Preparing for the Transfer of Research Results to Practice: Best Practice Heuristics

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Abstract Although the development of methods and tools was for many decades the main focus of design research, transfer of research results to practice has been fragmented and limited and, hence, had a low impact. Various studies into the problems involved in transfer have been undertaken the uptake of the recommended improvements has been limited. One of the reasons, in our opinion, is the lack of a coherent, and agreed upon set of heuristics. This is where we intend to contribute. In this chapter we focus on the transfer of design research results into practice as experienced by those who have been involved in their development. Our aim is to propose a preliminary set of best practice heuristics for researchers to enhance the chances of successful transfer of research results into practice as a starting point for discussion and further research.

1 Introduction

People have undertaken and attempted to improve design processes for centuries, but it was not until well into the second half of the twentieth century that researchers became interested in designing as a topic of research, with its own body of knowledge, related but not identical to other sciences (including engineering science) (Blessing and Chakrabarti 2009). General agreement seems to exist that design research integrates two aims: the development of *understanding* and the

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development of *support*[1] based on this understanding. These aims are closely linked and should therefore be considered together to achieve the overall aim of design research: to make design more effective and efficient, in order to enable design practice to develop more successful products (Blessing and Chakrabarti 2009). In the terms used by Horváth, design research is "generating knowledge *about* design and *for* design" (Horvath 2001).

Even though the development of support was for many decades the main focus of design research, transfer of research results into practice has been fragmented and limited and, hence, had a low impact. Since the mid 1980s the design research community has expressed their dissatisfaction and worry about this situation (e.g., Andreasen 1987). Most results end up in scientific publications rather than being transferred into practice. This has several reasons (Blessing 2002). Many guidelines, methods, and tools have weak foundations: empirical data are hardly used. Evaluation is poor and implementation issues are rarely addressed (as, e.g., pointed out by Cantamessa 2003). If the aim of design research, as a discipline, is to improve design, and if this research is to be successful, it should have some effect in practice (Blessing 2002). This does not imply that each individual research project has to have an effect in practice. There are still important contributions to be made to our basic understanding of the design phenomena.

Various studies into the problems involved in transfer and implementation of research results have been undertaken and recommendations for improvement proposed. Benefits of using design tools have been reported if they are fully implemented (Booker 2012; Cantamessa 1999), but overall the uptake and impact is still considered insufficient. What has changed is that politicians and funding agencies increasingly focus on transfer and impact of research results (see, e.g., the European Commission's Horizon 2020 program). Innovation is heralded as the main factor for economic growth and the expected economic and/or social benefits have become important—if not the most important—criteria for investment in a research project. The issue of transfer has thus become more relevant than ever before.

In our opinion, there is a need for a coherent and agreed upon set of heuristics to enhance the chances of successful transfer of research results into practice. This is where we intend to contribute.

Our focus is on academic engagement not commercialization, although commercialization may follow (Perkmann et al. 2013). Our interest is the transfer processes, rather than the outcomes, in line with the findings of Ankrah et al. (2013), who found that "the immediate outputs of relationships between university and industry actors might not necessarily take a tangible form, such as inventions, patents, prototypes or products, but could be 'intermediate outcomes.' These could be bits of knowledge, hints, clues, ideas for new projects, opportunities, or even

[1]The term *support* refers to "the possible means, aids and measures that can be used to improve design. This includes strategies, methodologies, procedures, methods, techniques, software tools, guidelines, information sources, etc., addressing one or more aspects of design" (Blessing and Chakrabarti 2009).

negative findings. They found that "the majority of benefits were less-tangible" and concluded that "It could well be that evaluating the transfer process by looking for tangible outcomes such as cost-effectiveness is looking in the wrong place."

We concentrate here on the work of individuals rather than institutions, as we consider individual contacts between academic and industrial actors as essential for starting collaboration and for long-term engagement.

The organization of the paper is as follows. After a short overview of studies into the uptake of design support and university–industry collaboration in Sect. 2, the chapter focuses on the results of two, day-long workshops intended to develop an initial set of heuristics to guide the transfer of research results into practice (Sects. 3–5). This chapter concludes with the main contributions and an outline of further research.

2 Current State-of-the-Art

Various research areas, whether applied or not, involve interaction with industry or society. "Researchers in these areas are more likely to be engaged on real-world problems and interacting with industry, and their status is likely to be codetermined by their reputation among their peers and their standing in industry. This is especially true in the case of engineering" (Bruneel et al. 2010). It is therefore surprising that in the area of engineering design, despite close collaboration, uptake of design support (methods, tools, systematic procedures, etc.) by industry is still slow. This has been discussed in the 1980s, e.g., by (Gregory[2] 1984; Andreasen 1987; and Gill 1990). Gill points at the lack of insight of researchers into practice and the fact that practitioners do not necessarily understand the process of design as an intellectual endeavor. Publications, he continues, "serve, collectively, to impede progress toward acceptance by practitioners because of their apparent dissimilarity and the consequent confusion this creates." He calls for "a period of consolidation" and for "field trials." The importance of consolidation has been repeatedly mentioned (e.g., Blessing 2003), and is still considered a very important issue (e.g., Birkhofer 2011).

Over the years a large number of empirical studies aimed to shed light on the issue of poor uptake of design support in practice (e.g., Gregory 1984; Araujo et al. 1996; Sheldon 2004; Booker 2012). In general the authors are convinced of the improvements that can be realized when design support is implemented, either based on their own experiences or on reports of successful implementation. Araujo et al. (1996) concluded that "many companies are unaware of the potential quality benefits of available methods." Nearly a decade later, Sheldon (2004) saw, "encouraging signs that academic design research in specific areas … are producing

[2]Gregory (1984) speaks of Design Technology comprising "general design technology and broadly applicable techniques, domain specific procedures and techniques, and CAD systems and processes" "It includes all the essentials for the execution of design work."

intellectually challenging outputs that are being adopted by industry." Booker (2012) lists very impressive measurable improvements made by design teams employing some well-known design support methods, such as FMEA or DFA.

The expected impact of the proposed design support will be an important criterion in deciding on an investment in its transfer, even if only for testing. Cantamessa (1999) shows that at operational level "design techniques are not important because of their objective value but, rather, because of the combined impact they may have upon the design capability of the firm." He found a positive impact of what he called best practice techniques (IT tools and engineering methods) on the design process and its outcome, if these are fully implemented (see also Booker 2012). The main finding is that "they do not deliver linear effects upon the design process, but interact in a complex manner with one another," so that "when considering their adoption or assessing their impact, it is necessary to consider them altogether and never in isolation." He suggests that it is the design capability of the firm that links adaptation and effects. "It is the endogenous evolution of routines which may lead to learning, while an exogenous injection of knowledge may not be as effective, at least on its own." The concept of design capabilities may lead to "sounder and more coherent plans concerning the adoption of widely publicized best practice." López-Mesa and Bylund (2011) confirm this in their study. "Measuring the impact of methods in terms of methods applied by the book may not yield a fair measure of the impact design methodology has had in the practical world." Researchers should expect an "incorporation of some features of the academic methods in their already working methods, or an influence in their way of thinking." The principles of a method should therefore "match that used in engineering thinking and should give the engineer the feeling that they own the engineering value judgments and decisions."

Yeh et al. (2010) observed that implementation fails because companies under-utilize design support or do not utilize it effectively. Companies also adapt design support in order to make them more appropriate for their own processes and products, sometimes with success (e.g., O'Hare et al. 2010), but sometimes leading to unreliable results (López-Mesa and Bylund 2011). According to Birkhofer (2011) the key problems are wrong or inappropriate use of methods due to conceptual misunderstanding of some of the key concepts, or "degeneration of design methods" when methods are applied "mechanically without gaining additional insights […] or a better understanding of the problems to be solved." "Development methods and tools may truly sustain sound design practice, but cannot be considered as surrogates to it" (Cantamessa 1999).

Thia et al. (2005) distinguish between internal reasons for non-adoption of design tools (user-friendliness, usefulness, time, monetary cost, flexibility, and popularity) and external reasons (project nature, organization, industries, and culture).

All these findings suggest that transfer cannot be addressed without taking into account the wider context, and that transfer requires collaboration over time and the building of trust. According to Bruneel (2010), trust in university–industrial collaboration is one of the strongest mechanisms to further collaboration, but "requires long-term investment in interactions, based on mutual understanding about different incentive systems and goals. It also necessitates a focus on face-to-face contacts between industry and academia, initiated through personal referrals and sustained by repeated interactions, involving a wide range of interaction channels and overlapping personal and professional relationships."

Literature on university–industry collaboration provides indications of areas to improve in order to facilitate the transfer. A distinction is made between academic engagement and commercialization (Intellectual Property creation and academic entrepreneurship) (e.g., Perkmann et al. 2013). Commercialization is the "prime example for generating academic impact," but academic engagement is considered the most important channel. Academic engagement is "knowledge-related collaboration," which includes "formal activities such as collaborative research, contract research, and consulting as well as informal activities like providing ad hoc advice and networking with practitioners." In addition a third type of interaction is frequently mentioned (e.g., Bodas Freitas et al. 2012): Employment-based interactions such as joint training and supervision of graduates, graduate recruitment, and personnel exchanges.

Studies suggest that "the effects of many of these 'technology commercialization' policies remain controversial" (Mowery 2011) and that "Universities income from academic engagement is usually a high multiple of the income derived from intellectual property," even though results are not conclusive (Perkmann et al. 2013). "For most industries, patents and licenses involving inventions from university or public laboratories were reported to be of little importance, compared with publications, conferences, information interaction with university researchers, and consulting" (Cohen et al. 2002 in Mowery 2011). This highlights the importance of addressing transfer and implementation in our publications, which is often found to be lacking (Cantamessa 2003).

Bodas Freitas et al. (2012) conclude that "personal contractual interactions with individual academics, which do not directly involve the university, appear to be more effective in facilitating the transfer of knowledge, especially to small firms, and in providing firms with knowledge relevant to their business, technology and production needs." According to Ramos-Vielba and Fernández-Esquinas (2012) "For the majority of universities the thrust of their collaborative experiences is devoted to tacit knowledge rather than to intellectual property rights." Their survey also showed that "It is important to recognize that a variety of different types of interactions contribute to increased absorptive capacity in specific industries because they generate long-term relations of trust that are associated with a variety of different collaborative experiences." Kozilsnka (2012) observed that "Mutual trust, commitment and shared goals are the most essential drivers" of university–industry relationships.

As early as 1984, Gregory (1984) suggested nine "aspects which seemed to be significant in helping adoption" based on the 12 procedures he analyzed in terms of what are believed to be important aspects of design technologies and their transfer. These 12 procedures played a significant part in the buildup of design technology and had relevance to both industry and academia, and include brainstorming, systems engineering, functional analysis and costing for design. The nine aspects are:

- Presentation of the item in a well-defined package, including a clear title;
- Specificity in nature, rather than abstract in presentation or use;
- Potential relevance to immediate tasks rather than acting as an infrastructure for design;
- Track record of success within reason;
- Potentiality for competitive advantage and legal or contractual compliance;
- Ease of application;
- Ease of acquisition;
- Ready identifiability;
- Quality or research work, argument, presentation.

Unfortunately, the generic value of these aspects as guidelines is not clear from Gregory's article, as the procedures he discusses only partially reflect instances of these aspects.

Booker (2012) provides an extensive overview of design tools and classifies their attributes and implementation issues he found in literature in "a set of questions that a manager or engineer would naturally ask in the context of design tool implementation in their business." Although a very useful and comprehensive starting point, the set seems to need further consolidation and reformulation in order to provide guidelines for researchers developing design support. The question also remains in how far the statements of the different authors are based on their experiences or their expectations.

As starting point of knowledge transfer, Kelli et al. (2013) suggest technical verification (proof of concept, scalability, robustness, production quality, cost, and yield) and business verification (SWOT or NABC: Needs, Approach, Benefits, Competition: a business verification method developed by the Stanford Research Institute).

This short study of the literature suggests that the transfer of design support not only depends on the quality of the support but on individual contact, long-term relationships based on mutual trust and commitment, and shared expectations. Any set of heuristics to support the transfer and implementation of design support should thus consider not only the qualities of the support, but a wide range of issues that concern both the researcher and the industrial partners and require development over time.

3 Approach

The findings presented here are the result of a comparison of the outcomes of two, day-long discussions on heuristics for guiding the transfer of research results into practice. The participants were the members of the Management and Advisory

Boards, as well as the leaders of the Special Interest Groups, of the Design Society (www.designsociety.org). The majority of participants took part in both meetings.

3.1 First Meeting 2012

The starting point of the first meeting in March 2012 were the experiences of the 35 participants with research results they knew had been successfully transferred into practice. Details of these results were distributed among the participants. They also received a set of 16 heuristics for transfer of research into practice prepared by the second author. Based on a discussion about their experiences with successfully transferred results, the participants had to assess the applicability of the 16 heuristics, and reformulate or add where they deemed necessary.

3.2 Second Meeting 2013

The seeding for the second meeting in March 2013 was a summary of exploratory interviews with people from industry, who are responsible for, or regularly involved in, contacts with universities. The participants were divided into five groups to discuss the results of the interviews, and to formulate statements on how to improve transfer of research results into industry. The statements were brought together and clustered into sets of thematically related statements. Each group of participants was given one set from which to derive heuristics.

3.3 Formulation of Heuristics

After the two meetings the authors analyzed and compared the two sets of heuristics and brought these together into a preliminary set of best practice heuristics for researchers to enhance the chances of successful transfer of research results into practice, as well as for further discussion and research.

4 Findings

Section 4.1 presents the findings from the first meeting, which comprised the review of the set of methods and tools based on research results and successfully transferred to practice. This is followed in Sect. 4.2 by the findings from the best practice heuristics discussions in the second meeting.

4.1 Heuristics Derived from Academic Experience

During the first meeting, two triggers were used: a set of cards summarizing successfully transferred research results and a set of 16 heuristics for successful transfer preformulated by the second author.

4.1.1 Successfully Transferred Research Results

Prior to the first meeting the participants were asked to provide the following information about research results they knew had been implemented in practice: the name and aim of the result, the research team, the companies using the product, and the value to the user. The participants were divided into 5 groups, each discussing the summaries produced by the participants in the group. A sample of the cards can be seen in Fig. 1.

Of the 54 entries, 51 concerned methods and tools and 3 entries concerned products that had been successfully transferred to practice. In 38 of the 54 entries, at least one of the participants had been involved (see "own" in Table 1). For further processing only 45 of the methods and tools were considered, as none of the participants were familiar with the details of the transfer of 6 established methods and tools.

Table 1 shows that the majority of the research results that were discussed are generally applicable. Many of these had been demonstrated in multiple application areas (last column). Those that were characterized as generally applicable, but had only been applied in one area, were recent developments.

Fig. 1 Input for first meeting: summary cards of successfully transferred research results

Table 1 Range of successfully transferred research results

n = 54 (38 own)	Specific application area	Generally applicable, applied in one area	Generally applicable
Support for a specific task	3 (2 own)	6 (6 own)	19 (13 own)
Support for multiple tasks	3 (3 own)	5 (5 own)	9 (6 own)
Not further considered	Products 3 (3 own)		Established 6 (0 own)

The research results were further divided into support for a specific task and support for multiple tasks. The latter usually offered a set of methods and tools or a methodology.

The largest cluster of transferred research results fell into the category of 'generally applicable and task specific support.'

One factor usually mentioned as key to success is the value created by the support in practice. This value is often expressed in terms of time, and cost savings, and quality improvement. Although important for the 45 analyzed research results, other values were equally important, as shown in Fig. 2.

A total of 74 values that were mentioned by the participants were grouped by the authors into the 8 categories as shown in Fig. 2. The grouping of values into categories is shown in the appendix. The variety in values mentioned is interesting, even the highest ranking value 'design' was only mentioned for 16 of the 45 research results.

Among the most frequently mentioned values are the direct support for the design activity (e.g., to support exploring solutions spaces or evaluation), i.e., the task at hand, and for collaboration (e.g., to support knowledge management, design rationale capturing, or multidisciplinarity). The value 'organization' includes support for changing organizations, lean product development, and stage-gate process

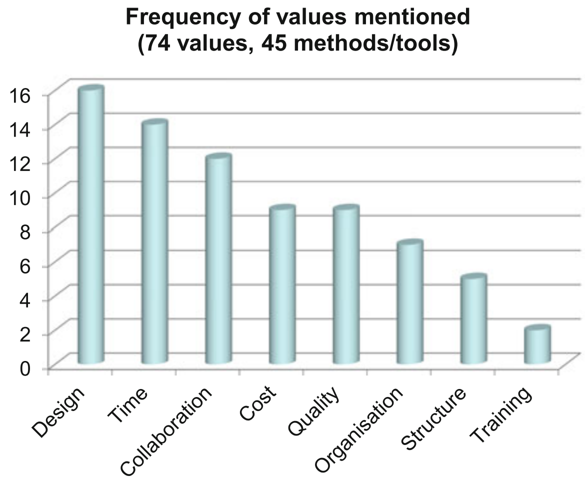

Fig. 2 Values for the user

Table 2 Dependency of values on type of support (*v*/*n* = number of values/number of transferred methods and tools)

	Specific application area	Generally applicable, applied in one area	Generally applicable
v/*n* = 74/45	*v*/*n* = 15/6	*v*/*n* = 23/11	*v*/*n* = 36/28
Support for a specific task (*n* = 28)	TCQ > DCO 6:2	TCQ > DCO 7:3	TCQ = DCO 11:11
Support for multiple tasks (*n* = 17)	TCQ < DCO 2:4	TCQ < DCO 4:7	TCQ < DCO 2:8

management. The value 'structure' refers to the product structure and includes support for modularization and robust architecture. 'Training' refers to results that are used for training purposes.

Grouping the values Time, Cost, and Quality (total frequency TCQ: 32) and the values Design, Collaboration, and Organization (total frequency DCO: 35) suggest that the values depend on the type of support (see Table 2). The numbers are small and the values mentioned for each research result may not have been exhaustive, but the findings are interesting. The more 'external' values cost, time, and quality were far more often mentioned for task-specific support, even though these values relate to the development process as a whole. Support covering multiple tasks seems to have a more 'internal' value, contributing to the designer, the team, and the organization.

4.1.2 Heuristics for Successful Transfer

After first discussions in the group about the successfully transferred research results, the participants received a set of 16 heuristics for transfer of research into practice, which had been prepared by the second author. The heuristics were divided into five categories: generally applicable, designer related, design artifact related, method related, software tool related. These categories reflected the set of design research areas defined in a meeting of the participants a year earlier in March 2011 (Seering and Oehmen 2012).

Based on their experiences with successful transfer, the 35 participants identified each of the 16 heuristics as

- Applicable in most cases (>90 % agreed[3]) → 3 heuristics
- Applicable in many cases (>70 % agreed) → 6 heuristics
- Applicable in some cases (>50 % agreed) → 7 heuristics

[3]The percentage indicates the percentage of participants who agreed that a particular heuristic applies to the successfully transferred research result.

In the emerging discussions 16 additional heuristics were formulated and existing ones reformulated. Of the 16 additional heuristics, 6 related to the research process. The final set of heuristics can be found in the Appendix.

The three heuristics that were considered applicable in most cases are:

- The question being addressed will be of substantial interest to practitioners
- Research results will be evaluated by practitioners
- Tools will improve process effectiveness and/or efficiency measurably

Interestingly, heuristics concerning the study of designers or artifacts were considered only relevant in some cases. The same was found for the heuristics on compatibility of tools with those already in use by practitioners and the quality of the user interfaces.

4.1.3 Conclusions

Many of the participants had been involved in successful transfer of research results. Whether this is exceptional or not, we cannot say. All participants are experienced researchers from a variety of countries, but their number is small compared to the size of the research community as a whole. In other words, we are likely to have only seen the tip of the iceberg, many more results are likely to have been transferred successfully.

It is promising to see that so many managed to bridge the gap between academia and practice, but we are of the opinion that this bridge is narrow and fragile as it seems very much dependent on personal connections and luck in timing. An incubation time is needed, as well as product champions within the company. In some cases publications seem to lead to wide spread use, in other cases consultants pick up the results and ensure their distribution. The trigger can differ: industrial need or academic interest (industrial pull or academic push), although the heuristics seem to suggest that ultimately, industrial need is essential.

Unfortunately, very little is published about results that were transferred, apart from some methods that have become widely known in industry, such as QFD or FMEA. In fact, many of the 45 mentioned methods were not known to the other participants.

Our aim was to extract the lessons that were learnt in order to formulate heuristics that can be shared and that will improve the likelihood of successful transfer. For that purpose, we started a series of interviews with practitioners and used preliminary results as input for a second round of discussions.

4.2 Heuristics Derived from Industrial Input

The seeding for the second meeting came from outside academia. Our view as researchers on what makes transfer into industry successful will only provide a one-sided perspective, which may be strongly colored by the fact that we are the developers of the support. The first author, kindly supported by Tim McAloone (TU Denmark) conducted a set of exploratory interviews with people from 12 companies in 5 different countries, who are responsible for or regularly involved in contacts with universities. The interviews were based on the same set of questions:

- What makes a particular research result (method/methodology/tool) interesting for your company?
- What are the reasons to accept or at least try out such results?
- What are the reasons to be skeptical or not even wishing to try out such results?
- Do you have procedures for testing, adapting, implementing of such results in your company?
- When would a research result be interesting enough to really implement, after having tried it?
- What are your personal good and bad experiences?

The interviews, even though only exploratory, revealed viewpoints that had not been taken into account in the heuristics derived during the first meeting in 2012. The interviews are still ongoing and will result in a separate publication.

In the second meeting, the preliminary findings of the interviews were presented. The participants were then divided into five groups and asked to discuss the findings, and to come up with statements on how to improve transfer of research results into industry, and on factors that play a role in this transfer. The statements (63 in total) were placed on the wall of the meeting room and then jointly clustered into related statements. The authors, as facilitators of the meeting, grouped the clusters into 5 sets. Each group of participants was given a set of statements and asked to bring these together in a set of heuristics for successful transfer.

Table 3 shows the themes identified by each group in the received statements, the number of statements, and the number of heuristics derived from these statements.

This second set of heuristics covered a wider range of heuristics than the first set. The role of education became explicit, and considerable emphasis was put on the need for continuous multilevel and multidirectional interaction between academia and industry in particular in order to understand industry. The heuristics also emphasized the careful preparation of the transfer and the importance of understanding the readiness level of the research results with respect to the company (the so-called methodological readiness level). All heuristics can be found in the appendix.

Table 3 Themes, received statements and derived heuristics

Group	Theme	Statements	Heuristics
G1	Education	9	3
G2	Understanding and addressing company needs, selling	12	8
G3	Relationships, champion, understanding the company, presentation	15	4
G4	Planning, mutual benefits, stepwise approach	17	5
G5	Methodological readiness, understanding of industry	10	6

Table 4 Themes covered by the two sets of heuristics

Trigger: own experiences and predefined set of heuristics (2012)	Trigger: experiences from industry (2013)
Generally applicable heuristics	Understanding and addressing company needs
Heuristics on studying designers	Relationships, understanding the company
Heuristics on studying artifacts	Planning, mutual benefits, stepwise approach
Method-related heuristics	Methodological readiness
Tool-related heuristics	Visibility, presentation
Research-related heuristics	Education

5 Comparison of Derived Heuristics

Table 4 shows the different themes covered by the two sets of heuristics. While processing the heuristics of the second meeting, the heuristics concerning visibility and presentation were put in a separate category.

The two sets of heuristics show some overlap, but, overall are surprisingly different, despite the fact that the majority of participants were involved in the formulation of both sets. It seems that the trigger (own experiences versus interpretation of industrial input) determined the focus and hence the themes covered, even though the interview results were only used as a trigger; the statements and heuristics were formulated by the researchers and thus included their personal and group view (as they did in the first meeting).

As discussed in Sect. 4.2, the input from industry in the form of a set of preliminary interviews about their experiences certainly added important additional points of view that had not been considered in the first meeting.

The first meeting was very much an inward looking, academic push model; when we have done our job well, industry will be happy to use the results. The focus of this first set of heuristics is on what academia needs to do, such as more realistic evaluations, and better understanding of industry.

The second meeting focused much more on what academia and industry need to do together, and on the fact that there is no quick fix: transfer takes time and requires continuous interaction that is professionally executed (see the heuristics on presentation). Furthermore, the university's educational role was introduced as a strong contributor to the successful transfer of research results.

6 Conclusions and Further Research

The two meetings, the analysis of the collected data and the initial interviews resulted in characteristics of research results that have been successfully transferred into practice, characteristics of the processes involved, and a draft set of best practice heuristics for enhancing the chances of successful transfer of research results into practice.

We found that a large concentration of successful applications of research results are in the area of support for a specific design task that is applicable in multiple settings. Our analysis also revealed that support for a specific task is more likely to affect the 'external' values of cost, schedule, and quality while support for a collection of tasks is more likely to be perceived as of value to internal stakeholders; designers, design teams, and organizations.

Concerning the process of transfer, the set of reviewed methods and tools and the stories of their development make clear that successful transfer of research results does not happen overnight. Those that were successful generally involved a vision, many years of development, the input of multiple researchers who worked together and built upon each other's work, as well as a personal contact with a company willing to collaborate. This is in line with the literature on university–industry relationships, discussed in Sect. 2.

One of the main messages is that researchers have to engage practitioners in their research. As illustrated in Fig. 3, their involvement should be continuous but requires different input, depending on the stage of the research.

We have achieved our aim to propose a preliminary set of best practice heuristics for researchers to enhance the chances of successful transfer of research results into practice, which could be used as a starting point for discussion and further research.

The study has its limitations. Even though the input for the second discussion came from industry and many participants have industrial experience or frequent contact with industry, the heuristics were formulated by the academic actors. The input from industry was based on a limited set of interviews and industrial actors were not involved in the discussions.

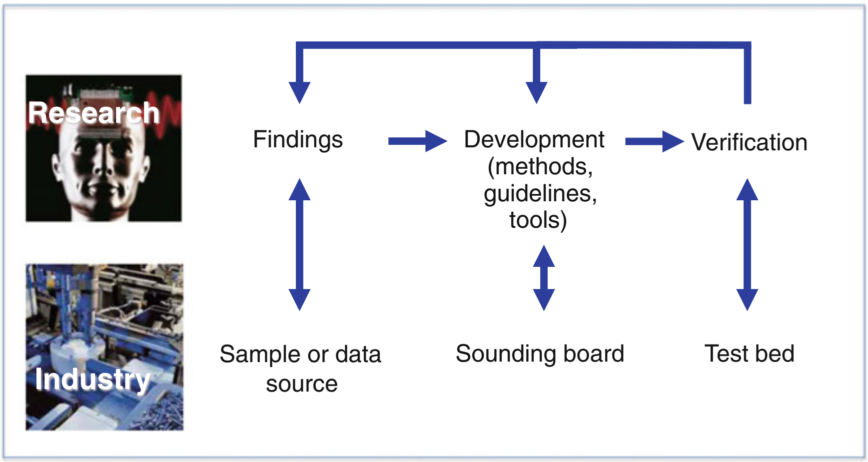

Fig. 3 Roles of industry in design research

The set of heuristics is therefore not yet suitable for practical use: refinement is required. A further input will be the results of the ongoing interviews with industrial actors involved in the transfer of research results into practice, and the results of the breakout session at the IDRP workshop at which this paper has been presented (see Blessing, Results of Breakout Sessions of Group A, Chap. 4).

The heuristics, though preliminary, are presented here to encourage the research community as a whole to address the issue of transfer of our research results into practice. If understanding and improving design is the purpose of our research, the currently not very successful transfer of our research results should be of major concern and, in the light of external pressures from funding agencies and politicians, be addressed as priority and joint responsibility.

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Appendix: Draft Set of Heuristics

Table 5 contains the categorized heuristics resulting from the two meetings. The first column indicates from which meeting the heuristic results. The second column contains the heuristics. The last column shows the applicability of each of the heuristics to the successfully transferred research results that were discussed in the 2012 meeting. No frequencies are available for the new heuristics that were proposed by the participants in 2012 and those that were proposed in 2013.

Table 5 Heuristics and their applicability (applicable in most/many/some cases) (blank: new heuristic which is at least applicable to some of the research results in one of the groups)

Generally applicable heuristics		
2012	The questions being addressed will be of substantial interest to practitioners	Most cases
2012	Practitioners will participate in setting objectives for the research	Many cases
2012	Research results will be evaluated by practitioners	Most cases
2012	Practitioners will be in frequent communication with the research team	Many cases
2012	Value should increase over time	–
2012	Results should have long-term impact in industry	–
2013	Concentrate on people: collaborate with the right people	–
2013	Apply exciting process goals and deliverables for research and project	–
2013	Design the research, plan with measurable deliverables	–

(continued)

Table 5 (continued)

Generally applicable heuristics		
2013	Balance the work: Problem Solving versus Research Vision	–
2013	Have a long-term goal and produce spin offs and continuous quick wins	–
2013	Understand the culture of company, the company's process, and the competition	–
Designer-related heuristics		
2012	Research will be conducted with practicing designers as the subjects	Some cases
2012	Activities being studied will be actual/representative design tasks	Some cases
2012	Studies will be conducted in settings emulating those of practice	Some cases
Artefact-related heuristics		
2012	The artifacts being studied will be professionally designed products or components	Some cases
2012	Artifacts/Product models will be sufficient in scope to address the problem	Some cases
Method-related heuristics		
2012	Methods will apply seamlessly to situations in design practice	Many cases
2012	Methods will be easy to understand and implement	Many cases
2012	Methods will yield benefits (early in the process of implementation)	Many cases
2012	Methods will be robust in the presence of differences in standard work process	Many cases
2012	Methods will be credible	–
2012	Methods need to be rational and self-consistent	–
2012	Methods should be novel	–
2012	Methods should be petty, feel good	–
2012	Long term maintenance should be guaranteed	–
2013	The readiness level of the method with respect to the company should be understood and related to the company's needs in communication	–
2013	Make a strategic plan and acquire expertise to bring the method to the next level readiness level	–
Tool-related heuristics		
2012	Tools will be compatible with those already in use by practitioners	Some cases
2012	User interfaces will be well designed	Some cases
2012	Tools will improve process effectiveness and/or efficiency measurably	Most cases
2012	Tools will improve satisfaction	–
2012	Tools should maintain data integrity	–
2012	Long term maintenance should be guaranteed	–
Research-related heuristics		
2012	The result should be relevant and provide input for further research	–
2012	The result should provide benefit for researchers	–
2012	Ethics of the research work should be considered	–
2012	Design research should be socially responsible	–

(continued)

Table 5 (continued)

Generally applicable heuristics		
2012	Research is capable of being done rigorously/scholarly	–
2012	The research should promote further collaboration in academia and industry	–
Education-related heuristics		
2013	Understand education as an ecosystem (educational institution, industry, alumni), dreams of researchers transferred via students into industry, and feedback from industry. You have to advertise the integrated ecosystem.	–
2013	Internships in industry for students	–
2013	Enhance collaboration by exchanging students	–
2013	Be systematic on how students work with industry	–
2013	Enhance educational system to better expose our undergraduate students and Masters students to design	–
2013	Two levels: bottom up—students to industry, Top-down—policy making (SIG?)	–
Interaction enhancement heuristics		
2013	Internships in industry for faculty	–
2013	Trust building—Enable bidirectional movement of industrialists and academic—Win-win situation	–
2013	Better communicate with industry—know client	–
2013	Offering continuing education	–
2013	Two levels: bottom up—students to industry, Top-down—policy making (SIG?)	–
2013	Start with consulting projects and build relationships before engaging the formal university process	–
2013	Understand the "customer", i.e. the company, and what the business case is for them if they use your ideas	–
2013	Inspire confidence!	–
Visibility-related heuristics		
2013	Publish/expose more in trade journals and non-academic journals (economist, HBR,…), tv, … to show our work	–
2013	Have journals add case studies/success stories section	–
2013	Build on a "crowd". Use the DS as testimony of competence. But, we rarely use or promote each other's work…	–
2013	Is it possible to create some "open source" platforms, documents, methods via the DS that can support the above?	–

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