Toward a Knowledge Creation Perspective on Design Science Research

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Recommended Citation
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ABSTRACT

At present, the Information Systems (IS) community is debating the relevance of its research results. Design Science Research (DSR) is considered a promising approach to advance the scientific body of knowledge while, at the same time, resulting in research results of high practical utility. As a consequence, a number of guidelines and recommendations have been proposed to support the researcher in conducting DSR. Interestingly, though, almost no contribution can be found so far which investigates the transfer of knowledge between researchers and practitioners in DSR. Without efficient and effective transfer of knowledge between those two communities, DSR projects will not be able to achieve their goals. Motivated by this research gap the paper at hand takes a knowledge creation perspective on DSR. It proposes an integrated model consisting of five different knowledge transfer activities between researchers and practitioners and vice-versa. The model is discussed on the basis of three recent DSR cases. The paper shows the general applicability of knowledge creation theory to DSR and lays the foundation for future research, in particular for further evaluation and elaboration of the model.

Keywords
Design science research, knowledge creation theory, theory for explaining, case study application.

INTRODUCTION

Motivation and Problem Statement

The Information Systems (IS) community is debating about the relevance of its research results. In 2009, for example, the focus topic of the International Conference on Information Systems (ICIS) was “Doing IT Research That Matters” and Gill and Bhattacherjee (2009) were provocatively asking whom we were informing. Recently, the European IS community made a statement for Design Science Research (DSR) in IS (Österle, Becker, Frank, Hess, Karagiannis, Krcmar, Loos, Mertens, Oberweis and Sinz 2011) which caused many discussions not only in Europe, but also in the US regarding a methodological pluralism of relevant IS research. Independent from this discussion, DSR is, in general, seen as a promising approach to address the issue of lacking IS research relevance. DSR is aiming at the development of research artifacts which make a substantial contribution to the IS body of knowledge and – at the same time - are of practical utility (Hevner, March, Park and Ram 2004; March and Smith 1995). In 2004, Hevner et al. (2004) presented guidelines for DSR which are based involvement of both the research environment and the scientific knowledge base. With its roots in engineering disciplines, DSR is focusing on identifying and designing “means-end” relationships in current phenomena rather than on finding explaining “cause-effect” relationships (Winter 2008). Gregor (2006) refers to the theoretical contribution of DSR as “theories for designing” and demarcates them from analytical, explaining, and predictive theories.

Based on the DSR foundations laid by Hevner et al. (2004), March and Smith (1995), and Walls et al. (1992), researchers have been proposing guidelines and recommendations to support the IS researcher in conducting DSR. Prominent examples are the Design Science Research Methodology (DSRM) by Peffers et al. (2008) and the Design Research Workshop by Rossi and Sein (2003). On top of that, suggestions have been made to support the explication of individual activities in the DSR process. Frank (2007), for example, proposes a multi-perspective framework for the evaluation of reference models. One of the four perspectives is “deployment” which focuses on the usability and utility of reference models in cases of practical application.

All available DSR contributions stipulate the involvement of knowledge and expertise both from the practitioners’ and the scientific community. Hevner et al.’s incorporation of “business needs” into the research and DSRM’s “Problem Identification & Motivation” phase require intensive transfer of knowledge between practitioners and researchers and vice-versa. Interestingly, though, is the fact that almost no recommendation and guideline is available supporting researchers in finding answers to the question how to achieve this knowledge transfer. What types of knowledge are to be transferred between the two communities? Which knowledge transfer processes should be applied in DSR projects? What problems
typically occur? At present, the IS research community remains silent in giving answers to these question. Researchers cannot draw on scientific knowledge in this regard, nor are there guidelines and recommendations available.

**Research Question and Research Approach**

The research presented in this paper takes up on the lack of understanding of knowledge transfer in DSR. It attempts to give an answer to the research question whether the application of organizational learning theory to the field of DSR helps to close the gap and allows for analyzing and explaining knowledge transfer phenomena in DSR endeavors.

The paper is based on an analysis of the literature on DSR with a particular focus on knowledge transfer in DSR projects. The paper also briefly summarizes the body of knowledge regarding organizational learning theory with a focus on knowledge creation theory formed by Nonaka and Takeuchi (1995). In the third section, the paper develops a knowledge creation perspective on DSR. This perspective represents a theory for explaining according to the framework of IS theories proposed by Gregor (2006). It aims at providing a first understanding of how knowledge is transferred between practitioners and researchers in DSR projects and at laying the foundations for further explication and investigation of the research topic. The development of the knowledge creation perspective follows a deductive approach which considers the current literature as evidence. In the fourth section, the paper introduces a case study in order to assess the applicability of its approach and to reflect its findings against “real world” examples. The paper closes with conclusions and a brief outlook to future research opportunities.

**THEORETICAL BACKGROUND**

**Design Science Research**

DSR has its roots in engineering disciplines and was first used in the IS community in the late 1980s and early 1990s. Walls et al. (1992) introduced a system design theory for executive information systems, and Simon (1998) as well as March and Smith (1995) investigated on the epistemological foundations of design-oriented research. Other researchers investigated the question whether there were different “traditions” of DSR in the multiple regional IS communities, in particular in the European community (Frank, Schauer and Wigand 2008; Winter 2008).

Over the last decade, researchers also came up with recommendations and guidelines for conducting DSR. As mentioned above, DSRM is a prominent example. Apart from that, DSR and its epistemological foundation has been increasingly seen as a research topic in its own right. The International Conference on Design Science Research in Information Systems and Technology (DESRIST), for example, will this year be held for sixth time in a row.

The question, however, how researchers and practitioners should transfer knowledge in DSR project is still relatively unaddressed. Existing research in this area mainly reports on individual cases of researcher-practitioner collaboration. Examples are:

- Living labs which are used to foster end-user involvement in software design projects (Følstad 2008);
- Collaborative practice research proposed by Mathiassen (2002);
- Lindgren et al. (2004) reporting on the development of design principles for competence management systems;
- Consortium research as a form of multilateral research collaboration (Österle and Otto 2010).

Apart from that, first contributions exist which analyze applicability of “engaged scholarship” to the IS domain (Mathiassen and Nielsen 2008). Engaged scholarship is an approach proposed by van de Ven (2007) aiming at the advancement of collaboration with public and private stakeholders in applied social sciences.

However, major DSR recommendations, as of today, do not address the question of knowledge transfer in a manner useful for researchers conducting a DSR project. Hevner et al. (2004), for example, stipulate design artifacts to be rigorously evaluated and that the “evaluation includes the integration of the artifact within the technical infrastructure of the business environment” (p. 85). But it is not elaborated in further detail how this should be achieved. And Peffers et al. (2008) demand for the DSRM phase “Definition of the objectives of the solution” that “resources required for this include knowledge of the state of problems and current solutions, if any, and their efficacy” (p. 55), but do not specify this any further.

The need for research in this area is articulated by a number of researchers. Hjalmarsson et al. (2010) argue that designers often were not in control in collaborative DSR settings. And Wieringa (2010) points out that the problem solving expertise in the practitioners’ community should be treated equally important as research knowledge in DSR projects.

Summarizing, the analysis of the current state of the art in DSR shows a need for more detailed understanding of how knowledge is transferred between practitioners and researchers and vice-versa.
Organizational Knowledge Creation Theory

Organizational learning theories in general help to understanding why and how organizations learn from changes in their actions which are due to volatile environments. The roots of organizational learning as an area of research go back to the 1960s when Cyert and March (1963) proposed a behavioral perspective on the firm. In the past decades, numerous contributions were made addressing various aspects of learning in organizations. Just two examples are Argyris and Schön’s (1978) distinction between single and double loop learning processes and Carlile’s work on the boundaries of knowledge exchange (Carlile 2002, 2004).

Fundamental concepts regarding the question how knowledge is created in organizations were investigated by Nonaka and Takeuchi (1995). They argue that organizational knowledge is created through an ongoing conversion and transfer of implicit and explicit knowledge. Implicit – often also referred to as “tacit” – knowledge is personal knowledge which people are aware of, but which they cannot make available to others (Polanyi 1958). Therefore, the exchange of implicit knowledge requires high levels of trust and intensive interaction between people. In contrast to implicit knowledge, explicit knowledge has been articulated and document to certain (e.g. scientific) standards.

Based on these foundations, Nonaka and Takeuchi (1995) introduce the SECI model (see Figure 1) which describes four patterns of knowledge creation in organizations.

- Socialization is the transfer and exchange of implicit knowledge through the interaction of individual, e.g. through observation and imitation.
- Externalization is the conversion implicit into explicit knowledge.
- Combination is the creation of knowledge through the merging pieces of explicitly available knowledge, e.g. through conversation or using information systems.
- Internalization converts explicit knowledge into implicit knowledge.

![Figure 1: SECI Model, adapted from (Nonaka et al. 1995)](image)

The knowledge creation theory has been used often in the IS community. Orlikowski (2002), for example, is using it for studying “knowing in practice”.

In the following, the paper at hand distinguishes explicit from implicit knowledge by its documentation according to scientific standards. Therefore, knowledge implemented in enterprise systems, for example, is interpreted as “implicit”.

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A KNOWLEDGE CREATION PERSPECTIVE ON DSR

An Integrated Model

Artifacts, as the results DSR, are characterized by practical utility. They must be useful for practitioners while at the same time add to the scientific body of knowledge. In order to ensure practical utility, the researcher must be aware of a variety of knowledge sources in the conduct of the research project. Examples are:

- Business problems;
- Measures for success in overcoming the problems;
- Successful and – perhaps even more important – unsuccessful practical solutions to the problems;
- Scientific state of the art;
- Current instantiations;
- Contribution of design artifacts to solving the problem;
- Context of artifact application.

Hevner et al. (2004) refer to the “practical” types of knowledge as being situated in the environment of the research. Wieringa (2010) takes the DSR framework a step further and stipulates an equal consideration of practical solving and scientific knowledge. Based on his contribution, the paper at introduces a knowledge creation perspective on DSR (see Figure 2).

Figure 2: Knowledge Creation Perspective on DSR

It acknowledges the fact that DSR projects make use of knowledge both from the environment and the scientific knowledge base and also contribute knowledge back to both. The integrated perspective also identifies researchers and practitioners as equally relevant actors in collaborative DSR activities.

In the conduct of a DSR project, five knowledge transfer activities are carried out with transform different types of knowledge from practitioners to researchers, vice-versa and within the two communities. The five activities occur throughout the entire DSR process, i.e. from early problem identification to communication phases.

Of course, there are activities to transfer explicit to explicit knowledge within the practitioners’ community. However, the model does not focus on those because they are considered not directly related to research activities.

Knowledge Transfer Activities in DSR

Table 1 explains the six knowledge transfer activities in greater detail. It outlines the role of the different activities in the DSR process by referring to the six DSRM phases (Peffers et al. 2008). Apart from that, it gives examples for research methods and techniques which can be applied to support the knowledge transfer activities. The list of methods and techniques
is not exhaustive. And due to space constraints, the paper will not elaborate on the role all of the listed methods and techniques play in DSR. Instead, two examples, namely action research and focus groups, are explained.

<table>
<thead>
<tr>
<th>ID</th>
<th>Description</th>
<th>Role in DSR</th>
<th>Example research methods/techniques</th>
</tr>
</thead>
</table>
| A  | Transfer of explicit to implicit knowledge from researchers to practitioners | • ID&M, for sharing scientific body of knowledge;  
• D&D, for sharing design principles and design iterations of artifacts;  
• Dem., for preparing application of artifact in real-life context;  
| B  | Transfer of implicit to explicit knowledge from practitioners to researchers | • ID&M, for sharing problem solving knowledge;  
• DOS, for sharing success metrics, constraints etc.;  
• D&D, for sharing knowledge about solutions in the past;  
• Eval., for sharing knowledge about the utility of the artifact. | Action research, case studies (cf. Benbasat, Goldstein and Mead 1987; Yin 2002), focus groups (Morgan and Krueger 1993), grounded theory (Glaser and Strauss 1967), interviews, reverse engineering, surveys. |
| C  | Transfer of implicit to implicit knowledge within the practitioners' community | • ID&M, for getting a “big picture” of the problem across the boundaries of departments etc.;  
• DOS, for getting access to all requirement;  
• Eval.; for getting a comprehensive and complete assessment of artifact utility;  
• Comm., for disseminating the results in the practitioners’ community. | Action research, focus groups, training measures. |
| D  | Transfer of implicit to implicit knowledge within scientific community | • ID&M, for comprehensive understanding of the state of the art;  
• D&D, for making most appropriate design strategy available to DSR project and for sharing experiences;  
• Comm., for dissemination of research results. | Collaborative research. |
| E  | Transfer of explicit to explicit knowledge within the scientific community | • ID&M, for making state of the art available;  
• D&D, for making appropriate design strategy/approach available;  
• Comm., for dissemination of research results. | Scientific publications. |


Table 1: Knowledge Transfer Activities

Action research is a form of participatory research which is based on the participation of the researcher in an organizational change and learning process and on the bidirectional flow of knowledge (Baskerville and Wood-Harper 1996, 1998). In DSR project, action research allows for internationalization of explicit knowledge by practitioners and externalization of implicit...
knowledge by researchers. Hjalmarsson et al. (2010), for example, report on the use of action research in a collaborative DSR setting.

Focus groups are a special form of expert interviews (Morgan et al. 1993). They are conducted in a peer group and use knowledge sharing and transfer mechanisms of group work. Focus groups can be used to study the level of consensus of a group on a certain topic. They are therefore well suited to support evaluation and requirements specification activities in DSR projects. Both Sinha et al. (2004) and Schelp and Winter (2007), for example, report on the use of focus group during the design of reference models.

**CASE STUDY APPLICATION**

In order to illustrate the integrated model of a knowledge creation perspective on DSR and to study the model’s appropriateness it is applied to three cases of collaborative DSR. The three cases are taken from the list of accepted papers of the 5th International Conference on Design Science Research in Information Systems and Technology (DESRIST 2010). The first case describes a methodology for content-centered design of ambient environments (Janzen, Kowatsch and Maass 2010). The second case is about the design of focus area maturity models (van Steenbergen, Bos, Brinkkemper, van de Weerd and Bekkers 2010) whereas the third case reports on the design of a collaborative service infrastructure (Skorna, Bode, Baecker, vom Brocke and Fleisch 2010). The three cases represent three different types of design artifacts, namely a method, a model, and an instantiation.

<table>
<thead>
<tr>
<th>ID</th>
<th>Knowledge Transfer Activity</th>
<th>Case 1 (Ambient environment design methodology)</th>
<th>Case 2 (Focus area maturity model design)</th>
<th>Case 3 (Collaborative service infrastructure design)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Transfer of explicit to implicit knowledge from researchers to practitioners</td>
<td>• Use case demonstration; • Mock-up demonstration; • Prototype demonstration.</td>
<td>• Application of DyAMM in over 50 organizations; • Application of SPM matrix in 15 cases; • Publication of DyAMM in transfer outlets directed at practitioners.</td>
<td>• No evidence in case. Application of instantiation in case, however, envisaged.</td>
</tr>
<tr>
<td>B</td>
<td>Transfer of implicit to explicit knowledge from practitioners to researchers</td>
<td>• Expert interviews in workshops; • Creativity workshops with domain experts; • Survey among 46 graduate students for artifact testing; • Mock-up testing among 33 participants; • Prototype demonstration.</td>
<td>• Experiences from over 50 organizations using DyAMM; • Quantitative analysis based on 56 DyAMM cases; • Validation of SPM matrix in case studies; • Recommendation to use focus groups and case studies for method instantiation; • Creativity workshop with experts (brainstorming) to derive SPM capabilities; • Expert interviews with product managers during SPM matrix validation.</td>
<td>• Use of data from industry associations (the Manufacturing Institute and the Aberdeen Group) to motivate research.</td>
</tr>
<tr>
<td>C</td>
<td>Transfer of implicit to implicit knowledge within the practitioners’ community</td>
<td>• No evidence in case.</td>
<td>• No evidence in case.</td>
<td>• No evidence in case.</td>
</tr>
</tbody>
</table>
Table 2: Case Study Application

The application of the integrated model to three recent cases of DSR leads to multiple results. First, evidence can be found in the case studies for all knowledge creation activities, except for activity C. The transfer of implicit to implicit knowledge within the practitioners’ community remains unaddressed in all three cases. A reason for this might be the perception that knowledge transfer processes among practitioners per se are not considered research. The same argument was applied during the design of the integrated model in this paper when explicit-to-explicit knowledge transfer among practitioners was excluded. However, Österle and Otto (2010) argue that experts in the practitioners’ community simply outnumber researchers working in the same domain. Therefore, the transfer of knowledge within the practitioners’ community is considered necessary in order to “channel” the expertise and problem-solving knowledge to those individuals which participate in a collaborative DSR project.

Second, the cases show that a variety of methods and techniques is used to transfer knowledge from practitioners to researchers and vice-versa. The portfolio reaches from simple surveys to highly interactive settings such as “creativity workshops”. Apart from that, boundary objects (cf. Carlile 2002) such as prototypes and mock-ups are used to facilitate the knowledge transfer activities.

Third, certain methods and techniques apparently can be used independently from the type of artifact which is designed. Surveys, case studies, expert interviews, creativity workshops, and prototypes are used in all three cases.

CONCLUSIONS

Despite the fact that DSR is a highly regarded approach to overcome the relevance gap of IS research, the understanding of knowledge transfer activities between researchers and practitioners in DSR projects is still in its infancy. Motivated by this gap, the present paper takes a knowledge creation perspective on DSR and proposes an integrated model. The model describes five basic knowledge transfer processes between practitioners and researchers which are mapped to an established DSR guideline, namely DSRM. In order to illustrate the model and discuss its validity, three cases of DSR are selected and reflected against the model. The cases show the general feasibility of the approach and the validity of the model.

This paper makes a contribution to the scientific body of knowledge because it lays the foundation for a “theory for explaining” (Gregor 2006) a relatively unaddressed area of relevance both for practitioners and researchers. Future research opportunities are the testing of the model and its empirical evaluation.

Apart from that, practitioners benefit from the research because it helps understanding a type of research, namely DSR, which requires their engagement and involvement. Hence, the investigation of knowledge transfer in these research settings helps to increase both efficiency and effectiveness of the research and ultimately their engagement. This contribution also corresponds with findings laid out in the so-called “Aho Report” which analyses the impact of EU funded research under the Framework Program 6 (EC 2008).

ACKNOWLEDGEMENTS

The research presented in this paper was conducted as part of the Research Program Business Engineering at the University of St. Gallen (BE HSG).
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