, K., Eckert, C. and Stacey, M. (2017), “What do we need to say about a design method?” in: Proceedings of the 21st International Conference on Engineering Design (ICED17), Vol. 7: Design Theory and Research Methodology, Vancouver, Canada, 21.-25.08.2017, The Design Society, pp. 101-110
Gericke, K., Eckert, C., Campean, F., Clarkson, J.P., Flening, E., Isaksson, O., Kipouros, T., Kokkolaras, M., Köhler, C., Panarotto, M. and Wilmsen, M. (2020) “Supporting designers: moving from method menagerie to method ecosystem”, Design Science, vol. 6, e21, https://dx.doi.org/10.1017/dsj.2020.21
Goh, T. N. (2010), “Six Triumphs and Six Tragedies of Six Sigma”, Quality Engineering, Volume 22, 2010 - Issue 4, pp. 299-305, https://doi.org/10.1080/08982112.2010.495102
Grashiller, M., Luedeke, T.F. and Vielhaber, M. (2017), “Integrated approach to the agile development with design thinking in an industrial environment” in: Proceedings of the 21st International Conference on Engineering Design (ICED17), Vol. 2: Design Processes, Design Organisation and Management, Vancouver, Canada, 21.-25.08.2017, The Design Society, pp. 239-248
Hasso-Plattner-Institut (2018), [online] Hasso-Plattner-Institut School of Design Thinking, 2018. Available at: https://hpi.de/en/school-of-design-thinking/design-thinking.html (29.09.2018)
Harry, M.J. (1998), “Six Sigma: A breakthrough strategy for profitability”, Quality Progress, 31 (5), pp. 60-64
Hicks, D. (1995), “Published paper, tacit competencies and corporate management of the public/private character of knowledge”, Industrial and Corporate Change, Vol. 4, No. 2, 1995, pp. 401-424
IATF 16949 (2016), IATF 16949:2016 - Quality management system requirements for automotive production and relevant service parts organisations, Automotive Industry Action Group (AIAG), Southfield/USA
ISO 9000 (2015), ISO 9000:2015 - Quality management systems -- Fundamentals and vocabulary, International Organization for Standardization, Geneva/Switzerland
Jagtap, S., Warell, A., Hiort, V. Motte, D. and Larsson, A. (2014), “Design methods and factors influencing their uptake in product development companies: a review”, International Design Conference - Design 2014, Dubrovnik/Croatia, May 18-21, 2014, The Design Society, p. 231 - 240
Khabiri; N., Aslan, S.R. and Senin, A. (2012), “Identifying Main Influential Elements in Technology Transfer Process: A Conceptual Model”, Procedia - Social and Behavioral Sciences, Volume 40, 2012, pp. 417-423, https://dx.doi.org/10.1016/j.sbspro.2012.03.209
Kotter, J. P. (1995), “Leading Change - Why Transformation Efforts Fail”, Harvard Business Review, March-April 1995, pp. 59-67
Linderman, K., Schroeder, R.G., Zaheer, S. and Choo, A.S. (2003), “Six Sigma: a goal-theoretic perspective”, Journal of Operations Management, 21 (2003), pp. 193–203
McDermott, R.E., Mikulak, R.J., Beauregard, M.R. (2008), The basics of FMEA, CRC Press, Boca Raton/USA
Meyer-Krahmer, F. and Schmoch, U. (1998), “Science-based technologies: university-industry interactions in four fields”, Research Policy, No. 27 (1998), pp. 835-851
Moosa, K. and Sajid, A. (2010), “Critical analysis of Six Sigma implementation”, Journal of Total Quality Management & Business Excellence, Volume 21, 2010 - Issue 7, pp. 745-759, https://doi.org/10.1080/14783363.2010.483100
Prosci (2018), What is the ADKAR model?. [online] Prosci Inc.. Available at: https://www.prosci.com/adkar/adkar-model (27.11.18).
Rath & Strong (2008), Six Sigma Pocket Guide, AON Management Consulting / TÜV Media, Cologne/Germany
Rubin, K.S. (2014), Essential Scrum: Umfassendes Scrum-Wissen aus der Praxis. [trans.] Kathrin Lichtenberg. Heidelberg, Hüthig Jehle Rehm GmbH
Schlaeffer, C. (2018), Transformation of results of the ideation phase into requirements for product development, Master Thesis, University of Applied Sciences Upper Austria, pp. 18-28
Seaton, R.A.F. and Cordey-Hayes, M. (1993), “The development and application of interactive models of industrial technology transfer”, Technovation, Vol. 13 No. 1, pp. 45-53
Szulanski, G. (2000), “The Process of Knowledge Transfer: A Diachronic Analysis of Stickiness”, Organizational Behavior and Human Decision Processes, Vol. 82, No. 1, May, pp. 9–27, 2000, https://dx.doi.org/10.1006/obhd.2000.288
Wallace, K. (2011), “Transferring Design Methods into Practice”, in: Birkhofer H. (Ed), The Future of Design Methodology, Springer, London, pp. 239-248

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